

IFLA WORLD CONGRESS
SINGAPORE 2018

18–21 July 2018

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Marina Bay Sands, Singapore

IFLA World Congress 2018

e-Proceedings



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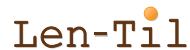


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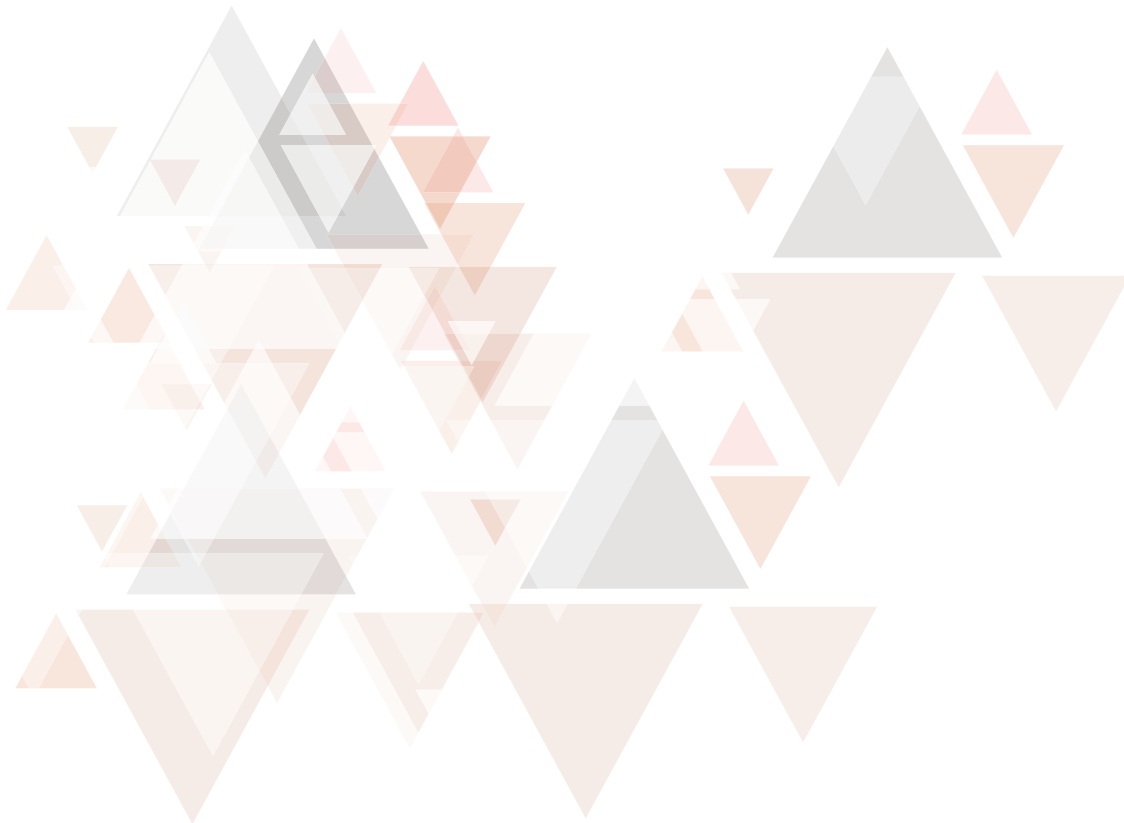
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[DAY 1 – 18TH JULY CONFERENCE PROGRAMMES]

Time	Programme		
0800- 0900	Registration		
0900	Opening Ceremony		
0900- 0905	Welcome by Congress Chair - <i>Damian Tang</i>		
0905- 0915	Address by IFLA President - <i>Prof. Kathryn Moore</i>		
0915- 0930	Opening Speech by Guest of Honour - Minister <i>Lawrence Wong</i>, Minister of National Development, Second Minister of Finance		
0930 - 1000	Opening Keynote - The Vision of Biophilic Cities <i>Prof. Timothy Beatley</i> , Teresa Heinz Professor of Sustainable Communities, in the Department of Urban and Environmental Planning University of Virginia: School of Architecture, United States of America		
1000 - 1030	Morning Refreshments		
1030 - 1100	Keynote Session - “Greening Our Red Dot” - Creating Liveable Density <i>Dr. Cheong Koon Hean</i> , Chief Executive Officer, Housing & Development Board, Singapore		
1100 - 1130	Keynote Session on Biophilic City - Ecosystem Services in the Urban Landscape <i>Prof. Peter Edwards</i> , Principal Investigator, Future Cities Laboratory, Switzerland		
1130 -1200	Keynote Session - Naturalising a High Density City. The Reality and Logistics <i>Henry Steed</i> , Director, ICN Design International Pte Ltd, Singapore		
1200 - 1230	Panel Discussion Moderator: <i>Daniel Cook</i> , Chief Executive Officer, Landscape Institute, United Kingdom		
1230 -1300	Sir Geoffrey Jellicoe Award & Presentation		
1300 - 1400	Networking Lunch		
	Featured Session - Biophilic City Biophilic Design and Culture	Featured Session - Smart Nation Smart tool and data - adoption of new technology and big data to inform design	Featured Session - Future Resilience Showcases integrated design solutions through projects by various design disciplines to make cities more resilient against climate change
1400 - 1420	Intertwined Culture and Nature for the Urban Future: Cultural and Natural Heritage Assets as a Platform for Landscape Architect’s to Achieve the UN Sustainable Development Goals-2030 Global Agenda <i>Patricia M. O'Donnell</i> , Founder & Principal, Heritage Landscapes LLC, United States of America	Cooling Singapore - Scientific Knowledge for Decision-Makers <i>Dr. Conrad H. Philipp</i> , Singapore-ETH Centre, Cooling Singapore, Singapore	The Ripple Effect - Building the Future of Resiliency <i>Ming-Jen Hsueh</i> , Landscape Architect, Sasaki Associate, United States of America
1420 - 1440	Nature System in Chinese Cities- Past, Present and Future <i>Prof. Wang Xiang-Rong</i> , Former Vice President of CHSLA, Dean of School of Architecture, Beijing Forestry University People's Republic of China	Green Intelligence - the Future of Plants and People <i>Veera Sekaran</i> , Founder, Managing Director, Greenology, Singapore	Living Infrastructure + Resilience <i>Gena Wirth</i> , Design Principal, SCAPE Studio, United States of America

1440 - 1500	Biophilic Railway Stations - Re-imagine the Nature of Transit Design <i>Dr. Philip Roös,</i> Deakin University, Australia	Punggol Digital District - A New Approach to Designing Singapore's Next Generation Business and University District <i>Aaron Tham,</i> Director, JTC Corporation, Singapore	Designing Resilience In Asia. Designing the Unpredictable, Planning with Uncertainty <i>Asst Prof. Oscar Carracedo,</i> Department of Architecture, National University of Singapore, Singapore
1500 - 1515	Discussions Moderator: <i>Yvonne Tan,</i> Director, DP Green Pte Ltd, Singapore	Discussions Moderator: <i>Muhammad Yazid bin Ninsalam,</i> RMIT University, Melbourne, Australia	Discussions Moderator: <i>Stephen Caffyn,</i> Principal, Stephen Caffyn Landscape Design, Singapore
	Paper Presentation Session- Greenery and Health	Paper Presentation Session- Performance Evaluation of Greenery and Public Spaces	Paper Presentation Session- Design for Climate Change
1515 -1530	Improving Mental Health in Prison Through Biophilic Design <i>Dr. Jana Soderlund,</i> Curtin University, Australia	Estimating Leaf Area Index of Urban Trees from Digital Zenith Cover Photography: A Framework on its Application for Urban Practitioners <i>Suen Ester Jun-Yu,</i> Singapore-ETH Centre, Future Cities Laboratory, Singapore	[Eco]Logical Urban Placemaking: Connectivity and Climate Change Resilience by Design <i>Prof. Stilgenbauer Judith,</i> University of Hawaii, United States of America
1530 - 1545	Living Landscape and Brain Reactions <i>Prof. Chang, Chun-Yen,</i> National Taiwan University	Tree canopy quantification of street canyons in high density urban environments using Google Street View <i>Gong Fang-Ying,</i> Chinese University of Hong Kong, Hong Kong, China	Recrafting Urban Climate Change Resilience Understandings <i>Prof. David Jones,</i> Deakin University, Australia
1545 - 1600	Impact of Learning Landscapes in Developing Cognitive Skills of Preschool Students: Case Study from Kandy, Sri Lanka <i>Herath Hiroshana Charith,</i> University of Moratuwa, Sri Lanka	The Application of Urban Flooding Potential Analysis and Area Inundated Land-Use Suitability for Detention Park - The Case for Taipei Da Gou Creek Park <i>Lin Kai-Tai,</i> Fujian Agriculture and Forestry University, People's Republic of China	The Landscape Carbon Calculator: A Tool to Understand and Improve our Carbon Footprint <i>Pamela Conrad,</i> CMG Landscape Architecture, United States of America
1600 - 1615	Creating A New Suburban Landscape by Means of Therapeutic Landscape - Xianhe Hainan Province <i>Sun Xue-Rong,</i> Beijing Forestry University, People's Republic of China	Research on Spatiotemporal Distribution and Environmental Demand of Physical Activities for the Elderly in Community Park at Cold Region Based on Healthy Perspective <i>Yu Yang,</i> Harbin Institute of Technology, People's Republic of China	Vegetation Succession Planning and Resilience <i>Prof. David Jones,</i> Deakin University, Australia
1615 - 1645	Afternoon Refreshments		
	Paper Presentation Session - Greenery and Health	Paper Presentation Session - Data for Design Insight	Paper Presentation Session- Disaster Resilience
1645 - 1700	Development of Biophilic Cities in Russia: From Ideal Scientific Town and Ecopolis to the Green Strategy of the Modern Megapolis <i>Dr. Maria Ignatieva,</i> University of Western Australia and Swedish University of Agricultural Sciences, Australia	Study on Urban Interior Bicycle Greenway Planning Based on Big Data Analysis of Shared Bicycle <i>Chen Xixi,</i> Beijing Forestry University, People's Republic of China	Hybrid City <i>Boonsom Yossapon,</i> Friends of River, Thailand
1700 - 1715	Garden Therapy in African Slums <i>Dr. Antolok Mariusz,</i> University of Warmia and Mazury in Olsztyn, Poland	Materializing Microclimate: Designing with Data for Thermal Effect <i>Walls Wendy Laurel,</i> University of Melbourne, Australia	Green Open Space and the Impact of Tsunami-induced Damaged on Banda Aceh City <i>Desy Fatmala Makhmud,</i> National Institute of Science and Technology Jakarta, Indonesia
1715 - 1730	A Landscape Approach to Urbanism for the 21st Century City <i>Dr. Beverly Ann Sandalack,</i> University of Calgary Canada	Irrigation Redefined-Designing Solutions for a Sustainable Future <i>Prof. Lam Yeng Ming,</i> Founder, FytoSol Pte Ltd, Singapore	Reconstruction Processes and Support Activities since the Great East Japan Earthquake <i>Prof. Hayashi Mayumi,</i> University of Hyogo, Japan



1730 - 1745	Traces of Water in the Coastal Zone of Lake Biwa: Toward Reconfiguring the Cities with Latent Natural Systems <i>Shuichi Murakami,</i> University of Shiga Prefecture, Japan	Big Data Analysis for Cultural Ecosystem Services in Landscape Research <i>Lilan Jin,</i> Korea University Republic of Korea	How to Minimize the Design of a Place Damage by Disaster <i>Prof. Akita Noriko,</i> Chiba University, Japan
1745 - 1800	Bioretention: Biophilic Technology for Urban Stormwater Management <i>Dr. Moura Newton Becker,</i> UNIFOR, Brazil	Smart investigation: Evaluation of Beijing Olympic Forest Park based on Online Big Data <i>Jiang Xin,</i> Beijing Forestry University, People's Republic of China	Disaster Management through the use of Animated Physical Model <i>Endo Kenya,</i> Ramboll Studio Dreiseitl, Singapore
1800 - 2000	Welcome Reception - Student Competition Awards & Charrette Awards		

[DAY 2 – 19TH JULY CONFERENCE PROGRAMMES]

Time	Programme		
0830 - 0900	Registration		
0900 - 0930	Keynote Session - Biophilic City in a Garden: Restoring Nature, Nurturing Communities <i>Kenneth Er</i> , Chief Executive Officer, National Parks Board, Singapore		
0930 - 1000	Keynote Session on Future Resilience - Christchurch New Zealand: Re-building a Resilient Post-Earthquake City <i>Rachel De Lambert</i> , Landscape Architect & Director, Boffa Miskel, New Zealand		
1000 - 1030	Morning Refreshments		
	Paper Presentation Session- Biophilic Landscape Design around the World	Featured Session - Smart Nation Modelling - simulate the environment and people behaviour to better understand reality	Featured Session - Future Resilience Respond to the question of how landscape architectural strategies could be successfully developed into best practice and guidelines which contribute toward the building of resilient cities.
1030 - 1050	The Restorative Value of Nature in Singapore's Landscape <i>Ryan Shubin</i> , Ramboll Studio Dreiseitl, Singapore Time: 1030 - 1045	Denser, Greener, Smarter <i>Prof. Thomas Schroepfer</i> , Professor and Founding Associate Head of Pillar, Architecture and Sustainable Design, Singapore University of Technology and Design, Singapore	Singapore's ABC Waters Programme: Integrating Blue- Green Designs in Urban Landscapes <i>Tan Nguan Sen</i> , Chief Sustainability Officer, Public Utilities Board, Singapore
1050 - 1110	Growing Fast and Staying Green - Vienne's Green Space Strategies <i>Thomas Knoll</i> , Knollonconsult Umweltplanung ZT GmbH, Austria Time: 1045 - 1100	Using Data Analytics and Geospatial Modelling to Strengthen Parks Planning <i>Huang Zhongwen</i> , Director, Digital Planning Lab, Urban Redevelopment Authority, Singapore	Biodiversity for Strengthening Resilience to Climate Change: The Singapore Experience <i>Dr. Lena Chan</i> , Senior Director, National Parks Board, Singapore
1110 - 1130	Embracing Nature through the Green Infrastructure Network of Extensive Urban Park System, Park Connectors and Suburban Forest Parks: Fuzhou, A Case Study of the Emerging Biophilic City in China <i>Wei Ren</i> , Fujian Agriculture and Forestry University People's Republic of China Time: 1100 - 1115	Connecting Landscaping and Human Well Being - Design for Outdoor Comfort in Tropical Climates <i>Wolfgang Kessling</i> , Partner and Principal, Trassolar, Germany	Building Urban Resilience in the Asia Pacific & Beyond <i>Saurabh Gaidhani</i> , Associate Director, 100 Resilient Cities, Singapore
1130 - 1145	Greening Chongqing: Creating a Green City on the Yangzi towards Enhancing 'Double Happiness' <i>Prof. David Jones</i> , Deakin University, Australia Time: 1115 - 1130	Discussions Moderator: <i>Srilalitha Gopalakrishnan</i> , Research Scholar, Architecture and Sustainability Pillar, SUTD 1 st Vice President, SILA Singapore	Discussions Moderator: <i>Emily Lim</i> , Singapore Polytechnic, Singapore
	Biophilia and Berlin: How Historical Conflict Establishes Progressive Biophilic Landscape Strategies and Design <i>Brent Greene</i> , Royal Melbourne Institute of Technology, Melbourne, Australia Time: 1130 - 1145		

		Paper Presentation Session- Smart Tools for Data Collection and Design	Paper Presentation Session- Resilient Community
1145 - 1200	The Landscape Recovery in Small Cities and Towns in China-Based on Liuying, Fengxiang County, Shaanxi <i>Zhang Weiping,</i> Xian University of Architecture & Technology, People's Republic of China	Applications of Unmanned Aerial Vehicles Remote Sensing Technology in Landscape Architecture <i>Han Weijie,</i> Beijing Forestry University, People's Republic of China	Infinitely Adaptive Socialised Housing Development for Urban Regeneration and Resiliency <i>Jouykovi Ignaecia Cruel,</i> Rizal Environment and Natural Resources Office, Philippines
1200 - 1215	History and Characteristics Of Urban Parks Those Have Been Built On Transportation Infrastructure <i>Jisoo Sim,</i> Virginia Polytechnic Institute and State University, United States of America	Geodesign Tools to Support Design with Nature in Urban Design <i>Huo Suyue,</i> South China University of Technology, People's Republic of China	Re-rooting Food and People to the Place and Re-exploring Landscape Locality for Future Resilience <i>Dr. Wang Kuang-Yu,</i> Chung Yuan University
1215 - 1230	Gaobeidian Ziquan River <i>Sun Hu,</i> Chief Executive Officer, S.P.I Landscape Group, People's Republic of China	Bird Tracking in Sungei Buloh Wetland Reserve, Singapore <i>David Li,</i> Manager, National Parks Board, Singapore	Sydney's Olympic Peninsula : Growing the Green Games Legacy - a Showcase for Urban Resilience <i>David Andrew Martin,</i> Sydney Olympic Park Authority, Australia
1230 - 1245	Strategies for the Recovery of Threatened Natural Systems and Their Role on the Mitigation of Rapid Urban Growth in Montes De Oca, Costa Rica <i>Prof. Laura Chaverri Flores,</i> Universidad de Costa Rica and Tecnológico de Costa Rica, Costa Rica	Transforming Data to Information: Multi-Source Data Fusion with Landscape Information Modeling Workflow in Landscape Design Project <i>Dr. Guo Yong,</i> Tsinghua University, People's Republic of China	Inclusive River <i>Boonsom Yossapon,</i> Friends of River, Thailand
1245 - 1400	Networking Lunch		
	Featured Session - Biophilic City Design of neighborhood landscapes with landscapes services. This session convenes policy makers, practitioners and academics in varying fields to share insights on an integrated design process applied in the planning and design of neighborhood landscapes in Singapore.	Featured Session - Smart Nation Cities and Innovation	Featured Session - Future Resilience Discourse on visions of sustainable society and resilient environment across scale and geography through a trans-disciplinary approach with the sharing of perspective from academics, activists and landscape architects.
1400 - 1420	Why Designing for Neighbourhood Landscapes Matter - Overview of Research Project <i>Prof. Tan Puay Yok,</i> National University of Singapore, Singapore	Living Digital in Smart Cities <i>Prof. Poon King Wang,</i> Director, Lee Kuan Yew Centre for Innovative Cities, Singapore	Landscape Approach, Ecosystem Services and Future Resilience <i>Dr. Himlal Baral,</i> Senior Scientist, Center for International Forestry Research Indonesia
1420 - 1440	Keynote Session 1 - Landscapes for Our Heartlands: A Biophilic Landscape Design Approach <i>Leonard Cai,</i> Deputy Director of Building & Research Institute, Housing & Development Board, Singapore	Cities & Innovations, Smart Nation Track: How Information Technology and Data Analytics May Provide Insights into the Design Processes by Better Quantifying Our Understanding of the Environment <i>Adam White,</i> Director, Davies White Ltd, United Kingdom	Between A Rock And Hard Place: Building Resilience in an Uncertain World <i>Prof. Jonathan Rigg,</i> Director of the Asia Research Institute and Department of Geography, National University of Singapore, Singapore
1440 - 1500	Keynote Session 2 - Escape from Sequestration Bondage: Soil Designs for Compact Neighbourhood Landscapes <i>Prof. Jim Chi Yung,</i> Education University of Hong Kong, Hong Kong, China	The Digitisation of Vegetation: From Solitary Trees to Whole Forests <i>Dr. Ervine Lin,</i> National Parks Board Singapore	Urban Wilds as a Resource of Resilient Cities <i>Asst Prof. Yun Hye Hwang,</i> Department of Architecture, National University of Singapore, Singapore
1500 - 1515	Discussions Moderator: <i>Prof. Tan Puay Yok</i> National University of Singapore Singapore	Discussions Moderator: <i>Simon Morrison,</i> Director, ICN Design International Pte Ltd, Singapore	Discussions Moderator: <i>Liu Huei Lyn,</i> Senior Landscape Architect, Public Utilities Board, Singapore

1515 - 1545	Afternoon Refreshments	Afternoon Refreshments	
1545 - 1600	Designing for Nature <i>Leonard Ng,</i> Ramboll Dreistl Studio, Singapore		
		Paper Presentation Session- Modeling for better design	Paper Presentation Session- Green infrastructure
1600 - 1615	“Gyeongui Line Forest Park” Abandoned Railway Transformation Project for Biophilic City <i>GyoungTak Park,</i> Dongsimwon Design Corp, Republic of Korea	Designing from the Field <i>Philipp Urech,</i> Future Cities Laboratory, Singapore	Re-framing Road Networks as Ecological Corridors in India <i>Nidhi Madan,</i> BBPL/ Studio EN, India
1615 - 1630	The Wenshan Oasis Project: Neighbourhood Landscape Design along the Waterway <i>Liu Po-Hung,</i> Chairman, Classic Landscape Design and Planning Ltd	Intelligent Landscapes: Information Modeling for a New Generation of Flood Control Strategies in São Paulo City, Brazil <i>Dr. Moura Newton Becker,</i> UNIFOR, Brazil	Garden Avenues: Strategies for Implementation of Greenways in Fortaleza-Brazil Road System <i>Raquel Moraes Cortez,</i> Universidade De Fortaleza, Brazil
1630 - 1645	Landscape Design with Ecosystem Services in High- Density Cities <i>Prof. Liao Kuei-Hsien,</i> National Taipei University	Assessment of the Structural Connectivity of Green Spaces to Identify Stepping Stones for Garden City Development of Quezon City Philippines <i>Aicel Mae Jovel Alvarez,</i> University of the Philippines, Philippines	Study on Effectiveness of Strategies to Re-establish Landscape Connectivity of Expressways <i>Nanayakkara Godakandage,</i> University of Moratuwa, Sri Lanka
1645 - 1700	The Role of Green Spaces in Community Formation Depends on the Urban Context <i>Dr. Vincent Chua,</i> National University of Singapore, Singapore	Smart Library for Landscape Information Modeling <i>Lee Chan Jong & Prof. Lee Yumi,</i> Seoul National University, Republic of Korea	Introducing Alternative Project Frameworks Through Landscape Design <i>Prof. Kathryn Moore,</i> President, International Federation of Landscape Architects, United Kingdom
1700 - 1715	Window View in a High-rise Neighbourhood and the Brain: The Effects of Floor Level and Green Cover on the Alpha and Beta Rhythms <i>Dr. Agnieszka O. Guizzo,</i> National University of Singapore, Singapore	Calibration of the Model ENVI-met V4 for Predicting the Microclimate Variation in an Urban Park <i>Li Yingnan,</i> Seoul National University, Republic of Korea	A Study of the Planning and Design Process of Green Infrastructure Focusing on Green Street Approach <i>Dr. Im Joowon,</i> University of Texas, United States of America
1715 - 1730	Discussions Moderator: <i>Prof. Liao Kuei-Hsien,</i> National Taipei University	Mapping the Equivalent Vertical Sunshine Duration Curve of Outdoor Space beside Buildings for Dynamic Landscape Planting Design <i>Dr. Lin Chuang-Hung,</i> National United University	Life Commemoration Post Earthquake Reconstruction <i>Prof. Lu Shiliang & Ju Xi,</i> Harbin Institute of Technology, People's Republic of China
1730 - 1800	Closing Keynote - Landscapes of the Future <i>Daan Roosegaarde,</i> Artist and Innovator, Studio Roosegaarde, Netherlands		
1800 - 1810	Closing Remarks by President Elected - Prof. James Hayter		
1810 - 1820	IFLA World Flag Handover Ceremony IFLA Asia Pacific Flag Handover Ceremony		
1900 - 2230	Awards Gala Presenting the AAPME Awards 2018		

DAY 1 TIME: 09:30 – 10:00

The Vision of Biophilic Cities

Professor Timothy Beatley

Teresa Heinz Professor of Sustainable Communities, in the Department of Urban and Environmental Planning
University of Virginia: School of Architecture
United States of America

Synopsis:

Evidence continues to build that the benefits provided by contact with nature are profound and deep. Biophilia holds that we are innately drawn to nature and living systems, that preferences for and benefits derived from nature are hard-wired, the result of a long evolutionary process. As the planet continues its rapid pace towards urbanization (new projections are that almost 70% of the world's population will live in cities by 2050), contact with the natural world becomes ever more important, and the need for biophilic design and planning is ever more critical. Daily contact with nature is not optional but absolutely essential flourishing life. We need more biophilic buildings, but we need as well to design the spaces between and beyond buildings with abundant nature. Beatley argues that we will need to reimagine cities as places of biophilic contact and flourishing, and as places that sustain and support biodiversity. We need to advance a new model of urbanization and city-building that puts nature at the center of design and planning.

This vision of future cities is one where citizens are able to live and work surrounded by and immersed in nature. The kinds of nature will depend on the city and its location and setting. Much of this urban nature is in the form of native flora, fauna, fungi, and wildlands, but much of it, especially in dense vertical cities, will take the form of human-designed and constructed nature (for instance, green rooftops and vertical living walls). Increasingly urban nature will take blended or hybrid forms (for instance the Supertrees of Singapore). There are other important metrics for judging the extent to which a city is biophilic, including the kinds and extent of engagement the public has with the nature around them (how much time is spend outdoors enjoying nature, how much time engaged in ecological restoration work or citizen science, how much do citizens care about plants and animals?)

Beatley will explain this new model of urbanism, its key elements and will describe some of the early efforts of cities to put this vision into practice. He will also progress made in developing and growing the new global Biophilic Cities Network and provide examples of innovative design and planning underway in these cities. Examples are provided a variety of emerging Biophilic Cities, including San Francisco, Washington, Wellington, Edmonton and (of course) Singapore, among others. Each is doing remarkable work in protecting, celebrating and integrating its unique nature(s).

Beatley will argue that becoming a more biophilic city will also make a city more sustainable and resilient. Finally, Beatley will explore some of the key challenges faced globally in implementing the Biophilic Cities vision, including the need for a more socially just distribution of urban nature and the need to more effectively confront the unintended consequences of investing in urban nature (the issue of eco-gentrification). Other challenges include how biophilic design and planning can be applied to the growing informal housing sector in many cities of the Global South, and the ways in which cities must also support conservation of more distant nature.

For additional information about Biophilic Cities please visit BiophilicCities.org

DAY 1 TIME: 10:30 – 11:00

“Greening our Red Dot” – Creating Liveable Density

Dr Cheong Koon Hean

Chief Executive Officer
Housing & Development Board
Singapore

Synopsis:

Today, many cities face rapid urbanisation, insufficient infrastructure and housing and environmental degradation. Many strive to green their cities as a means of improving the living environment, but implementation is difficult, often hampered by a lack of resources and weak institutional and legislative processes.

Urbanisation challenges are even more stark for Singapore, a city state sometimes referred to as the red dot, which has to deal with severe land constraints, a high density environment and climate change. Yet, Singapore has worked hard over the decades to become a City in a Garden. In her presentation, Dr Cheong will illustrate how greenery and water elements are intrinsically woven into its planning processes and institutionally embedded to ensure successful execution so as to create liveable density and a resilient Singapore.

She will also share how the Housing & Development Board (HDB), Singapore’s public housing authority, plays a key role in shaping the living environment, through town planning, urban design and greening. With more than 80% of Singapore’s population housed in some 26 high density HDB towns and estates, it is critical that HDB deploys innovative strategies to achieve a good quality living environment. These include deploying the enduring planning principle of creating a hierarchy of greenery. In addition, Dr Cheong will share HDB’s latest Biophilic Town Framework which was recently launched, arising from its R&D efforts in partnership with other agencies. The new generation of HDB towns will be guided by biophilic design strategies which incorporate multiple uses for green and blue spaces to enhance social and ecological connectivity and functions, assisted by urban environmental modelling to address environmental, ecological, economic and socio-cultural needs.

DAY 1 TIME: 11:00 – 11:30

Ecosystem Services in the Urban Landscape

Professor Peter Edwards

Principal Investigator
Future Cities Laboratory
Switzerland

Synopsis:

Until rather recently, the main motivations for greening urban areas were aesthetic and recreational. However, we now recognise that plants and vegetation do much more than look beautiful, but provide a wide range of other benefits that are known as ecosystem services. In this talk, I consider some of these ecosystem services, and their contribution in mitigating environmental problems in urban areas. I focus especially upon cities of the humid tropics, notably Singapore, and the role of vegetation in cooling the city and preventing flooding. I argue that vegetation and other ecosystems are the 'natural capital' of a city. But to realise the full value of this capital, we need much more information about the capacity of different types of urban vegetation to deliver ecosystem services.

I make four points about how ecosystem services can be incorporated into planning. Firstly, I argue that a systems approach is important in planning for these services. A good example is Singapore's Active, Beautiful, Clean Waters (ABC Waters) Programme, which is based upon a detailed understanding of how water flows through an urban catchment. The ABC programme incorporates a variety of measures for retaining water at the source, thereby ensuring that less water is lost in storm runoff and reducing the need for large storm drains.

Secondly, urban landscapes need to fulfill many functions, especially in a land-scarce city such as Singapore. In particular, all green areas should contribute to regulating environmental conditions, rather as in the rainforest that existed before the city was built. A good examples of how this can be achieved, is the Kallang River segment in Bishan Park, Singapore.

Thirdly, the ecological links between green areas need to be strengthened. In this respect, I welcome the emerging trend in Singapore and elsewhere for hard boundaries between buildings and green spaces to disappear. Buildings are increasingly clothed with greenery, which merge – sometimes imperceptibly – with the vegetation of the surrounding land.

Finally, to obtain the greatest value from ecosystem services, new tools and approaches are needed. Interactive computer tools can allow designers to access ecological information, in much the same way as they can access information about the properties of building materials, and use this information to assess the environmental benefits of particular designs. An exciting new source of information is point-cloud data obtained from Lidar scanners. I describe some recent research aimed at developing such tools.

I conclude with a vision of a sustainable tropical city that uses ecological processes to keep cool, to avoid flooding, and to purify air and water. Such a city is less dependent upon expensive infrastructure, such as storm drains and large, centralised water-purification facilities. And the buildings are closely integrated with the surrounding ecosystems, and are themselves a source of ecosystem services.

DAY 1 TIME: 11:30 – 12:00

Naturalising a High Density City. The Reality and Logistics

Henry Steed,

Director

ICN Design International Pte Ltd

Singapore

Synopsis:

The concept is to convert the man-made, high-density City into a liveable green place for us and our wildlife neighbours. To be more than a concept, we have to build it, pay for it, plant it, nurture it, and maintain it in perpetuity. Let's look ahead for the next thirty years.

Given the current state of many cities, the scale of transformation will be big. For the concept to be feasible, relevant policies and resources in manpower, machinery, materials and money are needed. For all those, including practising Landscape Architects, whose job is to physically turn the hard city to a soft city, balancing concrete and steel with gardens, parks, shaded streets, and sky-rise greenery these are concerns. This has been my work here for 35 years, but I am the past generation. Now younger and better educated generations will have to step up to see these ideas designed and built.

So how do we make sure these Biophilic concepts can be built and sustained? Many urban districts in most cities need to be upgraded. The prime tools for stimulating necessary change are workable policies, and the means for implementation. In Singapore, the Urban Redevelopment Authority and NParks have introduced many policies aimed at stimulating mass urban landscape at a nation-wide scale. The 100% Landscape Replacement Area policy is a dramatic response to the stripping away of real land in the City confines. With City land in such short supply, we can't keep on going out sideways, making vast cities. The sky is empty, so up we go.

Nevertheless, high buildings present environmental difficulties for 'sky-rise greenery' that are not adequately understood. There is a need for all parties to share communal know-how, about the complex integration processes needed for simulating nature in City conditions. Nature colonises easily, but for us it will be much harder to truly achieve the benefits that this enhanced status will bring. Are we geared up for the challenge?

The Biophilic Vision demands increased resources: large numbers of quality trees, and mountains of high grade soil-media are just two items. Every part of the new land-scape must be transformed to an industrial scale, with well-crafted and agreed industry standards, properly paid for.

City-wide landscape maintenance will also escalate to an industrial scale. Though in desperately short supply, large numbers of skilled people are needed, but young people are not attracted. Automation will not be the answer for many years, so it will still be people who do the work.

Where do we go from here? I will explain, through some recent examples of projects we have worked on in Singapore, which begin to touch on the Biophilic subject.

Long term landscape resilience will come from a combination of intelligent design, good contractors, qualified and educated workforce, planned logistics and programming, effective technology, fair and appropriate pricing, and enlightened authorities and building owners.

Creating and sustaining of Biophilic Green Cities as our habitat is a truly worthy task, though it will be difficult and endless.

DAY 2 TIME: 09:00 – 09:30

Biophilic City in a Garden: Restoring Nature, Nurturing Communities

Kenneth Er

Chief Executive Officer
National Parks Board
Singapore

Synopsis:

Singapore is widely recognised as one of the greenest cities in the world. This greening movement took roots from the country's early years in the 1960s, when its former Prime Minister Lee Kuan Yew directed that a tree planting campaign be launched across the island. Today, a well-established matrix of lush greenery, park spaces and natural habitats form the foundation of what we know to be the City in a Garden. Yet, reality presents growing land constraints and urbanisation in the coming years for the island, making the future for greenery in Singapore inevitably hard to articulate.

This presentation will share how Singapore has leveraged on the existing green infrastructure in a systematic manner, strengthening urban ecosystems and building community stewardship, to augment the current City in a Garden vision to an even more biophilic one. Real-life projects undertaken in recent years by the National Parks Board Singapore illustrate key initiatives that lend to this aspiration.

It is essentially a two pronged strategy; one, to add legibility to the current network of green spaces so that the overall ecosystem is a more resilient one where enhanced ecological benefits can be gleaned. Second, to help communities become active stewards of nature, recognising how a virtuous cycle can be established between the flourishing of our green spaces, and the enhancement of civic ownership.

Strategy 1: Restoring nature through the defragmentation of ecological connection

Each one of Singapore's nature reserves represents a distinct natural habitats ranging from primary to secondary lowland rainforests, freshwater swamp forest, mangroves and mudflats. It is therefore vital to strengthen the resilience of these habitats which forms the main sources of biodiversity for the nation. Taking reference from Richard Foreman's landscape ecology concepts, the presentation will share how efforts have been taken to achieve resilience — not only through the safeguarding of nature parks as buffer spaces, nature ways and park connectors as ecological corridors between the remaining tracts of habitats that are available in Singapore, but also enhancing and restoring of natural habitats within parks so that they become important ecological 'stepping stones' for native biodiversity.

Strategy 2: Nurturing communities to delight and steward nature

Being a biophilic city goes beyond just having nature in the built environment. Nature and urban parks are increasingly curated to allow visitors to engage more closely with nature and to glean a better understanding of them through interpretive elements.

There is also an intentional shift in programming from participation to active stewardship, recognising that this is a more effective way in nurturing a biophilic community. When various stakeholders, ranging from researchers, conservation and heritage enthusiasts, as well as regular park goers, have a say in how spaces should be activated for all, more community ownership can be built and green spaces sustainably stewarded.

DAY 2 TIME: 09:30 – 10:00

Christchurch New Zealand: Re-building a Resilient Post-earthquake City

Resilience: an ability to recover from or adjust easily to misfortune or change.

Rachel De Lambert

Landscape Architect & Director
Boffa Miskel
New Zealand

Synopsis:

Before dawn on September 4th 2010 Christchurch experienced a massive 7.1 magnitude earthquake -- a force on par with the devastating January 2010 earthquake in Haiti. Although infrastructure was disrupted, the city was back up and working within days.

Tremors -- numbering into their thousands -- continued; and on February 22nd 2011, a shallow magnitude 6.3 aftershock rocked the city.

This devastated Christchurch's commercial city centre and eastern residential suburbs. 185 people were killed. If Christchurch was to remain it would need to be re-built.

Christchurch City Council began a process of engaging with the city's residents, asking people to 'share their ideas' for a re-imagined city. Public forums were initiated with local, national and international speakers invited to identify opportunities that the re-build presented.

The New Zealand Government established the Canterbury Earthquake Recovery Authority (CERA) to progress the city's recovery, informed by the ideas and aspirations captured during community consultation.

CERA put forth a competitive tender calling for the development of a spatial masterplan within 100 days. This plan -- called "The Blueprint" -- would provide a framework for the re-build of central Christchurch.

The successful Blueprint 100 Consortium comprised Boffa Miskell (landscape architects, urban planners and designers); Warren + Mahoney (architects); Sheppard + Rout (Christchurch-based architects); Woods Bagot (architects); Populous (architects) and RCP (project managers).

Rachel de Lambert, landscape architect and partner at Boffa Miskell, was the Spaces and Places Anchor Project lead.

Seven years later, completed Spaces and Places Anchor Projects include: Ōtākaro, the Avon River Precinct; Ruaora, a new 'East Frame' parkland; the Canterbury Earthquake Memorial; the Margaret Mahy playground; and a re-created Victoria Square. These landmarks have led the way in creating a reinvigorated central city.

Alongside the official rebuild projects, a new creativity and proactive citizenship has emerged. The people of Christchurch initiated tactical projects involving memorials, temporary landscapes, installations, 'Gap Filler' activities and place making; and re-use of demolition materials.

The city's interim "Re:Start" container mall gained worldwide recognition and provided a downtown destination whilst much of the traditional centre remained fenced-off or bulldozed flat.

Christchurch has shown its resilience. The city is re-emerging -- ecologically enhanced, culturally more diverse and fit for purpose in a post-quake world.

DAY 2 TIME: 14:20 – 14:40

Landscapes for Our Heartlands: A Biophilic Landscape Design Approach

Leonard Cai

Deputy Director of Building & Research Institute
Housing & Development Board
Singapore

Synopsis:

Over the years, the Housing & Development Board (HDB) has been actively pursuing a better living environment through the provision of urban greenery to create vibrant and sustainable towns that support active and cohesive communities. As our heartlands develop into high-density townships, neighbourhood landscapes take on a critical role in mitigating the high densities and ensuring a quality living environment.

Being an integral part of the urban fabric, it is essential for urban landscapes to be carefully considered at all scales, from the master planning level, to the design of individual precincts and buildings. To achieve that, HDB developed a Biophilic Town Framework, which elaborates on the strategies and initiatives to achieve “Enhanced Greenery & Biodiversity”, one of the 10 desired outcomes under the broader HDB’s Sustainable Development Framework.

The HDB Biophilic Town Framework proposes a calibrated and holistic approach in the planning and design of urban landscapes to optimise the delivery of urban ecosystem services and to enable people to forge deep and meaningful connections with nature. Through the implementation of this framework, our towns and estates will promote greater sense of place, better well-being and an enhanced quality of life for our residents.

DAY 2 TIME: 14:40 – 15:00

Escape from Sequestration Bondage: Soil Designs for Compact Neighbourhood Landscapes

Professor Jim Chi Yung

Education University of Hong Kong
Hong Kong, China

Synopsis:

In compact urban areas, the grey infrastructure prevails over the green infrastructure. The tight urban fabric imposes multiple challenges on tree growth to frustrate nature-based solutions. Fast urbanization and densification have increased pressure on trees. Most studies focused on subaerial parts and neglected the subterranean domain. From field and laboratory studies of urban soils in diverse landscape sites, field evaluations in different cities and literature review, key problems were analyzed and alternative solutions were proposed. Compact planting sites are beset by critical physical soil constraints, especially confined soil volume at narrow roadsides. They include internal (micro-scale) restrictions due to compaction and excessive coarse fractions such as gravels, and external (macro-scale) restrictions due to limited soil depth and width. Confined soil volume limits root spread, tree health and tree safety, inducing poor tree performance and premature decline. Poor soil quality is also traced to impermeable paving, organic-matter deficit, low nutrient and water holding capacity, and meagre nutrient stock. Soil volume expansion can be accompanied by a designed soil mix. Soil area provision (SAP) is assessed based on moisture need of trees. A creative soil design scheme is proposed to expand soil volume. Based on the principle of soil volume sharing, subsurface soil conduits and subsurface soil corridors supplemented the routine open soil corridor. SAP could extend from the narrow footpath to adjoining carriageway as soil peninsula and greenspace as offset soil volume. The surface of shared soil area can be co-used by pedestrians or vehicles. Soil compaction could be prevented by suitable suspended paving methods. Underground utility works can adopt mature trenchless technology to protect roots of important trees. Porous and pervious paving materials can enhance root growth. Modern subbase design of footpaths can prevent cracking and heaving of pavement by roots. Degraded soil of heritage trees can be rehabilitated. An urban soil specification for trees to forestall problems and ensure long-term maintenance of soil quality can be established. Urban tree managers can readily adopt out-of-the-box thinking to integrate soil design in landscape works. Interactions between science and practice can be cultivated to fulfil the goals of resilient cities.

Keywords: *Urban soil; Soil volume restriction; Urban soil design; Subsurface soil conduit and corridor; Offset soil volume; Soil volume sharing*

DAY 2 TIME: 17:30 – 18:00

Landscapes of the Future

Daan Roosegaarde

Artist and Innovator
Studio Roosegaarde
Netherlands

Synopsis:

Dutch artist and innovator Daan Roosegaarde presents 'Landscapes of the Future', highlighting his innovative practice which merges people, technology and space to create a better world.

Virtual floods, smart highways and smog sucking towers; Roosegaarde pulls technology out of the screens to examine and activate solutions to improve daily life in urban environments. In his interactive talk, Roosegaarde explores the social role of design, the importance of "Schoonheid" (a Dutch word meaning both beauty and cleanliness) along with his vision for the future.

As the new 'hippie with a business plan' to quote the New York Times, Roosegaarde has been selected as a creative change maker by Forbes and Good 100 and is a young global leader of the World Economic Forum.

BIOPHILIC CITY



[FEATURED SESSION SPEAKERS]

DAY 1 TIME: 14:00 – 14:20

Intertwined Culture and Nature for the Urban Future Cultural and Natural Heritage Assets as a Platform for Landscape Architect's to Achieve the UN Sustainable Development Goals- 2030 Global Agenda

Patricia M. O'Donnell

Founder & Principal
Heritage Landscapes LLC
United States of America

Synopsis:

By responding to three important questions this paper explores the opportunities for the Landscape Architecture professions' impact on culture/nature integration for healthful, livable, authentic cities.

How do the UN SDGs - 2030 Global Agenda relate to Biophilia, the urban future and Landscape Architects?

The United Nations Sustainable Development Goals (UN SDGs), 2030 Agenda, adopted by UN member nations in September 2015 lays out 17 goals and 169 targets that address human and planetary well-being through vectors of sustainable communities, life on land and in water, climate action, clean water and energy, reduced poverty and inequality, health, education and more (Figure 1- UN SDGs 17 Goals). Many of these interrelated vectors can be achieved through our landscape stewardship, respecting inherited public landscapes and creatively innovating our practice on behalf of the living and the unborn, of all species.

Cities are vessels of biodiversity and cultural diversity. Landscape architects fill a critical role in an urban future that embraces Biophilic cities, local people and uniqueness. By applying the idea cities can harmonize nature and people, we function at a critical intersection in humanity's global trajectory to achieve a sustainable planet or perish. As people weigh down a burdened globe, culture/nature integration in all we do offers a positive future. Action based on inseparable cultural diversity/biodiversity, rather than separated culture/nature, offers hope for our precious, embattled planet.

Why should culture and nature be integrated for a biophilic future?

Intensification of robust nature in cities is at the core of biophilic design. Landscape Architects can and should expand their work with allied professionals to enhance urban biodiversity that recognizes local cultural assets, traditions and practices. Working on this base, our interventions enhance authenticity of place, which is integrally linked to community pride, belonging, and true sustainability. Natural and cultural assets are shared uniqueness of human settlements, that foster authenticity and promote justice. The public commons provide the platform for inclusive urban revitalization that moves biophilia forward to aid in solving complex 21st century challenges. Implementing place-based landscape architectural works can be highly effective when based on a foundation of local peoples and valued places, toward achieving the UN SDGs.

How can every Landscape Architect aid the implementation of the UN SDGs yielding benefits to urban populations?

We see escalating human pressure causing rapid change, erratic weather, and resource scarcity that separates "haves and have nots". The projection of 150 million climate change migrants by 2050 is shocking. Landscape Architects can take a significant role in addressing imbalances toward achieving the UN SDGs. We begin by embracing this global agenda, a first comprehensive worldwide vision. Potential benefits are environmental/social/economic, the three pillars of sustainability. Fully engaging culture and heritage assets is a core principle for actions that underpin urban vitality. Examples of how to integrate the UN SDGs for urban public landscapes, inherited from our past that support a biophilic future, include Washington's National Mall, Chicago's Jackson Park, and Pittsburgh's Parks. Thank you for studying, integrating and championing the UN SDGs in your professional works.



Figure 1. 17 targets of the United Nations Sustainable Development Goals, 2030 Global Agenda. Image courtesy UN SDGs web, in the public domain for open use.

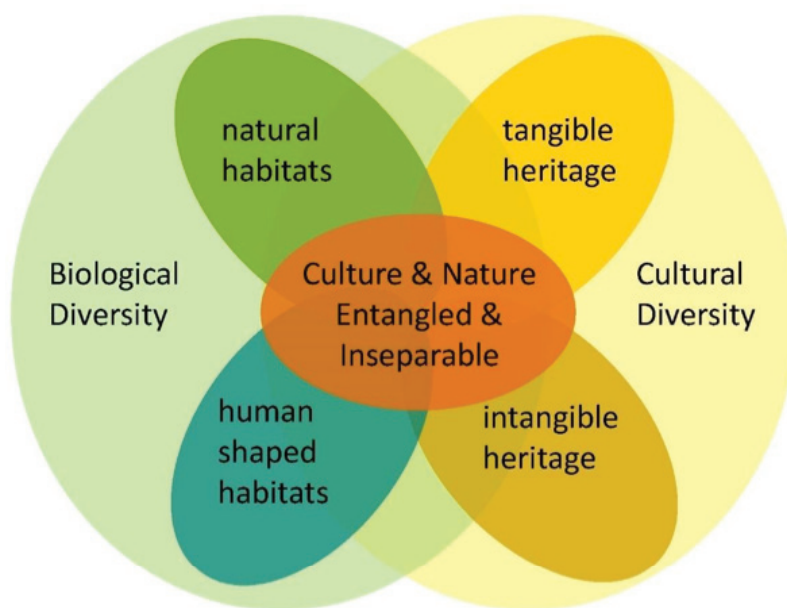


Figure 2. Human settlements all over the world are vessels of biological Diversity and Cultural Diversity working with this foundation of urban heritage Landscape Architects can aid in achieving the UN Sustainable Development Goals, 2030 Agenda. Diagram courtesy Patricia M. O'Donnell, building on the IUCN-ICOMOS Connecting Practices Initiative, permission to use and distribute with O'Donnell credited.

DAY 1 TIME: 14:20 – 14:40

Nature System in Chinese Cities- Past, Present and Future

Professor Wang Xiang-Rong

Former Vice President of CHSLA, Dean of School of Architecture
Beijing Forestry University
People's Republic of China

Synopsis:

China is a country with a vast territory. For thousands of years, this land has brought up huge population. Throughout the long history, people has been trying to control the flood, cultivate farmlands, develop agriculture, build settlements, and has gradually transformed this land into a granary.

Many Chinese artificial constructions in history, from buildings to hydraulic works, agriculture or cities, are all integrated with nature. Man and nature are in balance and in harmony, and lakes, ponds, fields, canal networks, villages and cities form a whole.

Most ancient Chinese cities are not large, but the site selection and the city construction were carried out with an integral vision and in big scale. The structure of cities was consistent with the landscape structure of the whole area, and cities and natural landscape have close relation and merge in a harmonious whole. Therefore, Chinese cities are full of natural spirit.

However, the landscapes have been rapidly changed during the last 40 years. The urbanization rate of China was 17.6% in 1977, while it surged up to 58.5% last year, and it is still increasing by 1% every year recently. In other words, there are more than 12 million

people swarming into the city from countryside every year, and the urban built-up area has sprawled seven times since the past 20 years.

In some areas, the natural system outside and inside the city are gradually separated apart, and the nature began to become fragmented. The previous balance between natural and artificial systems have lost. These lead to the weakening of landscape diversity and its ecological function. The reasons might be concluded as: 1. The expanded city occupied the surrounding natural and semi-natural spaces. 2. Different from the historical cities, the cities today have no longer developed in related to the natural and agricultural systems in their surrounding areas. 3. Human's attitude toward nature has converted from relying to modifying and intervening randomly. 4 More and more man-made systems have replaced the natural and semi-natural systems. The rapid urbanization will continue in the coming future , 170 million rural residents will move into newly constructed towns and cities successively over the next 10 years. Such scale and speed of urbanization has never occurred in the human history.

In the background of rapid urbanization, how to ensure the ecological security, and build the balance between city and natural system? With the premise that nature outside and inside the city are being continuous and integral as a whole, the approaches to construct this system are landscape preservation, restoration, transformation and integration

DAY 1 TIME: 14:40 – 15:00

Biophilic Railway Stations: Re-imagine the Nature of Transit Design

Dr Philip Roös

Senior Lecturer in Architect
Deakin University
Australia

Synopsis:

Across the world railway stations, transit centres and transport interchanges are rapidly evolving from purely functional transit spaces to new urban centres and destinations, resulting in activity hubs and gathering places. These stations generate high footfall creating life and vitality, and form the centre of daily routines for many urban dwellers. Train stations are places of connection, they are gateways to the city, and can be one of the most exciting places in an urban environment to experience. Some stations make great destinations with shops, restaurants, museums and exhibition spaces. New architecture for railway stations acknowledges the functions of transit; whilst the heritage of place, culture and the surrounding urban spaces can provide excellent public areas to celebrate our innate human connection to nature. Similar to the grandeur of old railway stations, new majestic spaces with biomorphic-inspired monumental elements can include the fundamental pattern language that underpins the principles of Biophilia.

Rail transport infrastructure, especially railway stations, significantly contributes to the quality of human life, sustainability and the economy of urban centres. Station buildings play a major role in efficient and vibrant places, and can be at the forefront of innovation and modernity. Due to the current unprecedented levels of global urbanization, cities and their governing entities are investing in more sustainable public transport systems. The rationale for this investment is to aid reduction in greenhouse gas emissions and, assist economic efficiencies in goods and people movements across and within cities providing better forms of transport, whilst assisting in the creation of improved sustainability and healthier urban environments. New major transit projects massively impact the city fabric, but also provide opportunities to reshape urban environments to include innovative biophilic design.

*This paper investigates the opportunities that new transit hubs and railway stations and their associated infrastructure can provide for creating more sustainable and healthy urban environments, through the lens of Biophilic Design. In the foreword of a recent study *Creating Healthy Places* (2017, p9), Professor Tim Beatley raises the question, "might we re-imagine the very nature of a transit trip? Could it be not simply a trip to work or a travel to the high street, but perhaps a visit to the forest, a chance to hear and celebrate native birdsong, or a chance encounter with a butterfly. Perhaps food production becomes part of transit design, so that one picks a tomato or a desert plum on the way to catch the train. Why not a transit station in a forest?"*

*This paper explores the patterns of Biophilia and its application to railway stations. It further benchmarks old and new examples of railway stations across the world against Biophilic patterns, and reflects on the *Creating Healthy Places* (2017) study recently completed for the Metro Tunnel Project in Melbourne, Australia. It concludes with recommendations of key principles to be considered for Biophilia-inspired railway station design that can assist in advancing the larger vision and agenda of ecologically sustainable and Biophilic Cities.*

Improving mental health in prisons through biophilic design

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Abstract

Increasing nature and natural elements within a prison offers the potential to de-stress residents, improve mental health, cognitive functioning and learning, reduce recidivism and increase receptivity for behavioural change and restorative justice opportunities. Biophilic design is outlined as a set of principles and practices for cities to bring nature into urbanites' daily life. The role of nature in restorative initiatives is traced back to the early work of innovative psychoanalyst Eric Fromm showing how his framework of human psychological pathways overlaps with biophilic design principles.

Fromm suggests that human awareness creates a division from nature, instilling anxiety and conflict. In seeking to overcome this anxiety there are choices in the pathways taken. A regressive pathway is where this anxiety is repressed, either by the collective culture through laws and religion or pathological behaviour such as necrophilia and narcissism. The opposite pathway follows a 'syndrome of growth' and here the anxiety is transcended and replaced. This is the progressive path, where love of life, *biophilia*, is the stronger force. Fromm saw cities as separating humans further from nature through their industrialised, commoditised and mechanistic designs, increasing anxiety and stress, as well lessening the impulse to pursue the progressive, biophilic pathway. He suggested that exposure to nature is needed to provide choice and strengthen the opportunity for *biophilia*, which is preferable in a prison environment.

Fromm was one of the pioneers in recognising the relationship between human psychology and environmental conditions yet it was the more recent conceptualising of the biophilic human being by socio-biologist, Edward Wilson, which more broadly launched the term *biophilia*. Together with fellow biologist, Stephen Kellert, the *biophilia hypothesis* emerged suggesting an innate human connection to nature. As with Fromm, Kellert and Wilson posited that humans have evolved to need nature for health, wellbeing and fulfilment. These two approaches of humanistic psychology and evolutionary biology overlapped and reached the same conclusion. As cities expanded, some theorists were suggesting cities were devoid of nature and thus human nourishment. Kellert and Wilson, along with a diverse group of colleagues, begun discussion of an approach to integrate nature in cities called *biophilic design*. Yet it is appreciating the origins of biophilic design through Fromm's original usage of 'biophilia', meaning 'love of life', that can deepen the essential understanding of the principles of biophilic design.

Through biophilic design the opportunity exists to change the environment to nurture not the negative, but the positive responses, to enhance the physiological as well as the psychological. As much as the environment can cause negative reactions, environments can also enhance mental health and well-being, decreasing anxiety and stress. In the right environment our

innate love of life and connectedness can be nourished and sustained. We can journey on the progressive path of biophilia. Biophilic design focusses on strengthening the progressive pathway through provision of a greater exposure to nature and natural spaces and patterns, thus encouraging connection to, and love of, life and life processes.

Utilising appropriate biophilic design approaches and principles should provide new ways to improve the prison experience.

biophilia; prison design; biophilic design; Fromm; psychological restoration; stress reduction; mental health; wellbeing; urban design; biophilic; nature;

1. Introduction

Global studies of prisoner health suggest that they experience high levels of mental illness (Fazel & Baillargeon, 2011; Fazel & Danesh, 2002; Fraser, Gatherer, & Hayton, 2009; Gunn, Maden, & Swinton, 1991; Wright, Jordan, & Kane, 2014). Mental illness is well recognised as an increasing problem within the prison system, with some research suggesting that 89 percent of prisoners have depressive symptoms and 74 percent have stress-related symptoms, many of which are not diagnosed until incarceration (Fraser et al., 2009; Nurse, Woodcock, & Ormsby, 2003; Ogloff, 2002). A study undertaken in five Australian prisons in 2004 revealed that nearly 50 percent of prisoners had a mental disorder, with post-traumatic stress disorder the most common (Butler, Allnutt, Cain, Owens, & Muller, 2005).

In a 2001 study of 23,000 prisoners in 12 countries, prisoners were found to have a two to four times higher rate of major depression and psychotic illnesses and a ten times higher rate of antisocial personality disorder than the general populace (Fazel & Danesh, 2002). Suicide rates in prisons are significant, often the most common cause of death (Fazel & Baillargeon, 2011; World Health Organisation & International Association for Suicide Prevention, 2007). The decrease of general societal mental

health services is considered to play a large part in this phenomenon (Birmingham, 1999; Fazel & Baillargeon, 2011; Jordan, 2011; Ogloff, 2002; Butler et al., 2005).

Prisons tend to develop, or exacerbate, mental health problems in their residents, and many reoffend on their release, to once again re-enter the prison system (Birmingham, 1999; Butler et al., 2005; Fazel & Baillargeon, 2011; Ogloff, 2002). The psychological impact of institutionalisation, especially on admission, is under-acknowledged, with little done to address the effects or potential long term damage, for inmates or their families (Fazel & Danesh, 2002; Haney, 2003).

Although mental health in prisons is still considered an under-recognised issue, there are increasing attempts to address this spiralling problem. The primary suggestions within the literature focus on staffing and policy changes, level of assessment, placement and care changes and facility and activity changes (Fraser et al., 2009; Jordan, 2011; Picken, 2012; World Health Organisation & International Association for Suicide Prevention, 2007; Wright et al., 2014). There are isolated reports of prisons which have introduced gardening, animal husbandry and community based programmes that have been successful in aiding the less severe forms of mental illness, but there is little in the research literature on the physical form of prisons themselves. Yet there is little doubt a

prisoner's physical environment plays a highly influential role on the prisoner's health and well-being and thus the ability to 'rehabilitate' towards progressive life choices. The potential to utilise this physical design influence to address mental health problems such as stress and depression has not received much recognition and is the focus of this paper. The question that is addressed is, can Fromm's perspective on biophilia be applied to the design of prisons and assist in improving mental health in prisons?

Biophilic design and biophilic urbanism has moved from academic and professional literature to being a new social movement in the design professions (Soderlund, 2016). The purpose of this paper is to discuss the potential of biophilic design to reduce stress and improve mental health in prisons. It is pertinent to delve into the origins of the term biophilia to begin the journey of understanding the potential of this approach as it was on this journey that the author discovered the pioneering work of Eric Fromm - a giant in the human psychology arena (See Fromm, *The Heart of Man*, 1964; *The Art of Loving*, 1956; *To Have or to Be?*, 1976; *Escape from Freedom*, 1941) - but little known by those in biophilic design.

2. The theory of biophilia: Fromm and beyond

Biophilia is often seen as being a term invented by Nobel Prize winning biologist E. O. Wilson (Wilson, 1984) and others since (e.g. Kellert & Heerwagen, 2008). This group developed the concept of human's having an innate need for nature

from their evolutionary biology perspective and thus created the concept that nature needs to be built into everyday life in our cities. However biophilia, meaning love of life, was a term first brought to life by the psychoanalyst Erich Fromm in his exploration of the "essence of man", that which defines us (Fromm, 1964). He saw that awareness of our 'beingness', our mortality, separates us from nature, instilling a deep anxiety and conflict. This is a contradiction inherent in human existence, the belonging to two conflicting worlds. Fromm suggests it is this frightening contradiction and the quest to seek a solution that defines humankind. This search reveals choices, which are reflected in humans' inherent ability for good or evil.

Early human societal existence tended to regress back to our unevolved roots – to our animalistic beginnings of nature and violence, our archaic selves, where the fear of the anxiety of separation can disappear. This regressive path is not just in primitive religions but also found in pathological behaviour involving necrophilia and narcissism. These are tendencies that may be repressed in a collective culture by laws and religions, but interestingly, if the tendencies are supported and shared by many, then consensus gives them credence, reason and reality. This pathway of *regression* Fromm calls 'the syndrome of decay' (p. 114).

The opposite direction, following the 'syndrome of growth', is where the anxiety of separation is faced and transcended, and replaced by our love of life, where there is a "full development of human forces" (p. 114). This is the *progressive* path of life. Fromm suggests that in the majority of

people there is mostly a blend of the two orientations.

Fromm saw our cities as becoming more mechanistic, industrialised and commoditised, separating us further from nature and increasing our anxiety and even hate for life (p. 10). In his 1964 book he was expressing concern that, even when there are known extreme consequences, such as in war, there is a stronger societal drive to go to war than to oppose it, which represents the regressive path being the stronger force. The potential for a triggered eruption of mass violence will always be present as long as there is any part of our archaic, regressive impulses within. Not until it is fully replaced by our love of life will this potential for regressive behaviour go. At the same time it is possible for our love of life to be fully replaced by the traits of regression. In either situation, the choice of which path to go down will be lost. It is of high importance therefore to retain the choice for prison inmates of which path to take and it is highly preferable to not foster regressive tendencies.

Fromm considers there are three orientations along the progressive path – freedom and independence, love for neighbour and love of life or biophilia (p. 110). Within the biophilic realm is the inherent motivation to live and survive that, as suggested by Fromm and other biologists and philosophers such as Spinoza (Fromm 1964, p. 41), all living substance possesses. Other biophilic qualities include the tendency to integrate and unite, to construct rather than just retain, to adventure to the new than stay with the certainty of the past, to use love and reason rather than force and control. “The biophilous conscience is motivated by its

attraction to life and joy; the moral effort consists in strengthening the life-loving side in oneself” (Fromm 1964, p. 43).

Fromm is not alone in his recognition of the relationship between environmental conditions and human psychology but he was certainly a pioneer in its modern conception. However the more recent conceptualising of the biophilic human being came in 1984 from sociobiologist Edward Wilson in his book ‘Biophilia’ (Wilson, 1984). Wilson utilised the term biophilia to describe his deep feelings of connection to nature during a period of exploration and immersion in the natural world. Wilson was able to provide an evolutionary biologist’s view of the biophilic connection to nature as something that humans have evolved to need. Wilson, with fellow biologist Kellert, hypothesised that our connection with nature is innate and that we are genetically programmed to respond to nature physiologically as well as psychologically (Kellert & Wilson, 1993). Our potential to have a love of life, to follow the progressive pathway, as outlined by Fromm, appears to also offer the potential to nurture health and well-being and all of this requires exposure and connection to the natural world in some form.

As Kellert suggests the inherent need to affiliate with nature fulfils aesthetic, intellectual, cognitive and spiritual cravings (Kellert, 1993, p. 20). By positing that it was genetically innate Wilson and Kellert took the term biophilia from Fromm’s inner psychological journey to a term extending into the contemporary biological. The two approaches of humanistic psychology and evolutionary biology have therefore

overlapped and have reached the same conclusions.

This blending of psychology and biology was hugely significant as by introducing questioning about biological (physiological) responses to nature, a base for scientific testing of the biophilia hypothesis was established.

3. Testing the theory: physiological and psychological responses

Research on psychological responses to nature is increasing with supporting physiological evidence through more sophisticated investigative technology also mounting. Positive responses are evident not only with direct exposure to nature, but also where the patterns of nature, such as fractal patterns, and the spaces of nature, such as refuge and prospect, are found (Appleton, 1976; Biederman & Vessel, 2006; Ryan, Browning, Clancy, Andrews & Kallianpurkar, 2014; Heerwagen & Gregory, 2008; Salinger & Masden, 2008; Taylor, 2006; Tenggart Ivarsson & Hagerhall, 2008). Physiological and psychological studies support both Kaplan's (Kaplan, 1995) Attention Restoration theory and Ulrich's Stress Recovery theory (Ulrich et al., 1991). The former theory proposes that prolonged directed attention and fatigue results in aggressive and irritable behaviour and that exposure to nature assists recovery from this (Kaplan, 1995). In Ulrich's studies he found both physiological testing and verbal survey results indicated that recovery from stress was faster in a natural setting than an urban one. The physiological results also suggested an involvement of the

parasympathetic nervous system in this recovery (Ulrich et al., 1991).

Studies since have shown that exposure to nature reduces heart rate variability and pulse rates, decreases blood pressure, lowers cortisol and increases parasympathetic nervous system activity whilst decreasing sympathetic nervous system activity (Li et al., 2011; Matsunaga, Park, Kobayashi, & Miyazaki, 2011; Park, Tsunetsugu, Kasetani, Kagawa, & Miyazaki, 2010; Tyrväinen et al., 2014). These responses contribute to improved cognitive functioning, working memory and learning rates and can also be triggered by indoor pot plants or even viewing pictures of nature (Berman, Jonides, & Kaplan, 2008; Berto, 2005; Raanaas, Evensen, Rich, Sjøstrøm, & Patil, 2011). In 2014, research by Ikei, Komatsu, Song, Himoro and Miyazaki demonstrated the use of both physiological and psychological markers. The study revealed that by simply viewing roses, parasympathetic nervous system activity increases, indicating lower stress and a greater sense of wellbeing (Ikei et al., 2014). Exposure to nature could be a valid supplement to treating depression and other disorders, with improvements to mood and memory span (Berman et al., 2012; Tyrväinen et al., 2014).

Reductions in pain and anxiety coupled with greater positive feelings have been exhibited in hospital patients with views of nature or potted plants in their rooms (S.H. Park & Mattson, 2008; Ulrich, 1984). A study in Michigan revealed a 24% less frequency of health care visits for prison residents with views of nature (Moore, 1981). Increasing greenery in housing estates resulted in less violence and aggression, less crime and better interpersonal relationships (Kuo &

Sullivan, 2001). Studies by Guègan and Stefan observed that short immersions in nature elicited a more positive mood and a greater desire to help others (Guèguen & Stefan, 2014).

It is not just direct exposure to the greenery of nature that has positive human responses. Researchers are discovering that there are different human responses to different natural forms and patterns. Prime amongst these are fractal patterns which studies reveal relax and de-stress people (Tenngart Invarsson & Hagerhall, 2008; Beiderman and Vessel, 2006; Taylor, 2006; Ode, Hagerhall & Sang, 2010).

From the research already reviewed a list of socio-psychological benefits of exposure to nature and the patterns of nature can be compiled:

Improved mental health: (Ulrich, 1979; Ulrich et al., 1991; Berman et al., 2012; Tyrväinen et al., 2014).

Reduced stress: (Li et al., 2011; Berman et al., 2012; Matsunaga et al., 2011; Park et al., 2010; Tyrväinen et al., 2014; Berman et al., 2008; Ikei et al., 2014; Hagerhall et al., 2012; Taylor, 2006).

Attention restoration: (Kaplan, 1995; Berto, 2005; Tenngart Ivarsson & Hagerhall, 2008; Raanaas, 2011).

Increased wellbeing: (Li et al., 2011; Berman et al., 2012; Tyrväinen et al., 2014; Berman et al., 2008; Ikei et al., 2014; Hagerhall et al., 2012).

Decreased violence and crime: (Kuo & Sullivan, 2001).

Faster healing rates in hospitals: (Ulrich, 1984; Park & Mattson, 2008; Moore, 1981).

Greater altruistic behaviour: (Guèguen & Stefan, 2014).

The ability of architectural design to influence individuals' physiological and psychological states is an extension of the biophilic connection to nature and the manifestation of Fromm's theory of biophilia. Salingaros and Masden suggest that "environments devoid of neurologically nourishing information mimic signs of human pathology. Drab minimalist surfaces reproduce symptoms of strokes and macular degeneration, for example" (Salingaros & Masden, 2008, p. 69). Environments that are devoid of any representation of nature can not only make us psychologically unwell and regressive in our behaviour but we can also display physical symptoms and responses. A recent study which examined human responses to design stimuli, concluded that the primal flight or fight response is increased when individuals are exposed to hard edged architecture rather than curving contours (Nanda et al., 2013). They also suggested that this response is heightened when a person is already in a stressful environment such as a hospital (Nanda et al., 2013). This would also include the prison environment. Reductions in depression, stress and aggression, coupled with increased sociability, empathy and connection to living things, are characteristics and outcomes that prison administrators' value and which aid reductions in recidivism (Nadkarni & Pacholke, 2013). They are qualities that

reflect a shift from regressive tendencies to a progressive pathway.

The reason it is important to now take the biophilic design approach into prisons is that the new professional approaches to biophilia are going beyond the individual psychological insights about prisoners and their plight, but take us into how the overall design and management of every aspect of prison life can be reviewed from the perspective of whether an innate connection to nature is being fostered or denied.

4. Principles of biophilic design

Expression of biophilia through biophilic design in architecture has occurred throughout history, not always consciously, or even acknowledged, conveying a subjectiveness which testifies to its inherent quality in humans. Nature can be mimicked by using the patterning, forms, materials, symbols and spaces which represent nature and evoke similar responses. Christopher Alexander recognised this in his seminal book “Pattern Language”, though not using the term biophilia, he expressed similar insights:

“Many of the patterns here are archetypal – so deep, so deeply rooted in the nature of things, that it seems likely that they will be a part of human nature, and human action, as much in 500 years as they are today” (Alexander, 1977).

As with biophilic design theory, Alexander believed that the pattern language of the nature of things in the environment “can make people feel alive and human” (Alexander, 1977). When we cannot

surround ourselves with nature, architecture and landscapes that contain some archetypal natural elements have found expression in our urban design.

Emerging in the literature on biophilic design is a growing list of these patterns and spaces considered to stimulate our innate biological responses. Although most designers are unaware of their linkage to Fromm’s theories the general acceptance of a psychological link to nature has its origins in Fromm’s work. Thus there are design practitioners who build detailed principles of what Fromm was attempting to explain in theory. In Table 1 the key design elements of biophilic architecture are summarized.

Table 1: Patterns of Biophilic Design

		
<p><u>NATURE IN THE SPACE</u> incorporation of plants, water and animals into the built environment, especially with movement.</p>	<p><u>NATURAL ANALOGUES</u> one degree of separation away from true nature; patterns and materials that evoke nature.</p>	<p><u>NATURE OF THE SPACE</u> the way humans respond psychologically and physiologically to different spatial configurations.</p>
<p>1. Visual connection with nature – plants inside and out, green roofs and living walls, water, nature artwork</p> <p>2. Non-visual connection with nature – sun patches, textured materials, bird sounds, weather, nature scents</p> <p>3. Non-rhythmic sensory stimuli – clouds, shadows, nature sounds, water reflections</p> <p>4. Access to thermal and airflow variability – shade, radiant heat, seasonal vegetation</p> <p>5. Presence of water – rivers, fountains, water walls, ponds, daylighted streams</p> <p>6. Dynamic and diffuse light – light from different angles, ambient diffuse lighting, circadian lighting</p> <p>7. Connection with natural systems – seasonal patterning, wildlife habitats, diurnal patterns</p>	<p>8. Biomorphic forms and patterns – organic building forms, structural systems (savannah effect),</p> <p>9. Material connection with nature – wood, earth and stone construction, natural colours,</p> <p>10. Complexity and order – fractal patterns, sky lines, plant selection and variety, material textures and colours</p>	<p>11. Prospect – views, balconies, 6 m and above focal lengths, open floor plans</p> <p>12. Refuge – protected spaces, overhead canopies or lowered ceilings, places providing concealment</p> <p>13. Mystery – winding paths, obscured features, flowing forms</p> <p>14. Risk/Peril – floor to ceiling windows, water walks, high walk ways</p>

(Adapted from Ryan et al., 2014)

Not all of these are possible or practical to be implemented within economic, safety and security constraints of prison design, but there is scope to incorporate biophilic design to improve prisoners' sense of well-being, mental health and behaviour.

5. Biophilic design in prisons

Many of the conditions Fromm suggested for nourishment of biophilic tendencies are absent in our prisons and indeed would not be appropriate. It is probable that prison residents did not experience biophilic, or progressive, circumstances prior to incarceration. It is highly likely that environments that foster the necrophilic traits were the stronger influence. These could be childhood experiences and parental attitudes or general societal conditions. Fromm discusses the evolution of our industrialised, mechanically focussed societies and the psychological impact: "...intellectualisation, quantification, abstractification, bureaucratisation and reification...are not the principles of life but those of mechanics. People living in such a system become indifferent to life and even attracted to death" (Fromm 1964, p. 54). This mechanistic disconnect from nature has been portrayed in the design of our cities, architected by desire to overcome and separate from nature. The sterile blankness perpetuates a further disconnect, with abstract urban planning forgetting the intuitive more humanistic designs of our history. Our cities have become places where people are encouraged to consume and to commoditise, and where many of our urban spaces are constructed with design by modernist fashions and economics rather than design by health, well-being and a love of life. When the abstract, regressive human

is nourished, anxiety and stress can be nurtured.

Many urban prison designs are an extension of this kind of urban design with the potential to reinforce narcissitic, mechanistic and necrophilic tendencies that may already have been established within the prison residents' psyche. Fromm suggests that prolonged imprisonment may break a person's psychic system, allowing the archaic tendencies to surge up (Fromm 1964, p. 117). Salingeros and Masden propose that "we will instinctively react in a negative manner to a built environment that is neurologically non-nourishing or actually causes physical anxiety and distress" (Salingeros & Masden, 2008, p. 68). An individual's surroundings are highly influential on their psychological and physiological being with the potential to reinforce either the progressive or regressive pathway (Burns, 2005; Nanda, Pati, Ghamari, & Bajema, 2013; Nesse & Williams, 1995).

The prison cellblock and associated buildings are built with security and function as the criteria, creating an environment that forces the disconnect from life processes and reinforces the regressive pathway of isolation and narcissism. Historically our prisons are designed to be effective in holding prisoners captive in a punishing manner, depriving them of comforts and reinforcing the fact that they have committed an offence. Prison designs tend to be bleak, sterile and barren, with incarceration within such a setting seen as the punishment (Lopez, 2014). Deprivation of freedom is extended by deprivation of sensory stimulus and connection to place. There is little opportunity to take Fromm's progressive path, to nurture love, including the biophilic love of life. Ironically, with the majority of offenders likely to have stronger

regressive tendencies, they are more in need of opportunity to foster qualities from the progressive path of life, rather than strengthening of the regressive path.

Utilising biophilic design features such as fractal patterning, prospect and refuge and direct greenery to trigger biophilic responses gives support to the possibility of strengthening the innate qualities of individuals that can aid the progressive journey of life as outlined by Fromm.

Forward thinkers are now beginning to examine prevailing prison design, which reflects punishment by incarceration, and to recognise the potential to change and work towards rehabilitation of prisoners through biophilic design.

6. Conclusions

From researching the current literature it appears that, while a small number of prison farms and gardening programmes have been successfully implemented globally, the incorporation of biophilic initiatives within prison design is a new and emerging field with few researched trials on the benefits of applying biophilic principles. Biophilic design has grown from a general need to link people in cities with nature in their everyday life. This approach that has been derived from evolutionary biology overlaps precisely with the insights of Erich Fromm in humanistic psychology. Fromm's theories of the regressive and progressive pathways of life and the influences that support either pathway, suggest the importance of connecting individuals with biophilia through biophilic design. Fostering a

biophilic love of life is an essential component of steering prison inmates from further regression into a 'life of decay' to a life where altruism and a sense of belonging are the greater forces. There is opportunity and potential to improve mental health and well-being for prison residents which can lead to a reduction in recidivism. Assisting prisoner rehabilitation and providing an opportunity to retain or increase their level of humanity would ultimately benefit all of society.

The ability of nature and the architectural patterns of nature to trigger positive psychological and physiological forces are a valid and valuable tool. Research has provided the generic evidence and technology has provided the ability, to not only implement biophilic initiatives, but to also monitor outcomes. It is time to now show it in prisons.

Detailed demonstration projects are needed that can establish biophilic designs in prisons and collect data on the physiological and psychological outcomes of people in highly stressed environments.

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Living Landscape and Brain Reactions

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Abstract

Our senses is stimulated by amount of information received from daily environments, and psychological and physical health is influenced by these scenes. According to past research, we know that natural landscapes is more preferred than urban landscapes, furthermore, connecting to natural environments could reduce mental stress, improve our attention restoration ability, and release muscle tension. Today, with the technique of functional magnetic resonance imaging (fMRI), we are able to examine the impact of different environmental traits on human health focusing on the nerve system function specifically. We are interested in examining the brain reaction when doing the landscape design with fMRI technique as well.

In order to examine the characteristics of natural landscapes which have beneficial effects to human health, preference, attention restoration and brain activation, we categorized landscapes by four distinctive environmental traits. First is habitat types, for example urban areas, natural areas, forests, waterscapes; second is the configuration of the elements in landscapes, openness, cover ratio of green areas; third is the texture of the landscapes, spatial frequency; at last is the characteristics of attention restoration. Preliminary results of fMRI images indicated that brain activated differently when people see different landscape categories and restorative environmental characteristics. The result showed that there are more activated brain areas when viewing urban landscapes and less activated areas while viewing natural landscapes. Fascination environments is correlated to high cognition brain regions. Moreover, being away, extent and compatibility environments activated occipital visual area. Waterscape is the most preferred landscape type, followed by forest, mountain landscapes, and the least preferred type is urban landscapes.

The other critical gap in the current knowledge that we would like to fill is how the brain works in the process of landscape design, we try to clarify the details of the “black box” of the landscape designing process. On the one hand, we tried to examine the related brain area while doing design. On the other hand, we are trying to understand the activation pathway of brain areas.

Keywords: functional magnetic resonance imaging; brain activity; landscape benefits; landscape design

1. Introduction

Living landscapes that people view and pass by daily have significant effects on human health. Research has shown that natural landscapes could restore voluntary attention (Berto, 2005; Berto et al., 2010) and positively influence one's emotional experience (Van den Berg, Koole, & Van der Wulp, 2003). Other research proved that people had higher preference toward green environments, and when people viewed preferred scenes, they achieved better attention restorative ability (Kaplan, 2001; Van den Berg et al., 2003; Purcell, Peron, & Berto, 2001; Kaplan & Kaplan, 1989). Natural landscapes not only had an effect on psychological health but also physical health. Previous research has proven that one's heart rate declined when watching videos of natural landscapes, while the heart rate remained steady when watching videos of urban landscapes (Ulrich et al., 1991). Another research suggested that when resting in a room with green views, the diastolic pressure reduced; however, when resting in a room without windows, the diastolic pressure increased (Hartig, Evans, Jamner, Davis, & Gärling, 2003). Therefore, previous studies have stated the positive influence of natural landscapes on humans in either subjective or objective manners. In recent years, the technique of functional magnetic resonance imaging (fMRI) has matured, which has enabled scientists to examine the influence of natural environments from a psychophysiological perspective, and it is a relatively precise method to discover the interaction between environments and human health, particularly brain activity. The fMRI technique can

distinguish the subtle differences in people's reactions to different scenes of varying compositions and meanings by measuring brain activity (Blondin & Lepage, 2005). While viewing photographs of familiar and unfamiliar locations, people responded more strongly to images of familiar locations in scene-selective regions of the Parahippocampal Place Area, the Retrosplenial Cortex, and the Transverse Occipital Sulcus (Epstein, Higgins, Jablonski, & Feiler, 2007). Walther, Caddigan, Fei-Fei, and Beck (2009) found that the primary Visual Cortex, the Parahippocampal Place Area, the Retrosplenial Cortex, and the Lateral Occipital Complex all contain information that distinguishes among natural scene categories (forests vs. mountains vs. beaches).

Understanding brain activity while watching landscapes introduced the question of whether the brain areas for perceiving landscapes are the same as the brain areas for imagining the design of landscapes. In the landscape architecture field, there is no precedent measuring brain activity while performing landscape design. Landscape design is a problem-solving process containing a series of steps, including problem scoping, preliminary solutions, refinement, and detailing. In the step of generating the preliminary solutions, methods such as associating and recalling past experiences are used to propose the various attainable programs. These initial generated ideas are ambiguous; later, a more specific and concrete resolution is generated after the refinement process. The former process is called divergent thinking,

providing a variety of possibilities, while the refinement process is called convergent thinking (Guilford, 1956). Goel (2014) hypothesized the correlative brain area of the cognitive process, with the right Prefrontal Cortex involved in divergent thinking and the left Prefrontal Cortex involved in convergent thinking. Dietrich (2004) also proposed that the Frontal Lobe dominates the functions of working memory, sustained attention, and flexibility, which are essential for creativity; furthermore, the Prefrontal Cortex was thought to be critical when contemplating solutions and performing divergent thinking (Dietrich, 2004; Dietrich & Kanso, 2010).

The present paper includes a series of studies to comprehend how environments affect people from a neuroscience perspective and uses an fMRI instrument to examine how landscape scenes influence human health on a deeper level. This paper has two purposes: 1) to evaluate the beneficial health impacts of different landscape types and characteristics regarding brain activity and mental reaction; 2) to evaluate brain activity while performing landscape design. There are three studies supporting the first purpose, while one study supports the second purpose. Study 1 compared brain activities and the perceived restoration effect of viewing natural landscape types, including mountains, forests, and water, and urban landscape types (Tang et al., 2017). Study 2 compared the different brain activities and emotional reactions of viewing urban

landscapes, natural green landscapes, and natural water landscapes, and it further examined the effects of these landscapes' characteristics (Chang & Hsu, 2017). Study 3 compared brain activities, attention restoration, and preference of viewing coastal, forest, and urban landscapes, as well as the visual image characteristics of these landscape types (Chang & Lee, 2017). Study 4 interpreted the activated brain areas while performing landscape design in an fMRI experiment (Tsai & Chang, 2015).

2. Methods

This paper separated the research into two parts: the first part examines the activated brain areas of landscape perception, while the second part examines the activated brain areas of the landscape design process.

The first part's three studies collected photographs from free online photography galleries and categorized the photos into urban and natural landscapes; and examined the beneficial effects of landscapes on human health through psychological questionnaires and an fMRI instrument. The last study used design tasks to examine the brain activity when performing landscape design.

2.1 *Participation restriction of fMRI experiments*

Participants had to be over 20 years old, with normal mental condition, normal vision and hearing abilities, and no color blindness. Excluded participants included those with tattoos, permanent and temporary metal

devices inside their bodies, brain damage, cardiovascular disease, depression, post-traumatic stress disorder, and fears or phobias toward closed and narrow spaces. Pregnant women were also excluded.

2.2 fMRI experiment procedure

A Siemens Prisma 3T MRI Scanner in the Imaging Center for Integrated Body, Mind and Culture Research at the National Taiwan University was used. The fMRI experiments proceeded as follows. Before going into the fMRI room, participants were instructed about the experiment, signed a consent form, confirmed again that their health condition fit within the restrictions, and removed all metal materials, including watches, glasses, etc., and cosmetics as well. With assistance from the Imaging Center's operators, participants entered the fMRI room and lay down on the fMRI instrument. The operators stabilized and adjusted the equipment to fit the participants' head and to prevent movement. Participants wore goggles for showing the stimuli, and buttons were placed by their hands and a safety ball was placed on their body; whenever participants did not feel well during the scanning, they could squeeze the ball, and the operator would stop the fMRI machine immediately. The experiment started with an anatomical image scanning, which acquired 45 images of both the vertical and horizontal sections of the brain structure. Then, the functional image scanning started. During the scan, participants watched landscape images and accomplished tasks.

2.3 Data processing

To avoid errors due to head movement during the scanning period, collected data was processed through a realignment step. In this process, the translation and rotation of the x, y, and z axes would be adjusted, and those data that exceeded the threshold were excluded.

3. fMRI studies of perceiving landscapes

The research method and the results of the first three studies will be explained individually in this section.

3.1 Study 1: Landscape types and brain activities

The purpose of Tang et al (2017) was to compare brain activities and the perceived restoration effect of viewing different landscape types. For landscape variables in study 1, landscape types were categorized into mountain, forest, water, and urban landscapes.

3.1.1 Study 1: Research methods

There were three chosen photographs for each landscape type. The baseline images for all landscape types were created by shuffling the three photographs into one image using the Pixuffle software.

For its psychological variable, study 1 examined attention restoration with the short version of Berto's (2005) Perceived Restorativeness Scale (PRS). Following Kaplan and Kaplan's (1989) concept of attention restoration theory, the PRS included four aspects: being away, fascination, extent and compatibility.

For fMRI data collection, the experimental design was a block design. There were four total runs during the experiment, and each run showed one kind of landscape type. The experiment began with some descriptions showing the details of the experiment, and then a cross symbol appeared, upon which the participants were to focus their attention. Next, the four runs appeared one by one. The first run was the urban landscape, and then the three natural landscapes of mountains, forests, and water would appear randomly.

3.1.2 Study 1: Results

There were 142 total valid samples in the psychological experiment. The results showed that water and mountain landscapes had better perceived restorative quality than forest landscapes and that urban landscapes had the least perceived restorative quality.

There were 13 valid samples in the fMRI experiment. Regarding the brain areas that activated while viewing the photographs of the four landscapes, the right and left Cuneus were activated while viewing urban landscapes as opposed to mountain landscapes. The right and left Cuneus, right Cingulate Gyrus, and left Precuneus were activated while viewing urban landscapes as opposed to water landscapes.

3.2 Study 2: Landscape types, emotions, and brain activities

Chang and Hsu (2017) compared the different brain activities and emotional reactions to viewing urban landscapes, natural green landscapes, and natural water landscapes. To examine the detailed

differences in the characteristics of these landscape types, the study depicted one characteristic for each landscape.

3.2.1 Study 2: Research methods

For the landscape stimuli, there were four types of landscapes. In the urban landscape group, the study examined street landscapes with and without trees; in the natural green landscape group, the study examined the openness of the landscape; in the natural water landscape group, the study examined dynamic and static waterscapes. There were six landscape stimuli categories total.

For the psychological variable, Chang and Hsu (2017) examined emotion with the scale proposed by Russell and Pratt (1980), a two-dimensional bipolar scale with separate spaces for arousal, sleepiness, pleasant, and unpleasant on each one of the poles, and the dimensions were measured with a nine-point Likert scale.

For fMRI data collection, there were five total runs in one experiment, containing six trials in each run, and three photographs of every landscape type were shown once randomly in each trial. In the end of each trial, the emotion scale displayed, and participants answered the scale by pressing buttons on the machine. There was a one-minute break between each run. In the entire experiment, participants needed to evaluate the emotion of one landscape stimulus category five times and viewed fifteen photographs of one landscape stimulus in total.

3.2.2 Study 2: Results

There were 34 valid samples in study 2. Participants' emotions toward these three landscape types were statistically significantly different. For the pleasant and unpleasant emotions, participants felt natural water landscapes were the most pleasant landscape, natural green landscapes were second, and urban landscapes were the least pleasant. For the arousal and sleepiness emotions, participants felt more aroused while watching the urban landscape than the natural green landscape. Next, in comparing the results of emotion when examining the characteristics of landscapes, the results indicated that participants felt more aroused while viewing dynamic waterscapes than static waterscapes, felt more pleasant while viewing open green landscapes, and felt more aroused while viewing closed natural green landscapes.

Before analyzing the results of brain activation, data was excluded for those participants whose head movement exceeded the threshold, meaning the translation shifted over 3.5mm and the rotation rotated over ± 1 degree.

There were 24 valid samples for the fMRI experiment. The results showed the participants' brains were more activated while watching urban landscapes than natural green landscapes and natural water landscapes. Contrasted with natural green landscapes, the right Fusiform Gyrus, the left Middle Occipital Gyrus, the right Lingual Gyrus, the left Parahippocampal Gyrus, and the right and left Posterior Cingulate were activated while watching

urban landscapes. Contrasted with natural water landscapes, the left Cuneus and the right Middle Occipital Gyrus were activated while watching urban landscapes. Regarding the influence of the landscapes' more detailed characteristics on brain activity, only the left Lingual Gyrus activated while viewing closed natural green landscapes as opposed to open natural green landscapes.

3.3 Study 3: Landscape types, attention restoration, preference, and brain activities

Chang and Lee (2017) aimed to compare brain activities, attention restoration, and preference for viewing coastal, forest, and urban landscapes. Comparing the differences of the landscapes with different spatial frequencies was a relatively new manner of analyzing image characteristic.

3.3.1 Study 3: Research methods

Chang and Lee (2017) categorized natural landscapes into coastal and forest landscapes, and they separated the photographs of each landscape type into two groups, the high and the low groups, by analyzing the spatial frequency.

For the psychological variable, Chang and Lee (2017) examined preference with a five-point Likert scale and attention restoration using the Sustain Attention to Response Test (SART), which is a widely used attention test in the landscape research field. The SART results would provide accuracy rates and response times.

For fMRI data collection, there were six runs in the experiment. When the functional image scanning started, the experiment began with a pre-SART that lasted for 180

seconds, in which participants watched six photographs of one kind of landscape stimulus, and then the participants performed a post-SART that lasted for 180 seconds, and finally the photograph preferences were evaluated. This was the procedure for one run. Each run showed one kind of landscape stimulus, and the landscape stimulus order was random.

3.3.2 Study 3: Results

There were 34 total participants. After excluding participants whose SART accuracy rate was under 75%, there were 23 valid samples. The coastal landscape was the most preferred landscape, the forest landscape was second, and the urban landscape was the least preferred type; the spatial frequency had no significant influence on preference. Landscape types had no significant influence on the SART accuracy rate and response time, nor did the spatial frequency variable. In comparing the effect of spatial frequency on preference and attention restoration in the same landscape type, the findings proved that in the urban landscape, photographs with high frequency were more preferred than those with low spatial frequency; in the forest landscape type, participants who watched photographs with a high frequency had less response time in SART.

Comparing the fMRI results among landscape types found that subtracting the brain areas activated by urban landscapes from the brain areas activated by coastal landscapes determined the Parahippocampal Gyrus and the Frontal Lobe Sub-Gyral were

the contrasting brain areas. Contrasted with watching forest landscape images, the Middle Occipital Gyrus, the Occipital Lobe Sub-Gyrus, the Temporal Lobe Sub-Gyral, and the Cerebellum Culmen were activated while watching urban landscapes. Lastly, contrasted with coastal landscape images, the Lingual Gyrus was activated while watching forest landscapes.

Comparing the brain activity differences between pre-SART and post-SART under the influence of spatial frequency, the results showed that the activated brain areas during post-SART after watching the low frequency landscape photographs were Lingual Gyrus and Cuneus. The activated brain area in the same situation after watching high-frequency landscape photographs was the Lingual Gyrus.

4. Discussion about brain activity while perceiving landscapes

Regarding the psychological response of different landscape types, study 2 indicated that natural water landscape photographs were the most pleasant landscape. Study 3 indicated that water landscapes were the most preferred landscape type, although the results did not support that natural landscapes can provide better attention restorative ability. Study 1's results showed that water and mountain landscapes provided the best attention restorative quality among the four landscape types. Regarding preference and attention restoration, the results are in line with the previous research; White, Smith,

Humphryes, Snelling, and Depledge (2010) suggested that water landscapes were the most preferred landscape type.

In terms of fMRI results, in general, when watching urban landscape photographs, participants needed to pay more attention, and the brain was processing and engaging in numerous matters. According to these three studies, brain areas such as the Middle Occipital Gyrus, the Lingual Gyrus, the Fusiform Gyrus, the Cuneus, the Precuneus, the Posterior Cingulate, the Parahippocampal Gyrus, the Occipital Lobe Sub-Gyral, the Temporal Lobe Sub-Gyral, and the Cerebellum Culmen were the activated brain areas when contrasting the results of urban landscapes with natural landscapes.

Some portion of these brain areas manage the function of visual image processing; for example, the Middle Occipital Gyrus, the Occipital Lobe Sub-Gyral, and the Fusiform Gyrus process color information. The Cuneus processes the visual and spatial environment, while the Parahippocampal Gyrus processes complicated images. The Lingual Gyrus is where the brain processes vision.

Other brain areas are related to cognitive, attention, language, and memory, which refer to higher levels of information processing and cognitive activity. The Occipital Lobe Sub-Gyral is related to emotion and attention. The Cuneus is the area in charge of attention, and the function of the Precuneus is cognitive activity, including episodic memory and

consciousness. The Posterior Cingulate also functions for episodic memory and controls emotion and memory. The Parahippocampal Gyrus functions for coding and extracting memory. The Temporal Lobe Sub-Gyral performs perception, memory extraction, and emotional reactions. Some areas, such as the Fusiform Gyrus and Lingual Gyrus, are associated with language, words, and character recognition.

According to the studies' results, certain brain areas related to a higher level of cognitive activity were more activated when watching urban landscapes. This may be because information from natural landscapes is effortless to process; hence, there were more activated reactions in the brain while watching urban landscapes, and this consumed more cognitive functions and attention. Besides the composition and textures of the urban photographs, the studies also provided images with high variations, and the elements in the urban landscapes contained extensive visual information, which would lead to more activated brain areas related to a high level of cognition.

5. fMRI study of landscape design

5.1 Study 4: Brain activities during design process

The object of study 4 was to locate the brain areas related to the landscape design process and to separate the landscape design into two portions: the preliminary solutions and the process from refinement to detailing.

5.1.1 Study 4: Research methods

To measure the activated brain areas for performing landscape design, study 4 customized an acrylic table for participants to draw inside the fMRI machine. There were two tasks with two kinds of materials: landscape plans (Task A) and geometrical patterns (Task B). There were two parts in Tasks A and B. Task A1 was to read the landscape plans and imagine being inside the landscapes, the reading condition, and Task A2 was to copy those landscape plans, the copying condition. Task B1 was to think and develop a landscape diagram with some given geometrical patterns, the brainstorming condition, and Task B2 was the creative drawing condition of drawing the developed landscapes. The entire experiment was composed of two runs, with two A tasks and two B tasks in each run; to counterbalance, there were two kinds of texts with the order of ABAB BABA and BABA ABAB.

5.1.2 Study 4: Results

In the preliminary solutions, which was the brainstorming condition compared to the reading condition, the activated brain area was the Lateral Ventricle, and this area mainly functions as the buffer for strikes, the circulation of nutrition, and waste elimination. However, this brain area is not related to cognitive function. The outcome of examining the activated brain area for the refinement and detailing process, which was the creative drawing condition compared to the copying condition, showed the activated brain area was the left Middle Frontal Gyrus.

6. Discussion about brain activity when performing landscape design

The Middle Frontal Gyrus belonging to the Dorsolateral Prefrontal Cortex controls working memory and cognition. The process of drawing one of the imagined plans in the mind can be seen as refinement and detailing, and the result was in line with Goel's (2014) hypothesis.

7. Conclusion

The first three studies showed the relationships between landscape types and brain areas, and the results showed the brain would be busier and more active while watching urban landscape photographs than natural landscape photographs; the results also explained that different landscape types might cause different brain areas to activate. Over half the population lives in urban areas with manifold landscape composition; thus, understanding the relationship between landscapes and brain activity may support residents in getting the exact desired function when in contact with urban landscapes.

Exploring the relationships between landscapes, landscape design, and brain activity is a relatively new perspective in the landscape architecture research field. The brain's neuron network is complicated and interconnected; therefore, one experiment may not be able to examine all the brain areas related to the stimuli, and the results cannot assure other brain areas are not correlated to the stimuli. There are a variety

of characteristics inside landscapes, and even the same landscape type may activate different brain areas because of their subtle characteristics. Hence, future research should continue exploring the detailed and specific characteristics in landscapes. Furthermore, comparing the correlation between creative performance and brain activation would also be worth investigating.

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Impact of learning landscapes in developing cognitive of preschool students; cases from Kandy, Sri Lanka

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Abstract

‘Learning landscape’ is an innovative approach incorporated in the current global education arena to facilitate optimal learning in students with the use of their need to affiliate with nature; biophilia. Being a concept which has not yet being introduced to Sri Lankan context, the present investigation focuses on the potential impacts of combining landscape in the design of preschools on the development of cognitive skills in local children. The factors which contribute in creating effective learning landscapes namely; flexibility, playfulness, safety, graduate challenges, and scale (Moore, 2013) were tested with reference to three preschools located in Kandy having incorporated the landscape in the learning environment in three levels; high (HLE), moderate (MLE) and low respectively (LLE). 20 students per each case were examined adopting a mixed method including behavioural mapping, interviews, close questioners and Marmara cognitive development scale.

The study established a direct association between the impact of landscape on learning and development of cognitive skills in pre-schoolers. The children exposed to HLE were found to have the highest ranking on Marmara cognitive scale while the children of LLE obtained the lowest ranking. As revealed via the behavioural maps, the highest involvement of the children was recorded in HLE which also witnessed the presence of the highest number of favourable responses regarding learning landscape characteristics; flexibility (95%), playfulness (95%), safety (90%), graduate challenges (90%), and scale (95%) and vice versa in terms of LLE; 15%, 10%, 5%, 15% and 5% respectively.

Based on the findings, introducing the concept of learning landscapes in designing future primary learning environments in Sri Lanka is highly recommend.

Key words: learning landscapes, Child’s Cognitive development, Preschool students

1. Introduction

‘Biophilia’ is explained as the inherent human need to affiliate with nature (Wilson 1984, Kellert and Wilson 1993). This need is found to be influential on the physical and mental well-being of a human being. Biophilic design strengthens and enforces one's affiliation with nature, which leads to a more contented and well-balanced person. However, this need is not thoughtfully considered in most of the architectural and landscape architectural design interventions. ‘Learning landscape’ is an innovative and effective approach incorporated in the current global education arena which is to facilitate optimal learning in students with the use of their need to affiliate with nature. However, this concept is yet to be introduced in the Sri Lankan context.

1.1. Problem statement

This investigation looks into the potential impacts of combining landscape in the design of preschools on the development of cognitive skills in local pre-schoolers.

1.2. Objectives

- Exploring the potential of using ‘learning landscapes’ in improving learning environments.
- Identifying design strategies in introducing the concept of learning landscapes in designing future primary learning environments in Sri Lanka.

1.3. Methodology

Using a mixed method, several research tools were adopted for the investigation namely; behavioural mapping, interviews, close questionnaires and Marmara cognitive development scale. The observations were done to examine the level of involvement of children in the given learning environment with reference to time and activities with nature. (See appendix 1 for a flow chart showing the methodology)

1.4. Case study selection criteria

The selected area for the case study was Kandy, a city having a unique topographical character, located in the central province of Sri Lanka (7.2906° N, 80.6337° E). Three preschools located in Kandy were selected as cases namely; First Friends Preschool, Glenfall preschool and Sokanji Preschool based on the level to which landscape has been incorporated with the learning environment. Selected students belong to the same age category, social cultural, background, abilities, qualities, the learning methods, the climatic and topographical characteristics in each and every way. The parameter that varies from one pre-school to another was the level of involvement of the landscape.

1.5. Outcome

- Creating conducive spaces for the cognitive development of children through learning landscape characters; biophilic design
- Developing learning landscape designs which contribute in

maximizing the benefits from the spaces.

2. Learning landscape and preschool student's cognitive skills.

2.1. Child and nature

Studies have proven that the natural environment supports to build children's cognitive development physically and emotionally. Since nature functions as a restorative environment, studies on nature have proven its benefits on childhood mentality [2] (Gibson, 1979). As a holistic idea, a child's interaction with the surrounding environment has found to help his/her growth. Connection, experience, and engagement with the nature have positive effects on the child's cognitive, physical, social, emotional and spiritual development. Nature helps the child in instantly capturing diverse components in the society and learn new things quickly. Instead of indoor learning, the child gets the opportunity to learn a lot through outdoor environment. Thus, the nature of the surrounding, outdoor environment teaches the child to adapt him herself depending on the context without much difficulty (Kellert, 1993).

2.2. Scope of learning landscape.

Learning landscapes is developed with the intention of supporting the child's growth. They give much attention on physical, social, cognitive and emotional growth of the child. The concept of learning landscape defines the designing of an environment which supports the child's growth by creating spaces, elements, visuals and links (Kellert, 1993)..

2.3. Preschool student's cognitive development

Children between three to five years of age are defined as preschool students. Children of this age are rapidly developing their physical, cognitive and psychological/social competence as they interact with their environment. [2] (Weave, 2000) Preschool student quickly grab what they experience from the surrounding nature. Thus, it is such and experience they come across or face freeing themselves from the fetters of the indoor areas. Therefore, the soul function of the concept of learning landscape is to support the growth of physical, social, cognitive and emotional skills through various factors in a way appealing to the child. (Kellert, 1993).

2.4. Theoretical framework of the study

There are many factors affecting human behavior in learning landscape designs. They help to develop children's cognitive development by building up the foundation for children to interact with nature and society. The factors influencing the cognitive development of preschool students established by the previous studies are as below. . (Kellert, 1993).

- Flexibility
- Playfulness
- Safety
- Graduated challenges
- Scale

2.4.1. Flexibility

Design space should be flexible for children without directing. If there is flexibility within

pre-school learning landscape, the child will engage in activities without any persuasion. It helps to develop preschool children's cognitive skills. . (Kellert, 1993).

2.4.2. *Playfulness*

Playfulness could be considered as a prominent factor within learning landscape. Colours, patterns and textures found in a learning landscape help him/her to gain a lot of new experiences. Therefore, it's diversity will directly influence the cognitive development of the child. (Kellert, 1993).

2.4.3. *Safety*

Every human being has their own satisfaction through personal safety. Since a child is one who learns a lot through new experience, there should be a satisfaction within him/her that learning is not something troublesome. Child's engagement in a task makes him/her involve in the problem-solving, memorizing or realizing. These will affect all cognitive factors. . (Kellert, 1993).

2.4.4. *Graduated challenges*

This is one such important quality that could be found in a learning landscape. The mental development that takes place during the ear of pre-school will undoubtedly affect the child's personality in future. Therefore, children will have their own self-esteem and confidence through 'graduated challenges'.

2.4.5. *Scale*

Scale becomes an important and an effective factor of learning landscape as the child senses a lot through the scale. More often, preschool child shows a preference in gaining experiences symbolically. Therefore, the elements and their scales perceived by a child will directly have an effect on this

symbolic experience of space. (Kellert, 1993).

2.5. *Methodology of the study*

As explained above, behavioral maps were produced defining the children's activities and the places in which they were fond of spending time.

Children were randomly questioned in order to fill the questioner. When communicating with children, obtaining elaborate answers are not possible. As a remedy, 'closed-ended questions' were incorporated in the questionnaire design.

The Marmara Development Scale (Oktay and Bilgin-Aydin, 2002) was adopted to measure children's cognitive skills in this investigation. For the purpose of the present study, only the Cognitive Development Subscale scores were used to measure children's cognitive abilities. Teachers' report was used to measure children's cognitive skills.

3. Case studies and data presentation

3.1. *Case studies*

Three preschools located in Kandy area were selected based on the criteria mentioned above. A sample of normal, healthy 20 preschoolers (girls (n= 10) and boys (n=10), age; 4-5) were selected from each pre-school. These pre-schools were following the identical methods and techniques in teaching, learning and assessment. For instant all three was using AMI method and following their courses in English medium. The selected children were those who studied in the pre-school for seven months.

3.2. Case study 01: First friend preschool

First Friends pre-school located in Niththawela, Kandy is special since children were involved in studies and activities mostly in the outdoor environment. Children were taken outside the classroom for engaging themselves in various outdoor activities. Further, they were given the chance to blend themselves with the nature by allowing them to play with sand, plants clay and water. They were given the opportunity to engage in a lot of activities not only in the classroom but also outside the classroom.

3.2.1. Photographic survey of first friend preschool.

See appendix 2 for a mood board showing photographic survey of first friend pre-school

3.2.2. Marmara scaling in first friend preschool

See appendix 3 for a polar graph showing Marmara scale in first friend pre-school.

3.2.3. Behavioral study on first friends preschool

See appendix 4 for a map shows behavioral study on first friend pre-school

3.2.4. Learning landscape Flexibility

See appendix 5 for a bar chart showing learning landscape flexibility in first friend pre-school.

3.2.5. Learning landscape playfulness

See appendix 6 for a bar chart showing learning landscape playfulness in first friend pre-school.

3.2.6. Learning landscape safety in first friend preschool

See appendix 7 for a bar chart showing learning landscape safety in first friend pre-school.

3.2.7. Learning landscape graduated challenges in first friend preschool

See appendix 8 for a bar chart showing learning landscape graduated challenges in first friend pre-school.

3.2.8. Learning landscape scale in first friend preschool

See appendix 9 for a bar chart showing learning landscape scale in first friend pre-school

3.3. Case study 2 : Glenfal international preschool

This pre-school is located in Polgolla, Kandy, Sri Lanka. It has an outdoor landscape - apart from the classrooms - with sand pits and other play elements. However, children only get an opportunity to play during a specific time. There is a little space for children to run and play. Tranquillity and calmness of the environment cannot be seen in this location as it is located near the main road.

3.3.1. Photographic survey of Glenfal preschool.

See appendix 10 for a mood board showing photographic survey of Glenfal pre-school.

3.3.2. Marmara scaling in Glenfal preschool

See appendix 11 for a polar graph showing Marmara scale in Glenfal pre-school.

3.4. Case study 03: Sokanji pre school

Sokanji pre-school is located in Kandy, near the main road. Children have a very limited space and therefore, there is no sufficient spacious area for them to mingle themselves with the outdoor landscape. Except for the classroom, there is no such space for children to play and do their activities. Therefore, they do their activities inside the classroom. At the same time, noises from vehicles is a major problem since it's being located facing the main road. Although, there is a little space available, still there is a swing. Thus, the piece of land where the swing has been erected has no enough space to accommodate all children at one time.

3.4.1. Photographic survey of Sokanji preschool.

See appendix 12 for a mood board showing photographic survey of Sokanji pre-school.

3.4.2. Marmara scaling in Sokanji preschool

See appendix 13 for a polar graph showing Marmara scale in Sokanji pre-school.

4. Data analysis

4.1. Analysis according to the Marmara development scale

See appendix 14 for a polar graph showing comparison of Marmara development scale in each case study. According to the analysis, the highest growth of cognitive skills was shown by first friends pre-school whereas, Genfal International pre-school shows a medium growth whilst, growth of cognitive skill were depicted in a poor status or a low level in Sokanji pre-school. Thus, the reason for such result is the involvement of learning

landscape being the independent variable of all cases studied. Therefore, the study provides evidence that the learning landscape has a direct impact on the growth and development of cognitive skills of pre-school children.

4.2. Analysis according to the behavioral map

(See appendix 15 for a graph showing comparison of pre-school child behavior in pre-school premises.) Children were allowed to be in the learning landscape from 9am – 10 am and 10 am – 11 am in First Friend pre-school. During the day, they engaged in different activities and learning activities whilst staying in the learning landscape. Thus, there are different spaces with in the learning landscape which help children gain experience through nature and develop cognitive skills. For instance, different types of spaces such as active spaces, gathering spaces, experimental spaces, individual spaces and ecological spaces could be seen. There is limited space in the learning landscape of Glenfal International pre-school. They were allowed to play in the learning landscape from 10.30 am – 11.30 am. Because of the space limitation, all the children do not play at one time, in the learning landscape. Some children do prefer to stay inside the classroom. This has only two types of spaces: gathering space and active play space. A child in Sokanji preschool rarely uses the outdoor landscape. They spend the entire day within the classroom and prefer playing and performing activities inside the classroom during the interval. This study of the behavioral map shows that children of First Friend pre-school spend a lot in leaning landscape. Further,

children of Glenfal International pre-school spend a limited time whilst children of Sokanji pre-school do not use the learning landscape at all.

4.3. Analysis according to cognitive skill development factors in learning landscapes

4.3.1. Flexibility

See appendix 16 for a bar chart showing comparison on flexibility factor in each pre-school.

4.3.2. Playfulness

See appendix 17 for a bar chart showing comparison on playfulness factor in each pre-school.

4.3.3. Safety

See appendix 18 for a bar chart showing comparison on safety factor in each pre-school.

4.3.4. Graduated challenges.

See appendix 19 for a bar chart showing comparison on graduated challenges factor in each pre-school.

4.3.5. Scale

See appendix 20 for a bar chart showing comparison on scale in each pre-school.

4.4. Summery

The behavioural maps analysis, enabled the study to identify that the level of the children's involvement with the learning landscape at the respective pre-schools. Accordingly, the First Friends pre-school shows the highest number of learning landscape characteristics, followed respectively by Glenfal International pre-school and Sokanji pre-school.

According to the Marmara Development Scale, the highest cognitive skills was depicted by First Friend pre-school. Therefore, learning landscape factor has influenced the results taken through Marmara Development Scale.

The Behavioural map analysis shows that children's involvement, learning landscape characters, and cognitive skills development is high at First Friends pre-school, while it is moderate at Glenfal International pre-school, and low at Sokanji pre-school. Hence, cognitive development is high in the pre-schools where there is an involvement of the learning landscape characters which supports biophilia. This shows that learning landscapes has a direct impact on the child's cognitive skills development.

The literature review shows that factors affecting the cognitive development of the children are: flexibility, playfulness, safety, graduated challenges, and scale. These are high at First Friends pre-school and low at Sokanji pre-school. Glenfal International is relatively high in some areas while moderate and low in other areas.

5. Conclusion

This study investigated the factors of learning landscape and how the landscape impacts cognitive skills of preschool students. The five factors of; flexibility, playfulness, safety, graduated challenges and scale help in positively developing cognitive skills of a pre-schooler.

A learning landscape space has unique characteristics within it and the above factors facilitate the characters of its biophilic design. The study identifies these characters

as key spaces of a learning landscape. These key spaces are; active spaces, gathering spaces, individual spaces, ecological spaces, and experimental spaces. The research shows that these spaces help to develop the learning, perception, memory, thinking, and problem solving cognitive skills of the children.

Importantly, this research proves that when learning landscapes are created, the above mentioned factors should be taken into consideration so as to create effective spaces for the children. This is because, children without an outdoor learning environment, develops at a relatively low level during their early childhood.

The limitations of this study needs to be considered in future research. Thereby, further research would need to be performed in a larger area and many more educational institutions, in order to examine associations among variables of the learning landscape. Also, the study can be improved by analysing cognitive development of a child through a periodical method.

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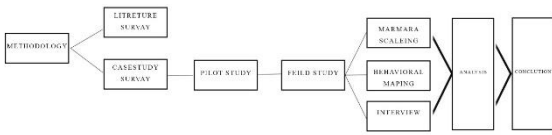
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Appendix

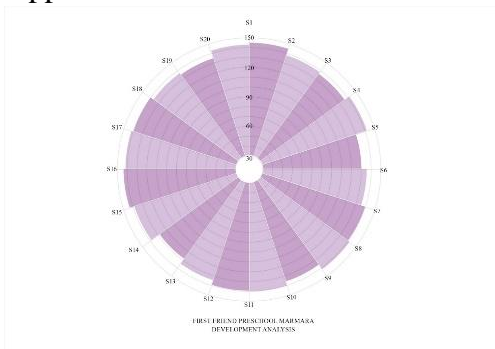
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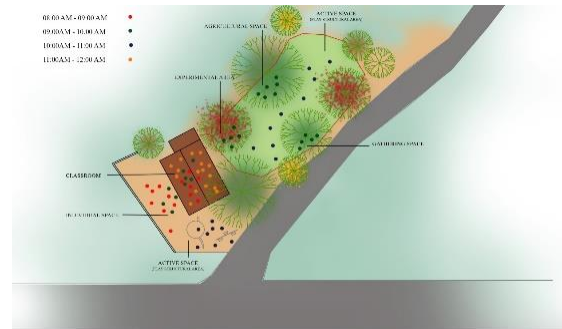
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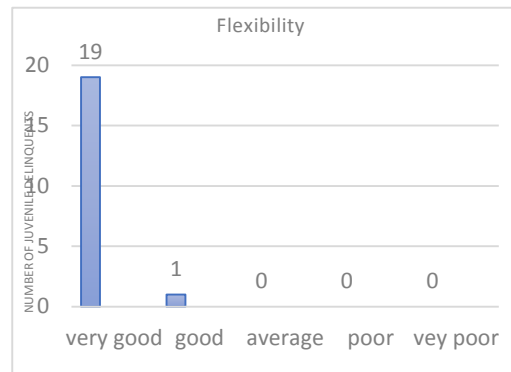
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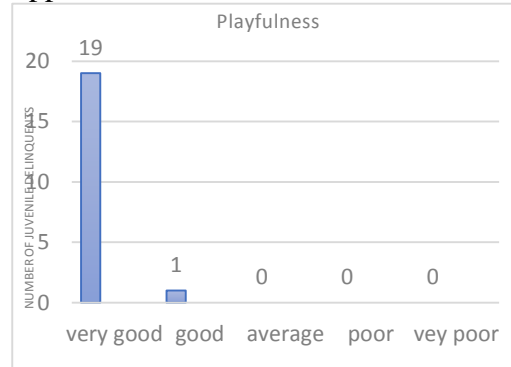
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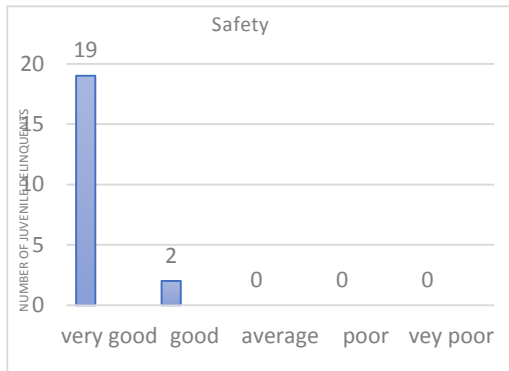
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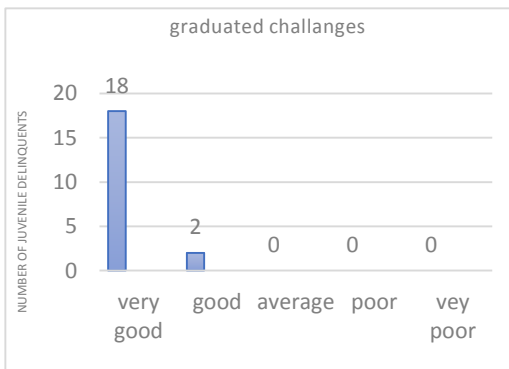
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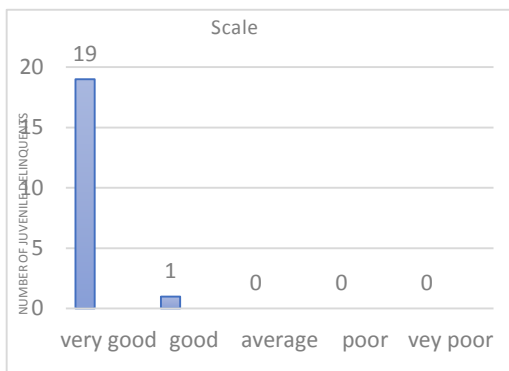
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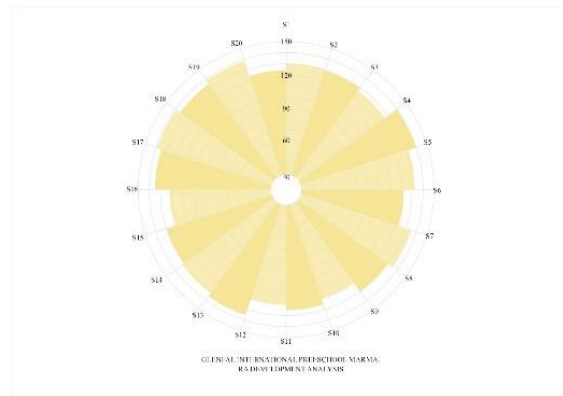
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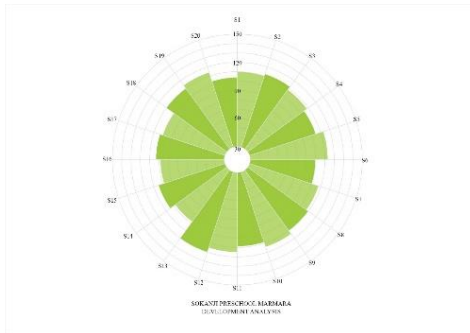
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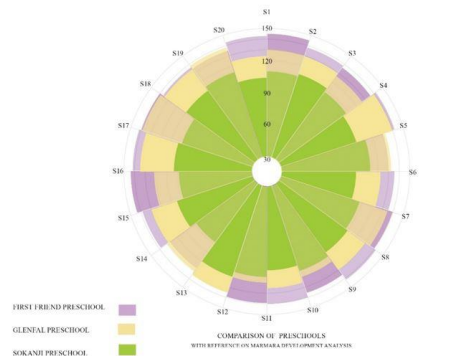
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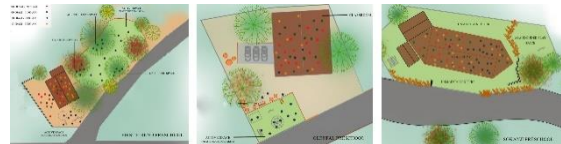
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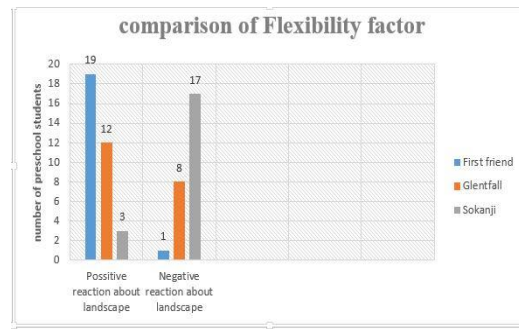
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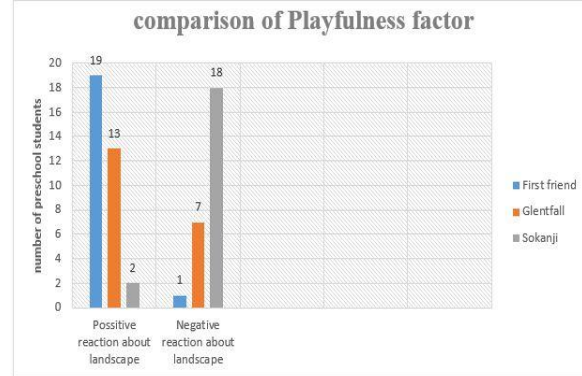
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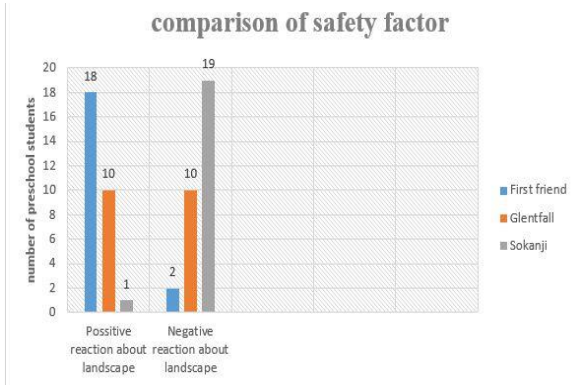
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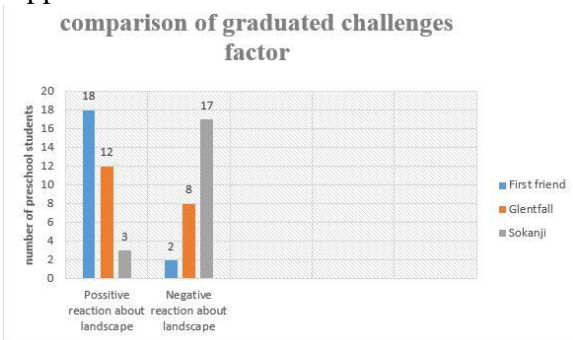
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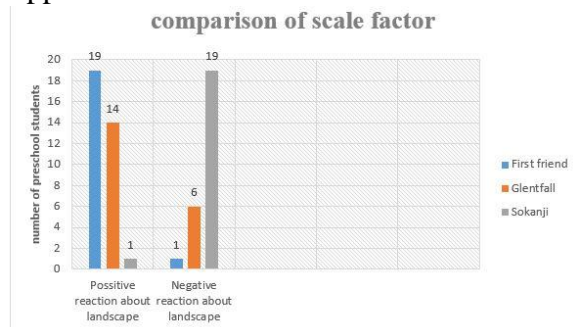
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Appendix 19



Appendix 20



Creating a New Suburban Landscape by Means of Therapeutic Landscape-A Case Study of Xianhe Hainan Province

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Abstract

With China's quick urbanization and modernization, big cities has attracted a large number of people to work in city leading to serious problems of left-behind children and empty-nesters in rural areas. In addition, the urban people have a fast-paced life, adults are usually in a state of high pressure with very tight schedules and it is rare for children to be close to nature. Over time, sub-health has taken place in both rural and urban areas, and everyone aspires to a "holy land" that can liberate the soul and the body. By introducing therapeutic landscapes to suburbs, we hope to achieve an effect on activating the vitality of city-suburban boundaries and promoting the physical and mental health of urban and rural residents. Taking the plant elements in horticultural therapy as the starting point, we will construct therapeutic landscapes by mobilizing the five senses of vision, hearing, smell, taste and touch. Colorful flowers and vast rice fields provide people with marvelous visual experience. By means of restoring water environment combined with the wetland design, water will be purified and biological diversity will be significantly increased in the restored ecosystems. The sounds of insects, diverse birds will bring a feast of hearing from nature. We plan to use a large number of local vegetables, featured fruits to create the edible landscape. The aroma of the plants and picking experience of fruits and vegetables will fully mobilize the sense of smell, touch, etc. We will try our best to protect the ancient and rare trees in the site, which will play a significant role in both public science education and economic value. "Four Southern Herbal Medicines" can provide convenience for the villagers' lives. Furthermore, we will do ecological design based on the low impact development. We will increase green infrastructure to improve suburban landscape service system. And we will also set up children's activity areas and outdoor science classrooms. There are two main categories of experience design, including static viewing based on leisure activities, and practical participation based on technical activities. These activities can enrich the leisure life of urban people. At the same time, they can bring considerable economic benefits to the villagers. This article takes Xianhe Village as the research object, exploring new ways that can activate the vitality of the city-suburban boundary and promote the coordinated development of the city-suburban areas. Introducing the new therapeutic landscapes in suburbs,

which can be edible, ornamental, and playable, can play an important role in alleviating the stress and restoring mental status of the urban people, rebuilding the connection between children and nature, and revitalizing the suburban economy.

Keywords: suburban landscape; therapeutic landscape; garden health; landscape architecture

1. Introduction

With the rapid development of China, a series of social problems have emerged in urban and rural areas. On the one hand, adequate job opportunities and high salary in cities have attracted a large number of rural young and middle-aged people to leave their hometowns and work in cities. This trend has led to a large number of left-behind children and empty-nesters in the countryside [1]. They are faced with both physical and mental problems and the quality of their life cannot be fully ensured. Insecure drinking water and backward medical conditions in rural areas affect their physical health. At the same time, they suffer from loneliness in the depth of their heart. On the other hand, the pace of life in the city is accelerating, and adults in the city are confronted with difficult problems from various aspects such as life and society. As a result, their physical and mental pressures are increasing, depressed emotions are getting worse, and immune system are declining. They have long been in a state of high tension and are vulnerable to diseases. Sub-health has become a common problem among urban residents. Health care has also become a hot topic in society. At the same time, children rarely have the opportunity to get close to nature, resulting in fractures between children and nature, such as stress, depression, loneliness, and attention disorders. It can be seen that people from all ages have different degrees of health problems wherever they are in city or in the countryside. The way to cure physical and mental diseases is not limited to drugs and instruments. The landscape approach has

become a unique way of influencing people's health and gradually grabs people's attention [2]. The suburbs, as the border between the city and the countryside, are the corridors to activate the vitality. The suburbs with convenient traffic have become the first choice for connecting cities and rural areas and narrowing the gap between cities and rural areas.

Based on this phenomenon, this paper takes the Xianhe Village project in Haikou City of Hainan Province as an example to carry out suburban landscape planning and designing. It is hoped that this study can provide reference for suburban landscape planning and designing with similar phenomena, so as to achieve the effective integration of production functions, ecological functions and recreational functions of suburban landscape, to achieve the social, economic and ecological benefits of suburban landscapes.

2. Site Condition and analysis of available resources

Xianhe Village is located in the northwest of Sanjiang Town, Meilan District, Haikou City, Hainan Province, 8 kilometers from Sanjiang Town center. With an excellent geographical location, abundant natural resources and a good ecological environment, Xianhe Village provides a good foundation for the later-period construction of therapeutic landscape.

2.1. Abundant natural resources

Xianhe Village boasts natural resources of lakes, forests, and farmlands, and has abundant plant resources. The site is mainly planted with economic trees like *Hevea brasiliensis* (Willd. ex A. Juss.) Muell. Arg, *Musa nana* Lour., *Areca catechu* L., native tree species like *Roystonea regia* (H.B.K) O.F.Cook, *Casuarina equisetifolia* Forst., *Cocos nucifera* L., etc, ancient and rare trees such as *Dalbergia hainanensis* Merr. & Chun, as well as fruit trees like *Citrus maxima* (Burm) Merr. , *Syzygium samarangense* (Bl.) Merr. et Perry, *Clausena lansium* (Lour.) Skeels, *Artocarpus heterophyllus* Lam, etc. The rainfall is abundant throughout the year and it is adjacent to the Dingrong Reservoir, which has abundant hydrological resources.

2.2. Good ecological environment

Xianhe Village has a good natural ecological environment and has natural scenery such as lush mountains, lucid water, wheat fields, and wetlands.

2.3. Excellent geographical location and traffic advantages

Xianhe Village enjoys convenient traffic, with Haiwen Expressway and S201 Provincial Highway connecting Haikou in the north and Sanya, Wenchang to its south. The project is of great significance for the integration of rural tourism resources in Hainan Province.

2.4. Human resources

Xianhe Village is an old district with revolutionary history, with red cultural resources and primitive ecological villages. Su Xunsan County is an important part of the Qionghai-Wenchang Revolutionary Base. Hainan Doll Opera and Tiger Dance are listed as intangible cultural heritage by China and Hainan Province respectively.

2.5. Industrial resources

According to the township tourism plan in compliance to the overall plan of Sanjiang Town, Xianhe Village is located in the waterfront tourism area. In the industrial layout of the town, Xianhe Village is on the axis of the leisure agriculture industry and can rely on Xianhe Lake to develop the suburban tourism industry. In addition, Xianhe Village is also the base for cross-country auto racing and the base of Sanjiang HaofuJiang wax apple base.

3. Planning strategy

Taking the whole village into consideration, this landscape planning system has designed different areas corresponding to their respective resources and functions. The plan mainly contains five basic strategies.

3.1. Building a complete road network

We plan to upgrade the roads, build a complete road network, and take use of the

geographical advantages to promote urban-suburban inter-connectivity.

The roads in Xianhe Village cannot ensure free traffic flow yet. Thus, it is necessary to upgrade the traffic network to build a complete transportation system in order to facilitate the exchanges of urban and suburban residents. Furthermore, given that the elderly in the village may have difficulties in movement, the width of the road and the size of the ramp are designed in accordance with the principle of barrier-free [3]. The material of the road is appropriately chosen to ensure the smooth passage of the wheelchairs.

3.2. Constructing a suburban park

Taking good use of resources of lake, farmland and forest within the field, we plan to construct a suburban park and make it a center to serve residents of the surrounding cities and the rural areas. We plan to set up some diversified attractions including the Famous Wood Cognitive Park, teahouse, Jungle Experience Bridge, and Farmland Watch Tower, etc. By setting up children's activity area and outdoor science classroom, we want children to embrace nature and be closer to nature. A variety of activities are carried out to bring vitality to the venue.

3.3. Improving the infrastructure

We plan to improve the infrastructure, narrow the gap between the urban and the rural as to life quality. At the same time, a large number of local materials, such as wood, stone, fruit trees etc., will be reserved

to preserve the suburban landscape. We will use low-impact development methods to carry out ecological design, increase the green infrastructures such as rainwater treatment devices, energy recycling systems, and garbage disposal, so as to improve the suburban landscape service system.

3.4. Establishing an ecological restoration mechanism

We plan to establish an ecological restoration mechanism to mobilize the human sensory system, in order to heal the body and mind. We plan to restore the water area in combination with the wetland design, and soften part of the water revetment. In the restored ecosystem, the water quality will be purified, the biodiversity will be significantly increased, and the sounds of various birds and insects will be added, along with the sound of water and wind blowing on the leaves, an auditory feast from nature is on the table.

3.5. Promoting multi-industry coordinated development

We plan to utilize the advantages of lakes, fields and forest resources in the site to promote multi-industry coordinated development, and establish a healthy cycle of urban-suburban collaborative development mechanism. This mechanism is driven by market. Taking an approach of therapeutic landscape, we plan to plant fruit trees and other economic crops, green fruits and vegetables, flowers and breed some fish in order to make the suburban land whose utilization rate was not high become a new opportunity for suburban development.



Fig. 1. Master Plan

4. Planning and Designing

Based on the existing conditions, the site will be divided into eleven areas: entrance service area, outdoor classroom area, wetland reserve, forest conservation area, internal staff working area, aborigines' living area, B&B accommodation area, land claiming area, picking area, forest exploration area, agricultural sightseeing area, according to the function and nature of the site.

4.1. Entrance Service Area

In the entrance service area, there are parking lots and visitor center. There are also other service facilities, such as coffee shop, convenience store and the medical station. This will facilitate people to play.

4.2. Outdoor Classroom Area

The outdoor classroom area is equipped with children's playground, interactive lawn, jungle experience viaduct, etc. This area can provide parent-child interaction landscapes. By setting up a jungle experience viaduct and planting fruit trees of different heights in this area, visitors can feel and touch the plants from different orientations and heights, and activate the body's nervous system through touch to create the sense of novelty, excitement and pleasure, thus improving mood and promoting all aspects of the body are fully coordinated to achieve the purpose of improving health [4].

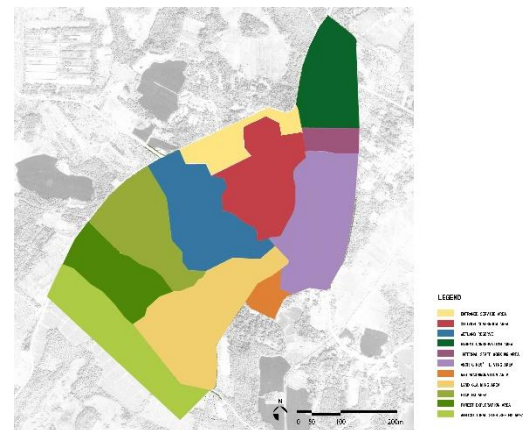


Fig. 2. Function division

Visual senses are the most direct way for people to perceive the environment. In the outdoor classroom area, colorful flowers and boundless farmlands are set up to provide people with a rich visual experience; different colors will cause people to have different levels of excitement, and exert adjustment and health care effects on people [5].

4.3. Wetland Reserve

We look forward to restoring the ecosystem's environment while enhancing people's contact with nature. In this area, people can experience the wetland's functions of water quality purification and biological diversity maintenance. Through planting native wetland species, attracting birds and insects to increasing bio-diversity and stability. By setting up facilities such as corridors, bridges, and stepping stones which visitors can get close to the wetland.

4.4. Forest Conservation Area

Suburban forest conservation area plays a very important role in coordinating and protecting the urban and suburban ecological environment. Due to the high topography of the north of the site and the fact that there are already good forest vegetation resource, this area is planned to be a forest conservation area, where fruit trees and cash crops will be planted, effectively transporting oxygen to the city while also mitigating urban noise, light pollution, etc. It can also well conserve water resources and prevent soil erosion. Suburban ecosystems are vulnerable and sensitive. The design fully protects the suburban ecological environment and provides migration corridors for various organisms, especially animals.

4.5. Internal Staff Working Area

The internal staff working area is a number of office buildings. The people who work there are field managers, operators,

professional horticulturists, representatives of village committees and so on.

4.6. Aborigines' living Area

The design of the aborigines' living area took full account of and retained the original texture of the villages such as its buildings, streets, and public spaces. Traditional villages are a type of heritage existing in life and production [6]. They are the vivid carriers of our country's history and culture. Traditional cultural landscapes in Chinese villages contain plenty of historical memories, clan cultures, idiom dialects, and rural township regulations [7]. The analysis of the village buildings and the reinforcement of the dilapidated buildings will help to preserve the village's texture, improve the infrastructure, increase the green space, and eventually improve the villagers' life quality and the environment.

By planting local medicinal plants, villagers can enjoy high-quality therapeutic landscape resources. When villagers have minor health problems, they can pick up the medicinal plants and other herbs in this area. Planting wild edible plants can provide convenience for the villagers' life. These measures can not only help the villagers to pick up the medicinal plants by themselves and eat vegetables and fruits within this area, but also create a unique suburban landscape.

4.7. B&B Accommodation Area

Next to the aborigines' living area, we set a series of B&B inns, combined with special food streets, suburban folk culture and creation exhibition halls and so on. This

design makes it convenient for tourists to fully experience the local characteristic culture. In addition, it can promote the economic development of the suburbs.

4.8. Land Claiming Area

This area mainly produces vegetables and fruits needed for the lives of urban residents. By land claiming, on the one hand, urban residents can harvest truly green, pollution-free fruits and vegetables. On the other hand, citizens can experience the joy and satisfaction of sowing in spring, growing in summer, and harvesting in autumn, so as to attract people into nature to participate in physical working and mental healing; at the same time, it can also promote economic development in the suburbs.

4.9. Picking Area

The cultivation of wild vegetables, fruits and other pollution-free organic food plants in this area can be enjoyed during the immature period and can be harvested during the ripe period. In the tea fields, visitors can pick up tea by themselves. When visitors walk into the teahouse, they can brew tea according to the recipes. Visitors' nervous system is stimulated by tasting and sniffing the leaves or fruits of different plants, which makes people feel happy and relaxed.

4.10. Forest Exploration Area

This area mainly includes rock climbing, jungle crossing, grass skiing, and outward-bound training. It mobilizes the public's body

and achieves physical and mental healing functions during the event.

4.11. Agricultural sightseeing area

Horticultural working activities are provided in this area. Participants plant their own plants and irrigate, fertilize, and prune by themselves, which are easy to produce a sense of satisfaction and achievement, and promote the restoration of physical functions and stimulate positive emotions.

5. Plants planning

The topography is basically flat and the soil characteristics are homogenous. Thus there is no effect of soil on the land use pattern. The area is surrounded by reservoirs and lakes in all sides which provide water sources for fishponds and for irrigation of the farmlands. The plants planning is mainly divided into the following eleven parts:

1. The dominant landscape tree species: *Cocos nucifera* L.
2. The key landscape tree species: *Cassia bakeriana*, *Bombax malabaricum* DC.
3. Native tree species: *Roystonea regia* (H.B.K) O.F.Cook, *Casuarina equisetifolia* Forst, *Cocos nucifera* L.
4. Ancient and famous trees: *Pterocarpus indicus* Willd. *Madhuca hainanensis* Chun et How, *Homalium hainanense* Gagnep., *Vatica mangachapoi* Blanco, *Aquilaria sinensis* (Lour.) Spreng., *Dalbergia hainanensis* Merr. & Chun, *Hopea hainanensis* Merr. et Chun, *Cephalotaxus hainanensis* Li, *Gmelina chinensis* Benth.
5. Fruit trees: *Drypetes cumingii* (Baill.) Pax et Hoffm., *Citrus maxima* (Burm) Merr.,

- Artocarpus heterophyllus Lam.,
Syzygium samarangense (Bl.) Merr. et
Perry, Mangifera indica L., Dimocarpus
longan Lour., Clausena lansium (Lour.)
Skeels, Litchi chinensis Sonn.
6. “Four Southern Herbal Medicines”:
Areca catechu, Amomum villosum,
Alpinia oxyphylla, Morinda officinalis,
which have been widely used in the south
part of China for a long time.
 7. Flowers: Zinnia elegans Jacq., Cosmos
bipinnata Cav., Ge Sanghua, Helianthus
annuus L., Cosmos sulphureus Cav.,
Gomphrena globosa L.
 8. Edible vegetable: Costus speciosus, Ixeris
denticulata, Gynura crepidioides Benth.,
Portulaca oleracea L., Youngia Japonica,
Brassica napus L., Spinacia oleracea L.,
Lactuca sativa Linn., Brassica oleracea L.
var. capitata L., Brassica oleracea var.
acephala f. tricolor, Atriplex hortensis L.,
Kochia scoparia (L.) Schrad
 9. Medicinal plants: Hemerocallis citrina
Baroni, Alternanthera bettzickiana, Piper
sarmentosum Roxb.

To a certain extent, all gardens have a certain convalescent effect. The difference between the therapeutic garden and general garden is the concern for users' needs and preferences at the beginning of design. How to fully explore the recovery characteristics of garden space and to express them is the key point of therapeutic landscape design. Therefore, rehabilitation garden is an active association with nature and health [5].

6. Activity planning

There are two types of activities design in the site, including static viewing activities

such as sit-in, viewing and slow-walking, and dynamic participation activities mainly including technical activities such as body-building and gardening work. These activities enrich leisure activities for urban residents, meanwhile it can also bring considerable economic benefits to the villagers.

Static viewing activities include: enjoying pastoral scenery, praying under ancient banyan trees, singing in colorful sea of flowers, enjoying the sunshine on green lawns, identifying southern herbal medicines and famous trees, taking outdoor classes, and jungle experience viaduct running; practical participation activities include: participating in gardening and farming, picking fruits and vegetables, picking tea and tasting tea.

7. Conclusion

Xianhe Village has a natural lake Xianhe Lake and the pastoral scenery, and has convenient access to the urban area. The establishment of the suburban therapeutic landscape can develop the ecological tourism industry and make it a new growth driver, and furthermore, change the industrial structure of the suburbs, and provide employment so as to encourage rural youth to return home [8]. In this way, the rate of empty nesters and left-behind children will be decreased, and the health and spiritual needs of urban residents can also be satisfied.

By means of therapeutic landscape, the suburban landscape displays a healthy, harmonious and stable state, transforming the traditional suburban pattern into a new suburban landscape model of “suburban

parks-the therapeutic landscape-providing high life for people”.

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Development of biophilic cities in Russia: From ideal scientific town and Ecopolis to the green strategy of the modern megapolis

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Abstract

In Russia, one of the most important steps in developing a biophilic vision and including nature as an important component of urban planning and design was the development of special ‘academic towns’ (*akademgorodok*) in late 1950s-early 1960s. Biophilic principles were perfectly expressed in the planning, design and management practices of such specially designed ideal towns. This was the first manifestation of Soviet progressive urban planning principles and of attempts to design sustainable green cities for the future. The vision had strong theoretical and philosophical foundations and aimed to create ideal living conditions for Soviet scientists, who would have daily contact with nature and receive emotional and physical inspiration (live in harmony with nature) and thus work productively and make scientific discoveries. A special urban planning department in Moscow and numerous botanical gardens (important scientific research institutions in Russia) dedicated their efforts to designing green areas for such new scientific towns. Green belts surrounding cities and forest patches of various sizes were included in all city zones.

The next step towards the truly biophilic city was the programme Ecopolis in the late 1970s. Its foundation was the principle of constructive ecology, which aims to help humans manage the natural environment as a tool in coherent evolution of nature and society towards the noosphere. One of the main goals of Ecopolis was to create an optimal ecological and socio-psychological urban environment that could also incorporate nature protection functions in urban areas. For the first time in Russia, urban ecology and sustainable design practices were

implemented in a real town, Pouschino (located 120 km from Moscow). Later, Ecopolis ideas emerged in other small, medium and large cities (Kosino, Korolev, Vologda and Uliyanovsk).

After 10 years of sweeping political and economic changes in Russian society in the 1990s, many cities revisited existing planning and design norms. In the past five years, a strong movement aiming to solve ecological crises has arisen in Russian megapolises (Moscow, St. Petersburg, Nizhniy Novgorod, Kazan, Novosibirsk, Vladivostok). Municipalities are revisiting planning and design policies and suggesting new visions for urban green infrastructure within their masterplans. In Russia, biophilia is traditionally associated with existing remnants of forests within city boundaries and protection strategies for these, especially trees. Concrete examples of using ecological design (design with nature) can be found in microdistricts of St. Petersburg and Moscow. Results from the research of academic towns, Ecopolis and examples from megacities are also discussed in this paper.

Keywords biophilic cities in Russia;academic town; akademgorodok;Ecopolis; technopolis

1. Introduction

In this paper, we chart the development within Russia of biophilic cities, defined as cities that allow humans to connect with nature within urban environments on a daily basis [1]

In Russia, a very important step in developing a biophilic vision with nature as an important component of urban planning and design at all scales (from master plan through neighbourhood level to the gardens of multifamily houses) was the creation of special 'academic towns' (akademgorodok) in late 1950s-early 1960s. These were a special type of settlement mode within the ideology of socialism, with one of the postulates being to create a sustainable urban environment based on a harmonic relationship between man and nature [2]

Biophilic principles were perfectly expressed in the planning, design and management practices of Russia's academic towns. They were the manifestation of Soviet progressive urban planning principles

and of attempts to design sustainable green cities for the future. The vision had strong theoretical and philosophical foundations and aimed to create the most comfortable living conditions possible for Soviet scientists, who would have daily contact with nature, gain receive emotional and physical inspiration (live in harmony with nature) and thus work productively and make scientific discoveries [3]. Academic towns were also accepted the microdistrict (mycrorayon), the innovative Soviet urban planning concept, which intended to reflect the ideas of the socialist society where people should be tolerant and unselfish, respect collective bargaining, debate for the collective good and hold socio-cultural values and harmonious 'brotherly' living in high esteem. Microdistrict (microrayon), residential clusters of 30-50 hectares for 12,000-15,000 people, consisted of multifamily 5-7-9-12 storey houses, shops, laundries, cleaning and repair stores, dining-rooms, schools and pre-school facilities [4]. This unified and standardised planning, design and greening strategy included quite extensive green areas as an important tool for improving quality of life and

environmental health. Microdistrict principles were also used in the academic towns, but in more progressive interpretations because of the availability of native forests.

The task of providing a suitable environment for academic excellence demanded new principles of planning structure and use of a functional zoning system. Thus a working zone (where research institutes were located), living zone, public administration zone, a rest and recreation and a provision zone were suggested for academic towns [3]. The academic towns were designed by specialist urban planning units in Moscow (e.g. GIPRONII, All-Union State Institute for Planning Scientific Research of the USSR Academy of Sciences), with the help of numerous botanical gardens. In the Soviet era, botanical gardens were also under the umbrella of the USSR Academy of Science and were considered important scientific research institutions. They were responsible for developing theoretical knowledge, but also for the application of findings within biological science in practice, and were thereby called upon for drawing up planting design and plant material recommendations for the new academic towns.

It was recommended that the academic towns be located within or near pristine nature, but also in close proximity to public transport links to major cities. One of the approaches during the planning stage was preservation of existing patches of natural ecosystems and including them in different town planning zones. Academic towns were planned as “cities of a new type, which are

closer to modern and future urban planning ideals” [5].

Biophilic principles also applied in the planting design. Drawing inspiration from surrounding native plant communities called for use of native species that could also sustain local climate conditions in the most effective way. One of the important principles of green infrastructure in scientific towns was maximum protection of surrounding native ecosystems and organising the network of protected reserves within the city’s boundaries. The list of plants for newly designed living neighbourhood also included decorative exotic species, which were intended to add a touch of interesting colour and texture, and thus reinforce the aesthetic appearance of novel urban vegetation.

2. Case study: Novosibirsk Academgorodok

One of the best examples of academic towns was Novosibirsk Academgorodok, located 30 km south of Novosibirsk city centre. The aim was to build an educational and scientific centre for Siberia. The site of the future town was on the shore of the Ob Sea (an artificially created reservoir on the river Ob), surrounded by birch and pine forests (Figure 1).

Fig. 1. Aerial view of Novosibirsk Academgorodok.

The town was founded in 1957, under the close patronage of the Academy of Sciences

of the USSR. In the 1970-1980s, the most prosperous years, Novosibirsk Akademgorodok was home to 65,000 scientists and their families. At that time the town had a good reputation and was a privileged residential area. Most of the population lived in nine-storey and four-storey multi-apartment buildings. Novosibirsk State University, 35 research institutes and a medical academy were located there, which created a good reputation and recognition of Novosibirsk Akademgorodok as a truly 'academic' town.

In the general plan for the town, every aspect of planning was subordinate to clear functional zoning. The zones were established in a very logical, scientifically proven sequence, with a zone of research institutes, a provision zone, residential areas and a green protective zone, beyond which was a reservoir and finally a recreation area. Zoning preserved as much of the existing forest and open natural ecosystems as possible. The forest on the shore of the reservoir was saved as an important windbreak from the prevailing south-westerly winds and as a protection buffer from traffic noise on the transit highways passing the outskirts of the town [6].

The zone of research institutes was located in the north-eastern part of the town, where the institutes were clustered according to their scientific interests and themes. This zone was built in an open spot where there was no existing forest, located on the leeward side of the residential area. The institutes' buildings were positioned taking into account their transport connection with the provision zone. The

provision zone was separated from the residential area by a protective forest belt. The residential zone was bordered by a large forest area. The concept of using a 'green ring' of protected forests and including green wedges in residential developments was very innovative and aimed to maximise everyday contact with nature. Green areas in the residential zone consisted of public parks and inner courtyard gardens. In each neighbourhood, optimal orientation and aspect of buildings was again ensured. One of the main planning themes of the entire town was preservation of natural forests and their use for recreational activities. The amount of green area allocated per person was very high, 26 m² of common green area and 200 m² of other types of greenery per person (Figure 2).

Fig. 2. Green areas in one of the microdistrict in Novosibirsk Akademgorodok.

The recreation zone was placed along the shoreline of the reservoir (Ob Sea), where, as a result of shore protection works, a 2.5 km long beach was created. Part of the zone was located within the town's administrative border, but the remainder continued further along the banks of the reservoir.

The Central Siberian Botanical Garden helped with designing the green areas. A specially created Forest Protection Station was made responsible for monitoring forest conditions, conserving, restoring and reconstructing forest ecosystems and helping with the greening of residential areas.

The architectural and planning structure of Novosibirsk Academgorodok can be seen as a very successful case of using existing natural conditions (topography, vegetation and hydrology) and including nature as a crucial structural element of urban spatial organisation. Another important outcome was the creation of a unified transport and pedestrian system, which provided convenient connections both between the city zones and within each zone, ensuring maximum safety for pedestrians, and excluded all types of transit through the territory of Novosibirsk Academgorodok. One of the positive features was organisation of cultural and consumer support services and creation of the novel architectural and aesthetic image of the city.

Taking into consideration its unique character as of one of the first academic towns and its special planning, architectural structure and urban development characteristics, in 2014 Novosibirsk Academgorodok was declared an object of cultural heritage (monument of history and culture) of the Russian Federation (cultural heritage of regional significance).

3. Case study: the Ecopolis programme and the academic town of Pushchino

The next step towards the truly biophilic Russian city was implementation of the Ecopolis programme in the late 1970s. Academics and scientists from Moscow State University were initiators of this project, the scientific foundation for which was the principle of constructive ecology, “which aims to help humans manage the natural environment as a tool in coherent

evolution of nature and society” [7]. One of the main goals of Ecopolis was to create an optimal ecological and socio-psychological urban environment based on native landscapes and man-made plant communities. For the first time in Russia, urban ecology and sustainable design practices were combined within a major interdisciplinary project and implemented in the real town of Pushchino.

Pushchino (population 20,000) is located 120 km south of Moscow, on the bank of the river Oka. It was founded in 1963 as the Scientific Centre of Biological Research of the USSR Academy of Sciences. It brought together the following research institutes and centres: Institute of Protein, Institute of Biological Physics, Institute of Biochemistry & Microbiology, Institute of Photosynthesis, Institute of Agrochemistry & Soil Sciences, Scientific Computer Center, Constructor Bureau of Biological Apparatus and Radioastronomy Station. These were tasked with making breakthroughs in biological science in Russia.

The urban design concept applied for Pushchino was very innovative and had strong scientific foundations. The town was created as three parallel zones: an institute zone (working space) and a residential zone (living space), separated by a green zone (broad pedestrian boulevard). An additional (functional) zone was located at the periphery of the town. The green zone became the compositional axis of the town. The boulevard consisted of five groves (birch, pine, oak, larch and lime), which gave special ecological and aesthetic meaning to the whole town. Pushchino is

surrounded by native forests and meadows, while on the opposite bank of the Oka river there is a huge green ‘sea’ of Prioksko-Terrassny Biosphere Reserve (5000 hectares) (Figure 3).

Figure 3. Location of Pushchino and the view from the town to the Prioksko-Terrassny Biosphere Reserve.

Patches of native plant communities with high biodiversity value (e.g. unique native meadows, Figure 4) were included with the city boundaries and acted as the ‘skeleton’ of the urban green infrastructure system.

Fig. 4. Natural floodplain landscape at Pushchino (the Ostrov protected reserve).

Most indigenous vegetation patches were included in the network of urban nature reserves. The town is also very rich in cultural heritage landscapes. Just on its outskirts is the Teschilov Gorodische archaeological monument from the 12-14th century and a mansion house with the landscape park of the 18th -19th century. Nature is so close to residential areas in Pushchino that people can collect wild strawberries and forest mushrooms just 5 minutes’ walk from their homes.

The Ecopolis programme ran for 18 years (1978-1996) and since then there have been broad investigations of different aspects of its urban ecosystems [8]. The local community was actively involved in the programme. People participated in conferences, surveys, excursions, lectures, discussions on Pushchino themes, film showings and simulation games. With local government support and the participation of local citizens, there were numerous implementations of ideas in practice, for

example the special decision on nature conservation, the establishment of new nature reserves, improvement measures for the town’s waste treatment system and introduction of ecological programmes in secondary and upper-secondary schools (Figure 5).

Fig. 5. Teaching session on botany in one of the nature reserves in Pushchino, 1991.

Later, Ecopolis ideas emerged in other small, medium and large cities in Russia, such as Kosino, Korolev, Vologda and Uliyanovsk.

4. Towards naukograd (technopolis)

The altered economic and political situation after 1991 resulted in re-evaluation of the approach to academic towns. In 1991, the new term ‘science city’ (*naukograd*) was introduced for the town of Zhukovski in the Moscow region, signifying the formation of a new Union for the Development of Science Towns. Since that time, science cities have emerged as targeted scientific and industrial complexes created specifically for the development of new science-intensive technologies. Such cities have to be based exclusively on close relations and interactions with universities and scientific and technical centres and with large industrial companies. Like the Soviet academic towns, the science city is designed as a special compact settlement with developed infrastructure that aims to provide productive and comfortable living and working conditions for researchers and

associated industrial staff. However, compared with the more idealistic academic emphasis of academic towns, the new technopolis is strictly pragmatic and orientated primarily towards housing scientifically progressive institutes and universities that produce new technologies and can contribute to economic growth.

Science cities are divided into seven research specialisations (aviation, rocket science and space research; electronics and radio engineering; mechanical engineering and instrumentation; chemistry, chemical

physics and the creation of new materials; nuclear complex; power engineering; and biology and biotechnology). The size of science cities is not restricted and can vary. Pushchino town received the status of *naukograd* (among 13 officially recognised science cities) in 2005. The idea of the technopolis was taken from the West (USA and Western Europe). Nowadays the technopolis is a very attractive concept for many countries and is also reflected in current globalisation trends.

4.1. Case study: The town of Tsiolkovsky

- One of the latest examples of using planning and design ideas for academic towns can be seen in the town of Tsiolkovsky (population 5000), a new settlement built next to the Vostochny space centre in Amur Oblast on the Bolshaya Pyora River, 110 km from the border with China. The most essential legacy of the classical Soviet academic towns, i.e. the interconnection with surrounding natural landscapes and the use of natural existing landscapes as part of the planning structure, is clearly visible in one of the proposed design of residential neighbourhoods in Tsiolkovsky (Figure 6).

- Figure 6. Proposed design for the town of Tsiolkovsky.

- This ‘city of the future’ uses modern technology and new innovative architectural and building construction techniques, together with more modern architectural forms and material. However, the main

ideology of *academgorodok* is still evident, as Tsiolkovsky is intended to be a special place for living and creative work by people united by one ideal, performing research that derives inspiration from biophilic landscapes. The future for Tsiolkovsky town is as an innovative *naukograd*.

5. Understanding biophilia in modern Russian megapolis

After 10 years of sweeping political and economic changes in Russian society in the 1990s, many cities revisited existing planning and design norms. In the past five years, a strong movement aiming to solve ecological crises has arisen in Russian megapolises (Moscow, St. Petersburg, Nizhny Novgorod, Kazan, Novosibirsk, Vladivostok). Municipalities are reviewing planning and design policies and suggesting new visions for urban green infrastructure within their masterplans. In Russia, biophilia is traditionally associated with existing remnants of forests within city boundaries

and protection strategies for these, especially trees. For example, 15 specially protected natural areas occupying a total area of 6142.5 hectares have been established in St. Petersburg. In the past decade, examples of using ecological design (design with nature) at the fine level scale have emerged in the microdistricts of St. Petersburg and Moscow [9]. For example, green roofs and principles of integrated stormwater management (low impact design) have been implemented in the St. Petersburg suburb of Devyatkinno [10]. One of the crucial concepts of modern masterplan strategies in megapolises is the green belt (involving urban forests) and green corridor and integration of all green and water-based elements into one united green-blue infrastructure system.

6. Conclusion

Recent decades have seen a tendency for re evaluation of the positive Soviet urban planning and landscape architecture legacy. Innovative practices of Soviet planning included the creation of microdistricts (*microrayon*), a unified planning, design and greening strategy using extensive green areas to improve quality of life and environmental health, and academic towns (*akademgorodok*), where nature was seen as an important planning and design

element and a major socio-ecological tool in creating a harmonious relationship with nature. This biophilic approach, in combination with the concept of creating compact pedestrian and public transport-friendly settlements within a safe environment, can be seen as a progressive achievement of the Soviet planning system. Some of the academic towns from this era, for example Novosibirsk Academgorodok, have even been recognised as cultural heritage, mostly because of the unique zoning structure, abundant vegetation and proximity to natural forests giving an identity of whole city (“the town-forest”). The character and features of the academic cities were very much in line with the Soviet aim of creating a new generation of settlements that would fulfil the task of creating a good living environment.

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- After years of turbulence and neglect of the past Soviet heritage in the 1990s, there is now a growing interest among urban planners and landscape architects in the academic town legacy. The new movement of the scientific city (*naukograd*) can be seen as today’s answer to market demand for advanced innovative technologies as an essential condition for societal progress. The scientific city model uses some ideas of academic towns, but the Ecopolis of co-evolution of man with nature has been subsumed within a more pragmatic model of technological development that is typical of a market economy.

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Appendix



Fig. 1. Aerial view of Novosibirsk Academgorodok.



Fig. 2. Green areas in one of the microdistrict in Novosibirsk Academgorodok.



Figure 3. Location of Pushchino and the view from the town to the Prioksko-Terrassny Biosphere Reserve.



Fig. 4. Natural floodplain landscape at Pushchino (the Ostrov protected reserve).



Fig. 5. Teaching session on botany in one of the nature reserves in Pushchino, 1991.



Figure 6. Proposed design for the town of Tsiolkovsky.

Garden therapy in African slums

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Abstract

Horticultural therapy is a method of therapy in which garden work supports the healing process. It has been used more or less mindfully for many years. Thanks to the involvement of patients in the design process, performance and care of the selected space, their health and well-being are becoming improved. This conclusion is confirmed by the numerous results of research carried out with patients suffering, among others for autism, depression and senile dementia. This method of therapy is also used in resocializing prisoners and treating addictions. Patients participating in design process and gardening work are in constant contact with nature and become members of the community that creates the garden. Thanks to their involvement in the project process and its implementation, they are more likely to identify with and care for a given place. In January 2015, there was launched authorial project entitled: *Global Garden Project*. It is a scientific, artistic and educational project in the field of landscape architecture, horticultural therapy, urban gardening and social communication. The project includes, among others, workshops on designing process and setting up school gardens in places where people exposed to social exclusion are present. The students undergo a kind of garden therapy during this activities. They forget about the problems of everyday life and learn how to produce food on their own. The first garden of this type was created at the MCEDO School in the Mathare Slum in Nairobi, Kenya in January 2015. The main goal of the project was to jointly design and implement school gardens, in which students themselves grow edible and decorative plants. School gardens have many functions, among others: aesthetic, utilitarian and educational. Gardens can integrate local community, but also be a place where lessons in the open air and horticultural therapy take place. Students become very involved in the project, because there are no gardens in the immediate vicinity and many of them have not seen a similar place so far. While working in the school garden, they acquire an extremely important ability to work in a group, learn sensitivity to the surrounding space and produce food themselves, which is a basic good in the neighborhoods of poverty.

Keywords: urban gardening, sack gardening, slums, school garden, occupational therapy, outdoor activities, Kenya, Mathare Slum

1. Introduction and research method

The rapid increase in the population of African cities causes an increased demand for fresh food for the residents. The development of urban agriculture in the 21st

century has become a good solution to this global problem [1]. School gardens have many functions, among others: aesthetic, utilitarian and educational. They can integrate the local community, be a place where outdoor lessons take place and in which food is produced. In January 2015,

there was launched authorial project entitled: Global Garden Project. It is a scientific, artistic and educational project in the field of landscape architecture, horticultural therapy, urban gardening and social communication. The first garden of this type was created at the MCEDO School in the Mathare Slum in Nairobi, Kenya. Main goals of the project were: implementation of an educational garden with a didactic function, mobilization of school pupils and popularization of the idea of urban gardening. The aim of the work is to present the results of this pilot project in the context of garden therapy in African slums. The initial stage of the work was the analysis of the literature of the subject of research and the library query. The next step was establishing contacts with NGOs operating in Kenya to find an appropriate teaching facility for pilot studies. The area of the study was inventoried and a master plan of the school garden was created. The next stage of the project was social research carried out among the participants of the project - a survey on the knowledge of basic issues related to gardening. Then, workshops on the design of green areas and workshops for setting up and nurturing gardens for school pupils were carried out. After these introductory activities, participants started to prepare garden. Plant material, fertile soil and drainage were obtained, the area was cleared of rubbish and debris from building materials, and basic earthworks were carried out - leveling the ground and bringing soil. The garden was established by school students.

2. Garden therapy in african slums

Slums are fragments of big cities inhabited by poor people, mostly immigrants or newcomers from rural areas. They constitute a big problem of the modern world, but at the same time they are also a global phenomenon [2]. For many years, attempts have been made to solve the problems that they generate [3], but these are not easy tasks. The external debt burden, high levels of inequality, unplanned and unmanaged urban growth, and the exclusionary nature of the regulatory framework governing the provision of planned residential land contribute to the prevalence of slums in African countries [4]. Considering that many of the slum dwellers had previously dealt with agriculture - applying the idea of urban gardening in the slums seems to be right. The problem of soil contamination was solved by using sack gardening. Thanks to it, we protect edible plants against soil contamination and we increase the production area. Sack gardening is popular in many African countries, among others in Kenya [5]. Work in the garden, in addition to traditional benefits in the form of food production is also valuable in terms of contact with nature. It is a kind of outdoor occupational therapy. Working in the garden helps you forget about the problems of everyday life. In the spatial structure of the slums, there are very few places covered with vegetation. Green oases are found mainly in areas that are not suitable for development. In the African slums, activities aimed at educating local communities have been undertaken for many years. Occupationally and artistically oriented activities are popular. However, it is also important to show how man can produce food yourself, with a small financial outlay and in a small space.

3. A case study of Mathare Slum (Nairobi, Kenya)

3.1. Mathare Slum

Mathare Slum was developed around nine separate villages strung out along three miles of the Mathare and Gitathuru rivers. It is one of the largest areas of uncontrolled housing in Nairobi. This space has been extensively examined and for many years various research [6], planning [7] educational and artistic activities have been carried out here. There are also practical activities that activate the local community and organize the space. Some of them also concern urban agriculture and horticulture. They take place in the slums itself or outside its borders. In 1979, the Undugu Society of Kenya launched the Katanga Agricultural Project. The aim of this project was to reintegrate boys from slum in the rural society by educating them not only in academic subjects but also through education in agriculture, animal husbandry, crop cultivation and so on [8]. The Mcedo School located in the central part of Mathare Slum was chosen for the project. The area, which was designated for the garden, covers an area of around 60 m² and adjoins the school directly (fig. 1).



Fig. 1. A part of Mathare Slum in Nairobi, Kenya - a view on the Mcedo School, 2015

3.2. Social research and garden workshops

As part of the project, a survey was conducted among school students. It was prepared on a 7-meter print and was part of the presentation. Children together answered the questions (fig. 3). The person conducting the workshop moderated the discussion. 32 respondents were asked 10 questions. The first question was: What is a garden in your opinion? The following phrases dominated the answers: a fragment of the landscape in which we plant flowers; a fragment of the land that makes the environment more beautiful and prevents erosion; a place where we can find flowers and plants. Then, three exemplary photographs were presented to the respondents (fig. 2) and asked if there is a garden presented on each of them. Respondents' opinions were divided. 53% of children confirmed the answer, 47% denied that each of the pictures presents a garden. Then the children were asked to choose which of the pictures they liked the most. The answer to this question was unambiguous. As many as 94% said they liked the picture No. 2 the best. 6% indicated photo number 1. None of the respondents chose picture No. 3, presenting a rustic backyard, decorated show garden in front of one of the houses in the Polish open-air museum.



Fig. 2. Attachment to the questionnaire: 3 sample gardens - urban minimalist, historical and rustic

To the question: Must every garden comprise flowers? 84% of respondents gave positive answers. Only 5 people gave the opposite answer. All persons participating in the research stated that they would like to have their own garden. Another question was: What are the components of every garden? The most frequent answers include: flowers, vegetables, fruits, soil, trees, fresh air, water, humus, light, plants, shovel, gardener. Then the children were asked: What objects can be used to plant? Among the most popular answers were such items as a flower pot, paper bag, tin, bowl, sack, bucket or mug. To the question: Have you ever plant any plant? Everyone agreed that yes and up to 91% of pupils said it was difficult. The children were then asked: Where can you get soil for planting? Most of the children immediately pointed to the area adjacent to the school. When asked to extend the answer, they also mentioned: the area around the river, the water reservoir, the shore, the common (public) space, the field. At the end, the students were asked: Would you like to have classes in a garden? 94% of them gave a positive answer to this question.



Fig. 3. Children during the joint replenishment of the survey

Another element of classes at the school were workshops on the design of green areas. The task was to design a garden from prepared templates. The students attached elements of the garden equipment to the sheets on which the projection of the residential building was printed. During the workshops, they were informed about the basic principles of designing green areas. After getting acquainted with the theory, practical workshops on arranging green areas were started and the gardening process was started. The aim of the project was to show that with a little willingness and using local materials they can also make their own small home garden. They were also given the idea that useful plants can also perform decorative functions, and explained what functions decorative plants perform, which for the workshop participants have so far been exclusively shade plants.

3.3. The school garden

Work on the garden began with the inventory. The area is located in the direct vicinity of the school. On the western and southern side, it is fenced with a high wall covered with corrugated sheet, in which there are windows. The garden from the rest of the school grounds is separated by two large water reservoirs, located on the eastern side. At the time of the inventory, this separate space was the place where construction materials were stored and garbage collected. The soil present in this area was quite fertile, but it contained a lot of residues of building materials and rubbish. A big problem was the numerous boulders and stones that prevented the proper growth of vegetation. There were no woody plants in the study area. The area was overgrown by monocotyledonous plants communities with a small admixture of dicotyledons. The future garden is quite sunny for most of the day. An exception is a fragment adjoining the wall, which practically does not reach the sun's rays. A small shadow in this area appears in the morning due to the trees growing directly behind the fence. At the time of the

inventory, the entrance to the future garden was located south of the water reservoirs. It was a small, several-dozen-centimeter gap between the water tank and the wall of the school.



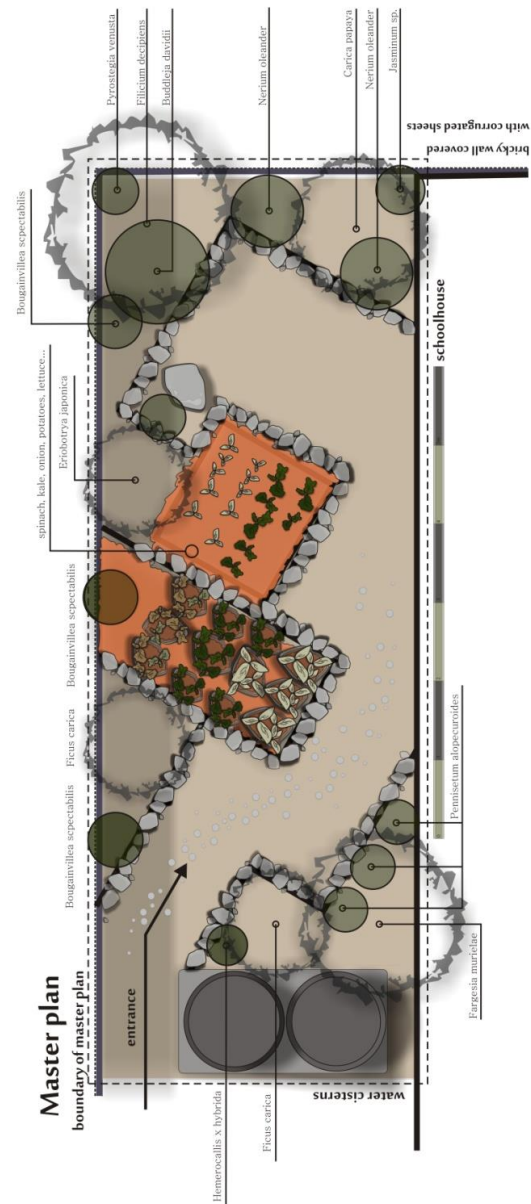
Fig. 4. Students during the garden planting workshop

According to the information obtained from the director and students, before the school was renovated, there was also a vegetable garden next to it and farm animals were raised here. However, it was completely destroyed, mainly due to the lack of fencing and improper care and lack of commitment of a gardener who was employed to take care of this place. The basic design assumption was to create a place where you can grow edible plants - vegetables and fruits.

In addition, the garden was to be a place where classes in "nature" could be carried out in the open air. It has to fulfill didactic, utilitarian and aesthetic functions. In the project were deliberately used not too expensive, local materials. Plants adapted to local habitat conditions were selected. The composition of the garden is simple and based on a grid of squares. In the central part of the garden there are two vegetable gardens (cultivation in the ground and in sacks). They were surrounded by other beds with edible and decorative plants. The composition of the garden has been underlined with local rock material and construction waste. In the garden there is also a gravel path leading to a boulder, which acts as a garden bench and a place of contemplation. The design uses decorative plants such as - thika palm, butterfly-bush, daylily, bamboo and fountain grass. In addition, on the wall surrounding the garden, the creepers were planted: bougainvillea, golden shower and jasmine. Along the border of the study, plants with edible fruits were planted: loquat, papaya and common figs. Also, vegetables such as kale, lettuce, onions, potatoes and spinach were sown and planted.

4. Discussion

A pilot study conducted at the MCEDO school in Nairobi shows how important role gardening can play in the education system. The new garden has become a place of integration and an additional class room in the open air. Students acquire an extremely important ability to work in a group, learn sensitivity to the surrounding space and produce food themselves, which is a basic



good in the slum. After the completion of the project, the garden began to live its own life. The workshop participants started to make planning decisions themselves. For example one of the decisions was to use vegetable seedlings as ground-cover plants. The free spaces were filled with vegetable cuttings. There were new seeds sown and

harvested first crops. The key in this case was not only the composition, species selection, small architecture and surface. The most important in this type of projects is to infect the passion of creating and preparing a space that is friendly to its users. The students undergo garden therapy during this activities. They forget about the problems of everyday life and learn how to produce food on their own. The students of the school were very involved in the project. For most of them, the topic turned out to be interesting. Most of them treat the garden as a place of production of edible plants. The most interesting moments of the workshop were planting activities. Everyone wanted to plant them as much as possible, believing that after planting they would become his or her property. There are no gardens in the immediate vicinity and many of the children have not seen a similar place so far. Research continues in other countries.

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Landscape: an approach to urbanism

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Abstract

We are an increasingly urban species. The United Nations (2014) predicts that by 2050, over 66 per cent of the world's population will be living in urban areas. Cities and towns, as human habitat, need to be addressing our needs in ways that are satisfying and sustainable. Urbanization was once viewed in terms of domination of nature, where the terms “urban” and “landscape” were in opposition. The reality is quite different. The city is complex - it contains both built form and natural form, and our changing values, combined with our increasing understanding of our world and our impact on it, now call for a more integrated approach in which development of land is coupled with environmental responsiveness.

Ideally, urbanism should be one of best expressions of good environmentalism, but in practice, cities are often hostile places for nature and for ourselves. The perils of the 21st century city now include the uncertainties of climate change, loss of species diversity, concerns about sustainability, threats to human health, and loss of sense of place. New tools, techniques and ways of understanding nature are required. Landscape, once thought of as a place of relief from the urban condition, should be viewed as integral with city form and process, and with important roles to play in sustaining life and giving cities greater resilience to withstand the unpredictability and extremes of climate that are now more common, in addition to providing places for recreation and entertainment or for aesthetic enjoyment.

A new and important landscape scale and approach could distinguish our current era, but we will require a revolution in environmental design at the impact and importance of the late nineteenth urban parks movement, which radically reconceptualized the relationship between nature and society. The intersection of the need for a landscape approach with interdisciplinary approaches may provide the framework for a new way of conceptualizing, and designing, urban landscape systems to address contemporary issues and to express societal values. The theories, tools and techniques from landscape ecology and urban ecology, with ideas of ecosystem services, could be combined for a new view of green infrastructure, where landscape and the public realm potentially intersect. This implies the need for changes in the education of future professionals as well as adaptation of our current methods, processes, and regulations.

Keywords: Landscape; urbanism; public realm; resilience; climate change

1. Introduction

We are an increasingly urban species. The United Nations (2014) predicts that by 2050, over 66 percent of the world's population will be living in urban areas [1]. Cities and towns, as human habitat, will need to be addressing more of our needs in ways that are satisfying and sustainable.

Ideally, urbanism should be one of the best expressions of good environmentalism, but in practice, cities are often hostile places for nature and for ourselves. The perils of the 21st century now include the uncertainties of climate change, loss of species diversity, concerns about sustainability, threats to human health, and loss of sense of place. The need is urgent: "this thin mosaic, the tissue of the planet, is in upheaval" [2].

New tools, techniques, and ways of understanding nature in the city are required. Parks and open spaces, once thought of as places of relief from the urban condition, should be viewed as integral with city form, having important roles to play in sustaining life, in addition to providing places for recreation and aesthetic enjoyment; these spaces are part of our very survival.

A *landscape approach* to planning and design is necessary and will require a revolution in thinking at the scale and importance of the late 19th century urban parks movement. Led by Fredrick Law Olmsted and other visionaries, it recognized the importance of urban parks to the health and welfare of city residents, radically

reconceptualizing the relationship between nature and society. The practices of urban planning and landscape architecture were set on a strong path, epitomized best by New York City's Central Park. With the new threats of the 21st century, another revolution in thinking is necessary.

2. Historic overview – landscape and public realm as reflection of values

How did we get here? The evolution of the city reflects the evolution of ideas and ideologies, and of changing theories and practices of urban design, landscape architecture, and planning. The values cultures place on the built and natural landscape are reflected in changing patterns of land ownership, land development, and environmental values, and consequently in the spatial, social, and ecological qualities of the public realm [3].

The first phase of urban development in many western cities, lasted up to approximately World War II and was marked by radical transformation of the landscape and by incremental urban change. New development usually extended and grafted onto the existing grid framework, and the street was considered a public space.

In Calgary, 1912 the Mawson Plan [4], influenced by William Pearce, an early Calgary visionary, viewed natural features as prime determinants of urban development, and Calgary was envisioned as a city of trees, with land along the rivers set aside for public use, all connected like links in a chain. Although representative of the urban and environmental design thinking of that time,

very little of this plan was to be put into place. For many decades, riverside land in the downtown was perceived to have low value, and Calgary's river banks were the site of lumber yards and industrial uses that would remain until the 1960s. Tree planting occurred through the efforts of a few influential leaders, in the face of a shortage of water, desiccating Chinook winds in the winter, alkaline soils, insufficient funding, the absence of a comprehensive plan, and conflicts with utility companies.

Early public spaces included railway gardens (a distinct North American form located adjacent to the railway stations whose primary functions were promotion of the towns and advertisement of prairie fertility), as well as central memorial parks, public spaces associated with public buildings, and recreation parks. As the city expanded, Council required dedication of a minimum of five percent of proposed subdivisions for parks purposes, guaranteeing that all citizens would have access to open spaces, recreation areas, and playgrounds.

The second phase coincided with the period of economic growth following World War II, and corresponded with modernism, corporate development, and the institutionalization of town planning. History, tradition, and local identity were thought to be anti-progress and old-fashioned, and land uses such as parking were considered more important than the public realm. As a result, huge swaths of urban fabric were torn down and replaced with surface parking, eliminating many public spaces.

In Calgary, there was an emphasis on the provision of parks and open spaces for the booming post-war population, focusing on residential neighbourhood planning. The neighbourhood was the planning unit for suburban development, with school and park as the social and functional centre as the baby boom population reached its teen years. This ushered in a shift from beautification, decorative parks, and playgrounds to family and athletic parks. As an unintended consequence, partly due to the growing requirement for standardized design and construction details, parks began to exhibit a more uniform design vocabulary. The diverse "natural" environment, which featured a range of environmental and microclimatic contexts, became more and more removed from what was built, leaving little indication of the original landscape.

At the same time, new ideas influenced society's notions of nature, notably Aldo Leopold's thoughts about environmental and land ethics [5], and Rachel Carson's critique of pesticides [6], which helped to launch the environmental movement and pave the way for broad acceptance of ecology as a way of thinking.

The third phase, from the late 1970s through to the last decade or so, continued to include standard details and replicated park types, but it also included completion of several significant projects, such as Nose Hill Park and Fish Creek Park, two large environmental areas, which came about through the efforts of an increasingly engaged and ecologically minded citizenry.

The land along the rivers was also finally dedicated as publicly accessible open space in 1991 via the Urban Parks Master Plan and now includes more than 800 kilometres of pathways connecting the rivers and other water bodies, and another 300 kilometres of bikeways and cycle tracks.

We have now entered into a **fourth phase** of urban development. Ideas about sustainability and sense of place, together with a concern for the public realm, are part of the value systems of society and the environmental design professions and should be informing the public realm that we create.

There are currently two parts of the city that have somewhat different processes of park development: new suburbs, that are required to have ten percent of developable areas set aside for public amenities, including parks, and the process of re-urbanization in the developed areas. In an effort to counter suburban sprawl, redevelopment and intensification are encouraged in inner city areas. These new urban residents require open space and also have a greater expectation of urbanity in their surroundings, and ambitious public realm improvement programs are more common.

However, with increased urbanization comes associated environmental issues related to pollution, creation of heat islands, and the amount of pervious/impervious surfaces, and maintaining a healthy urban forest, achieving minimum recommended canopy coverage, and creating sustainable parks are challenges in the presence of fiscal constraints. Urban landscape projects are frequently conceived

of as individual, stand-alone sites by those responsible for planning the city.

Climate change continues to emerge as a pressing issue and will have unknown impacts on our cities. Drought, flood, air quality, and water quality are now profoundly influenced by human actions; many of the ecological changes are “human-caused, rapid, and drastic” [7]. These climate events, which are likely to become more extreme and also more common, affect our parks and open space.

Resilience, a concept that has become more important as extreme climate events have been more common, can be considered defined as the capability of an organism (or a city) to adapt to change. The capacity for a city to cope with extreme climate events or other changes—its resilience—is affected in part by how well its parks and open spaces can absorb the impacts of change. The tendency to standardize details, species, and designs has likely been a negative process that should be addressed by embracing diversity. Parks and open spaces that function as systems rather than as discrete spaces—where they have a diversity of species, form and function—are more likely to be able to maintain ecosystem health and to offer a greater capacity for resilience [8].

Considerable research has shown how parks and open spaces are vital elements in improving the urban environment and mitigating climate change. As temperatures increase in Canadian cities, proper plant material selection becomes vital, since vegetation is important in regulating air temperature. The urban heat island effect, the phenomenon of higher temperatures in urban

areas due to the absorption of solar radiation by buildings and paved surfaces, is accentuated as more area is devoted to paved surfaces than to vegetated areas and water bodies.

In Calgary, what is often forgotten when flood events occur is that we are in fact living in a dry prairie landscape where water is the limiting factor to plant growth, and this calls for careful decisions in the selection of plant material.

3. A landscape approach to environmental design

Parks and open spaces are part of a more structurally complex environment and need to be thought of as more than just “green space”, a term that suggests a benign area with mown grass and ornamental plantings, irrigation-heavy practices that are significantly in conflict with the local and regional environmental constraints [9].

Have our approaches to landscape architecture and our methods and techniques kept pace with our values of sustainability, resilience, and ecological integrity? Are they sufficient to address the challenges of the 21st century, such as the uncertainties of climate change?

Our landscapes today will certainly not be those of tomorrow, and some forward thinking is necessary, and a bold framework for landscape architecture.

We have many building blocks for this approach:

- Ian McHarg [10] demonstrated that physical planning and design should be based on a thorough understanding of the ecology of the area, together with human values. McHarg once proposed that environmentally sensitive areas either remain in their natural condition, or be returned to that condition. He claimed that this single technique could address water quality, quantity, flood and drought control, and lead to “an immeasurable improvement in the aspect of nature in the city, in addition to the specific benefits of a planned watershed. No other device has such an ameliorative power” [11]. Hugely influential in environmental planning, McHarg’s ideas were, however, often considered to be anti-urban.
- Landscape ecology as a field considers regions in terms of a land mosaic, where landscape is understood as a network of patches and corridors. This approach provides a useful vocabulary, and could help to get away from thinking of individual parks as objects or discrete spaces, but is usually confined to the understanding of natural systems.
- The language introduced by Kevin Lynch [12] for understanding city form—as a system of paths, nodes, edges, districts, and landmarks—helps in understanding the public realm as a system as opposed to individual streets, parks, and other spaces.
- Michael Hough [13], in his detailed understanding of cities and the natural processes within them, proposed ideas of urban ecology as the basis for shaping cities, and also emphasized that in addition to increasing the amount of vegetated areas in the city, good design

practices need to be included. Sheltered, well-defined, and well-treed spaces are much cooler in hot weather, and also greatly increase comfort in winter. These ideally should be in the form of a “fine mesh of small spaces, distributed evenly over the whole city” rather than relying only on a few large ones. Anne Whiston Spirn [14], whose early writing coincided with Hough’s, similarly addressed the need for integration of urban living and natural processes.

- By combining the language of landscape ecology and urban design, the city can be thought of as an integrated system of urban and landscape, where parks and neighbourhoods are connected by corridors—like streets, linear greenways and rivers—within larger districts. It is within this combined system of urban and natural that habitats and species (including humans) can live healthily. Merging these vocabularies and theories also allows something typically thought of as purely “urban”, such as streets, to be considered as a part of the urban ecological framework, and something thought of as purely “natural”, such as the urban forest, to be considered as part of the city.
- The shifting bio-climatic regime that has been recently documented in the Climate Atlas of Canada [15] provides a sobering glimpse of the world that is coming, and suggests that our design approach, as well as the vocabulary of parks, domestic landscapes, and the public realm, should be radically re-thought, in anticipation of these changes.

The combination of our current values with the needs of today call for a renewed approach to environmental design and different ways of conceptualizing urban planning and design. It is likely that a new convergence of interests in a high-quality public realm, in public health and sustainability, and in the unknown future that comes with climate change, will help to further the agendas of good environmentalism and good urbanism. We are in a transitional state, becoming a different kind of city in many ways, with our tools and techniques needing evolution to evolve as well.

By examining the layers of the built environment, we can understand the important role that the landscape and public realm play [16]. Too often we have placed more value on the less permanent layers, such as buildings and decoration, rather than on the more permanent layers of landscape, parks, and public space.

Landscape and the public realm constitute the deepest layers of urban infrastructure, and are essential and fundamental, with even more importance if the need for resilience is considered. Viewed as part of the permanent infrastructure of the city, they cannot be viewed as afterthoughts, or as frills. They need to be understood as foundational for the city, and therefore deserving of higher profile, and increased emphasis in budgets.

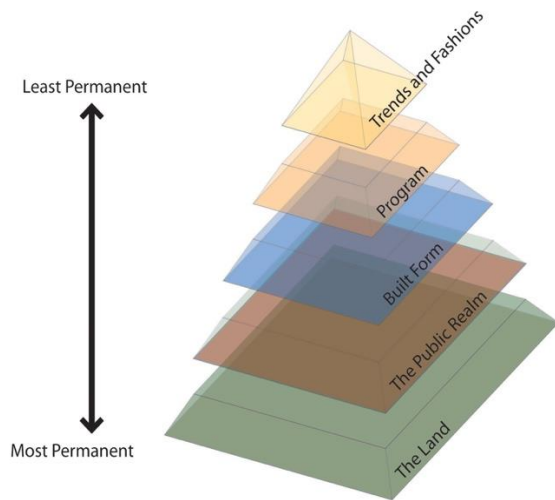


Fig. 1 Pyramid of permanence (Sandalack and Nicolai 2006)

Layer 1 – the land

Landscape is the most permanent aspect of the built environment, with the greatest potential to contribute to ecological health and sense of place. Attention to topography, natural features, views, and connections is required as foundational knowledge. Good urbanism is good environmentalism.

Layer 2 – the public realm

The public realm—the shared city spaces made up of streets, squares, parks, and plazas—is part of the city’s connective tissue, providing space for circulation and gathering and helping to define the city image. Once established, block patterns, land uses, and creation of public spaces are difficult and costly to redevelop.

Layer 3 – buildings

Buildings are the most visible part of the urban environment, but not the most

permanent – several generations of buildings will come and go within the life cycle of the urban structure, but they shape the edges of public space. The outsides of buildings form the inside wall of the public realm; all buildings have a responsibility to help positively shape public space.

Layer 4 – activities or program

Each individual building, and each neighbourhood, if its form is resilient, may be used for various activities or programs. Cities are at their best where there is a mix of uses, housing types, and people, and where they provides more opportunity for adaptation and continuity.

Layer 5 – trends and fashions

The least permanent aspects of the built environment, and of design activity, are the ephemeral trends and fashions, including colours, decoration, and public art. These add delight and contemporariness to the built environment and reference contemporary culture, and they can help to express the sense of place by reflecting environmental features or conditions.

This ‘pyramid of permanence’ helps in understanding the inter-relatedness of the built environment. Theories, tools, and techniques from landscape ecology and urban design, combined with more recent understanding of ecosystem services, also help to view the public realm as part of connected urban ecosystems, rather than discrete spaces, where landscape and urbanism potently intersect. Landscape and the public realm should be the deepest layer of urban infrastructure and need to be established first,

before roads, land subdivision, and building plans.

Complicating matters further, the anticipated future climate regimes should be included in the design process. Green infrastructure is all of the “natural, semi-natural and artificial networks of multifunctional ecological systems within, around and between urban areas, at all spatial scales” [17] emphasizing both the quality as well as the quantity of urban green spaces. Municipalities should incorporate practices that the urban ecology fields use “for measuring and managing urban land cover to maintain hydrological function, promote air quality, regulate microclimate, sequester carbon, and preserve species and habitat diversity” [18].

This requires a proper valuation of landscape and ecological function. The ‘natural capital’ of many places is often a major asset. Where capital is understood as any resource that can increase economic opportunity, natural capital means the resources that we rely on for life, provided by geology, soils, air, water, and all living organisms.

The notion that natural resources have capital value, leads to the concept of ecosystem services, which provides a way to evaluate parks and open space systems, determine their impacts, and then set measurable goals. Ecosystem services refers to “the benefits human populations derive, directly or indirectly [19], from ecosystem functions”

De Groot et al. [19] identified twenty-three ecosystem services that included biological, physical, aesthetic, recreational and cultural benefits. Many of them, such as climate

regulation, water supply and aesthetic scenic properties, contribute directly to human health and wellbeing, but others, such as pollination and nutrient cycling, more indirectly contribute to sustaining ecosystems themselves.

Understanding the deep value of our city’s parks and natural landscapes, and the ecosystem services they provide, elevates the urban natural environment to a deserved position of importance and a higher priority for investment.

4. Summary

The planning and design of parks and open spaces through history have reflected the values that were held at the time, such as aesthetic criteria, practical needs, or demands for recreation. We have entered worldwide into a new phase where concerns about sustainability, resilience, public health, sense of place and an emphasis on the public realm, and the urgency of climate change—all topics within the domain of Landscape Architecture—are in the forefront, and this presents the opportunity to articulate a position and an approach.

We need a common vision for the future that emphasizes the importance of landscape and the public realm for all people and all places. The values that they provide go beyond the aesthetic or recreational—the ecosystem services that they provide, and the potential to adapt to more extreme conditions, will help ensure our very survival. In order for this landscape approach to the 21st century city to be realized, we need to address several urgent issues.

Climate change is going to have a profound influence on our physical environment and on our quality and way of life. The potential impacts need to be recognized and understood, and the role that parks and open spaces might play in increasing the resilience of our cities needs to be emphasized. This implies the need for changes in the education of future professionals as well as adaptation of our current methods, processes, and regulations.

Integration of new theories and new practices with some of our foundational theories and methods, and the recognition of the potential impacts of climate change, should become a priority for our profession, our education programs, and our local and national governments, as a matter of urgency. Too often, the limitations of training and legislation constrain many of the design disciplines, and consequently segregate the professions and result in discrete and un-related individual projects. However, if we can emphasize the inter-relationship of scales of thinking, rather than disciplinary concerns or boundaries, and focus on the quality of our environments and the quality of life of the inhabitants, there is a unique opportunity for Landscape Architecture to emerge as a stronger leader.

Acknowledgments

An earlier version ‘Green City: A landscape approach for the 21st century city’ by BA Sandalack was published in March 2017 by Park People in the *Heart of the City* papers.

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Water traces in the coastal zone of Lake Biwa : toward reconfiguring cities with latent natural systems

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Abstract

Water traces are spatial elements that indicate that water areas have been changed into land areas owing to past developments. Water traces enable determining the original appearance of the land and examining the land allocation in the future. However, as society's demands on the land change, further overwriting of the land is occurring and water traces are disappearing. Therefore, the objectives of this paper are 1) to comprehensively document the places wherein former water areas became land areas in this region, 2) to find elements of potential water traces at these locations and to catalog their characteristics, 3) to examine research methods to identify these elements as water traces to be preserved, and 4) to examine the possibilities for water traces when drawing future plans for these cities. Field survey based on a comprehensive map analysis of the water areas that changed into land areas showed elements that are likely water traces. Such elements include 1) height differences in the ground matching linearity of former shorelines, 2) outlines of land surfaces matching the recesses of former shorelines, 3) outlines of land surfaces matching the linearity of former creeks, and 4) height differences of the ground matching the outlines of former lagoons. To identify these elements as water traces, the details about the formation of these elements must be investigated. In addition, the existence of elements with a high risk of extinction emerged. A student-led study of ideas for incorporating these elements into the land history resulted in three methods to use and pass on the elements. These methods were 1) to make it easier for people to recognize the element, 2) to regenerate the water area, and 3) to apply a new program to the element and use it as a space.

Keywords: natural system, reclamation, remnant, land history, water area

1. Background

For a city to coexist with nature in future, it is important to reveal the latent natural systems obscured by the present urban condition. One of the key elements to excavate this hidden nature is determining the water traces. Water traces are spatial

elements that indicate that water areas have been changed into land areas owing to past developments. For example, a previous study of a coastal city reported that the retaining walls of a residential land area indicated the locations of the original lake shorelines and that a road in the city had retained the shape of a filled-in river ^[1]. Water traces enable determining the original appearance of the

land (the former water areas) and examining the land allocation in the future. However, as society's demands on the land change, further overwriting of the land is occurring and water traces are disappearing. The present condition of water traces should be recorded, and measures to preserve them and pass them on to future generations should be implemented.

2. Objectives

Many water traces are likely to be distributed in the six cities along the coast of Lake Biwa, which is the largest freshwater lake in Japan. This is because water areas, such as lakes, lagoons, ponds, creeks, and rivers, have been transformed into residential, industrial, commercial, and agricultural land via rapid developments in the modern era [2]. Some water traces have been reported; however, those in this area have not been completely identified. Therefore, the objectives of this paper are 1) to comprehensively document the places wherein former water areas became land areas in this region, 2) to find elements of potential water traces at these locations and to catalog their characteristics, 3) to examine research methods to identify these elements as water traces to be preserved, and 4) to examine the possibilities for water traces when drawing future plans for these cities.

3. Methods

This study was executed using the following methods.

1) The water areas that changed into land areas in this region were mapped out on a

geographic information system by overlaying maps from 100 years ago on current maps.

2) Field surveys were conducted using the above-mentioned maps. The elevations of the ground and the outlines of land surfaces of the mapped out areas that matched the shapes of the former water areas were investigated. The positions, types, and conditions of such elevations and outlines were recorded as the possible elements of the water traces.

3) The recorded elements were classified based on the data obtained via the survey.

4) Research methods for identifying those elements as water traces to be preserved were considered.

5) The ideas were studied to use and to pass on some of the recorded spatial elements, and the possibilities for water traces were explored for future development.

4. Results and Discussion

4.1. Water areas changed into land areas

A map of the water areas that were changed into land areas was created by overlaying maps from 100 years ago on current maps (Fig. 1). This map showed that former water areas were distributed throughout the research area. These areas were roughly divided into those exhibiting linear and planar forms. The ones exhibiting a linear form were shorelines, rivers, and waterways. The locations that were once water areas around Lake Biwa had been filled in and constructed into ports, parks, levee beds, and roads adjacent to the former shorelines. The recesses in the shorelines (creeks and ship pools) had become farmlands and roads. The rivers and the creeks, in the forms of single lines, tree

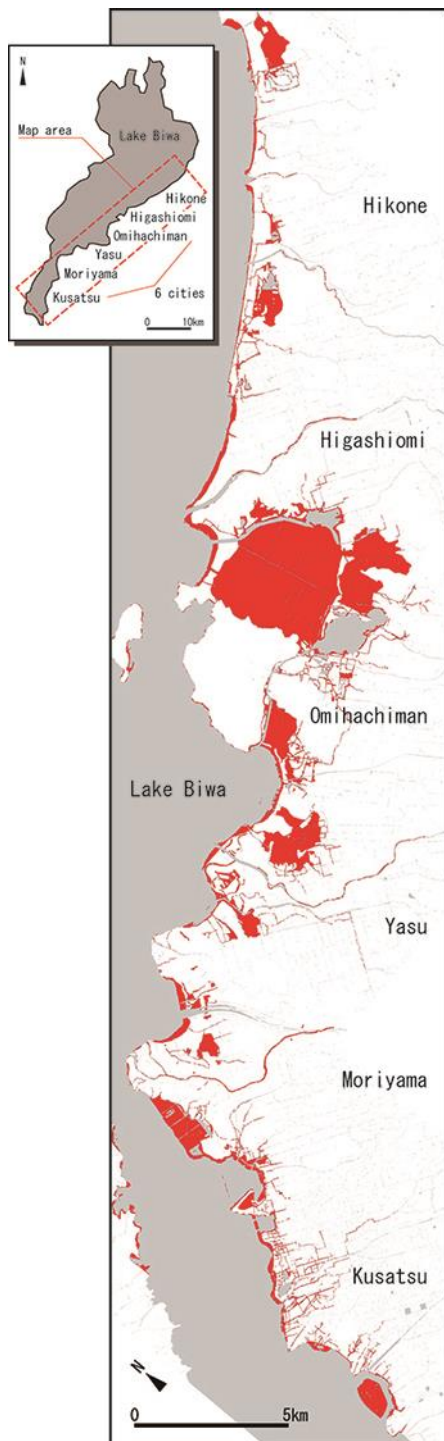


Fig. 1. Map of the water areas changed into land areas (red part)

shapes, and meshes, had become farmland and roads. However, cases wherein the water areas had not completely disappeared existed but had remained as waterways along the roads. Water areas that had been lagoons and ponds had become farmland, building sites, parks, and landfills.

To understand the reason for changing these water areas into land areas, several development projects in the catchment area of Lake Biwa were cited. First, a River Water Control Project was conducted from 1942 to 1953. By controlling the weir at the exit of Lake Biwa, the water level of the lake was lowered by a maximum of 1 m and the discharge from the lake was increased to secure the water supply and industrial water in the downstream urban areas and to increase the amount of electricity generation. Some shallow water areas probably became land areas owing to the lowering of the water level ^[3]. Next, lagoon reclamation projects were implemented from 1944 to 1968 ^[4]. At Lake Biwa, 15 lagoons were reclaimed to increase farm production and eight of these lagoons were included in the research area. Further, the Lake Biwa Comprehensive Development Project implemented from 1972 to 1997 should be mentioned ^[5]. In this project, embankments were constructed off the lakeshore. The renovation of rivers pouring into Lake Biwa also advanced. In addition to these large-scale development projects that covered all of Lake Biwa, the development of fields was promoted in various locations and the development of residential lots and roads was promoted along with the expansion of urban areas; these were also considered to be factors for changing the water areas into land areas.

4.2. Elements having the possibility of being water traces

The elevations of the ground and the outlines of land surfaces, which matched the shapes of the former water areas, were found via a field survey. Herein, these elements are classified according to their types based on the survey results. Moreover, research methods for identifying these elements as water traces to be preserved were considered.

4.2.1 Height differences of the ground matching the linear features of the former shoreline

Figure 2 shows a site of a temple surrounded by a masonry retaining wall. The height of the wall is 1 m. This temple is located in the residential area closest to the



Fig. 2. Image of a masonry retaining wall supporting the site of a temple

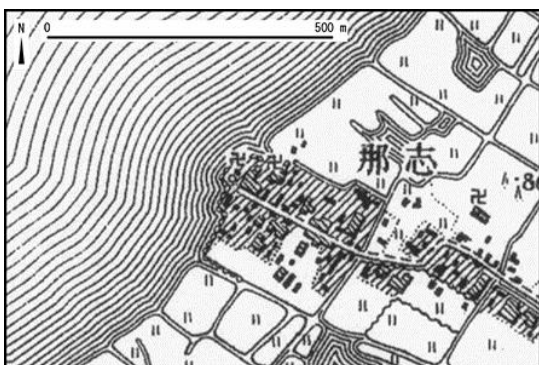


Fig. 3. Map showing the residential area 100 years ago^[6]

lake. An embankment with a road running along the top and a park with an artificial pond are located in-between the wall and the lake. These features were constructed during the Lake Biwa Comprehensive Development Project. The map from 100 years ago showed that the temple had been facing the lake and that there had been revetments between the temple and the lake (Fig. 3). The map symbol for the revetments continued not only in front of the temple but also in front of the residential area. The residential site adjacent to the temple was 1 m higher than the road on the front, with the retaining wall.

The method to identify the retaining walls as traces of the shoreline was as follows. The park in front of the temple site and the road in front of the residential site were 2 m higher than the standard water level of Lake Biwa. Despite considering that the water level had reduced by 1 m owing to the River Water Control Project, the ground contacting the retaining walls were higher than the water level recorded 100 years ago. This showed that the former lake had been landfilled and bulked. To determine whether the temple and residential sites had been bulked the background of the landfill should be investigated in detail.

Places wherein the retaining walls discontinued also existed. The slopes connecting the garages of the residential sites and the front roads cut into the retaining walls. Moreover, residential sites with no elevation difference with the front roads also existed. When renovating residential sites with a high elevation, the retaining walls might have been lost as the height of the grounds were adjusted with the surrounding lower residential sites.

4.2.2 Outline of land surface matching the recess of the former shoreline

Figure 4 shows an image of a turning space in a road passing through the center of a residential area adjacent to a fishing port; it is a rectangular space with a length of 65 m and



Fig. 4. Photo of a turning space in a road



Fig. 5. Map showing the residential area adjacent to the fishing port in Fig. 4 100 years ago^[7]



Fig. 6. Image of the old fishing port^[8]

a width of 25 m, and there is a small square and a bus stop at the center. The fishing port and a road bridge crossing over the fishing port are in-between the turning space and the lake. Both were constructed during the Lake Biwa Comprehensive Development Project. The map from 100 years ago showed that the shore had been indented in this region and had functioned as a fishing port until a new one was built (Fig. 5). An image of the old fishing port indicated that this area had been used as a ship pool (Fig. 6). Therefore, it is obvious that the turning space is the trace of the ship pool.

However, the following issue was cited as a factor for preserving the trace of this ship pool. When boats were used for daily transportation, this place was used as a ship pool. When vehicles were used for daily transportation, this place was used for car maneuvering, temporary parking, and as a bus stop. Thus, this residential area has always been a hub of transportation; however, the fact that this area was once a part of the lake cannot be neglected. Since this area is located 1.5 m higher than the standard water level of Lake Biwa, it is now leveled with the surrounding residential sites. Therefore, it is difficult to determine whether it had once been a water area.

4.2.3 Outline of land surface matching the linearity of former creeks

Figure 7 shows an image of a road unnaturally winding through the center of a residential area. The width of the road is 7–10 m, and its length is 350 m. The residential sites are lined along the meander on both sides of the road. The map from 100 years ago indicates that a creek had flowed through the residential area instead of the road (Fig.



Fig. 7. Image of a road of a residential area

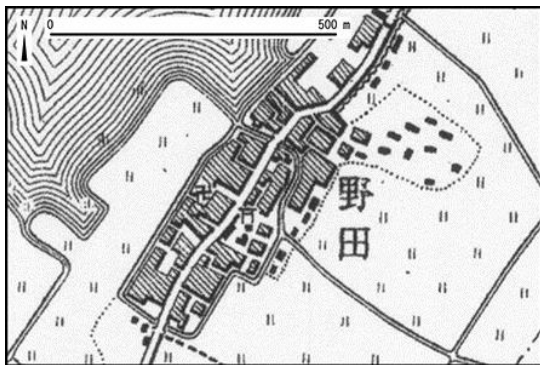


Fig. 8. Map showing the residential area in Fig. 7 100 years ago^[9]

8). The creek originated from a field upstream, flowed through the settlements, and met the lagoon downstream. It is obvious that the road is the trace of the creek; in addition, a previous study reported that the creek had been landfilled in 1972 during an improvement project for the surrounding fields^[10].

The following issue was cited as a factor for preserving the trace of the creek. The residents in this area previously traveled along the creek and now travel along the road. The concept of this linear space as a space for transportation in this community remains unchanged. However, the same consideration as mentioned above is possible. This linear space is 0.5–2.5 m higher compared with the standard water level of

Lake Biwa. In addition, no difference in height between the road and the surrounding residential sites is observed. No spatial elements that are necessary for using boats are attached to the residential sites along the road. Therefore, it is difficult to visually notice that the road had once been a creek.

4.2.4 Height Difference of Ground Matching the Outlines of Former Lagoons

Figure 9 shows an image of a grass-covered slope in the middle of a rice field. The height of the slope is 2 m. On the upper part of the slope, there are flat rice fields at an elevation of 85 m. At the bottom of the slope, there are rice fields at an elevation of 83 m, more than 1 m lower than the standard water level of Lake Biwa. On the map from 100



Fig. 9. Photo of a grass-covered slope (at the point of arrow in Fig. 10)

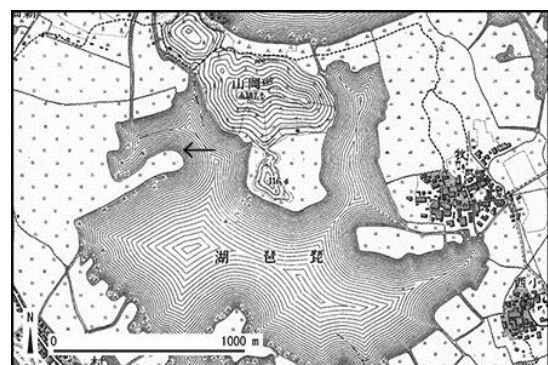


Fig. 10. Map showing the area in Fig. 9 100 years ago^[13]

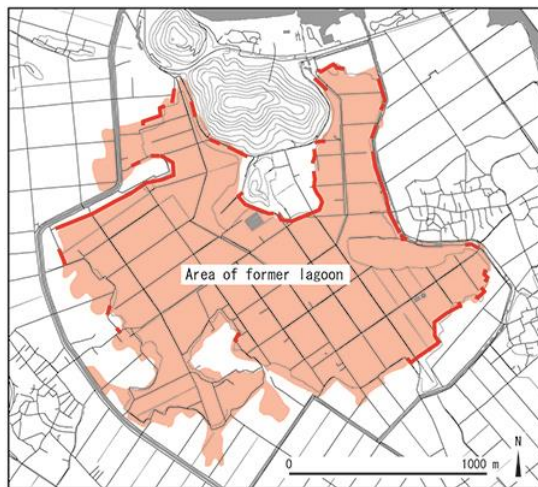


Fig. 11. Diagram showing the slopes and the shoreline of the lagoon

years ago, this had been a lagoon (Fig. 10). The lagoon had been reclaimed between 1944 and 1947^[11]. The line of this slope coincides with the previous shoreline of the lagoon (red line in Fig. 11). In addition, the water areas had not completely disappeared but had remained as waterways along the top or the bottom of some slopes.

The method to identify the slopes as traces of a lagoon is as follows. Because the lagoon was a 1–2-m deep, flat-bottomed water area separated from Lake Biwa by sandbanks and sandbars^[12], the slopes with a height of 2 m dotted on flat land that is at a lower level than Lake Biwa suggests the possibility of a trace of a lagoon. However, the shore of the lagoon had once exhibited a landscape structure from the land area to the water area, such as a waterside forest, a water extraction plant, a floating leaf plant, a submerged plant, or an open water surface^[14]. Therefore, not only the current slopes' land surfaces but also their cross-sectional shapes are different from the

original shore of the lagoon. Conditions wherein paths and waterways are located at the top and bottom of the slopes imply the possibility that the original shore was artificially altered during the lagoon reclamation project. In another lagoon reclamation project, to secure irrigation water to reclaimed land located at elevations lower than that of Lake Biwa, a waterway was established around the reclaimed land and embankments were built to prevent the reclaimed land from flooding^[15]. To identify the trace of the lagoon, the history of the lagoon reclamation and the improvements made to the fields around the lagoon must be understood.

The following issue was cited with respect to preserving and passing on the trace of the lagoon. At multiple locations, the slopes are interrupted (Fig. 11) and the elevations of the reclaimed land are the same as those of the surrounding areas (85 m). This land is used for agriculture and as a landfill. In both cases, the land was lifted, thereby eliminating the height difference with the surroundings and interrupting the slopes. Based on these circumstances, a detailed examination is necessary to determine how to deal with the elements of possible traces of the lagoons.

4.3. Possibilities for Water Traces when Imagining the Future of the City

Seven students studied the elements judged to possess the possibility of being water traces as a result of the field survey and investigated ideas to incorporate them as land history elements. Their design outputs were divided into three methods: 1) to make it easier for people to recognize the element, 2)

to regenerate the water areas, and 3) to apply a new program to the element and use it as a space.

4.3.1 Making it Easier for People to Recognize the Element

Lagoon-reclaimed land below the lake level that has been separated by levees from the lake. The surfaces of the levees will be covered with ground-cover plants, and rows of trees will be planted on them. Every season, the levees colored by the trees and the ground-cover plants, such as cherry blossoms and fall foliage, will highlight the edge of the lagoon that once existed (Fig. 12).

Fields have been created by landfilled wetlands in the water district. The appearance of the fields will change during the course of cultivation according to the season. A tree deck will be built on the fields so that people

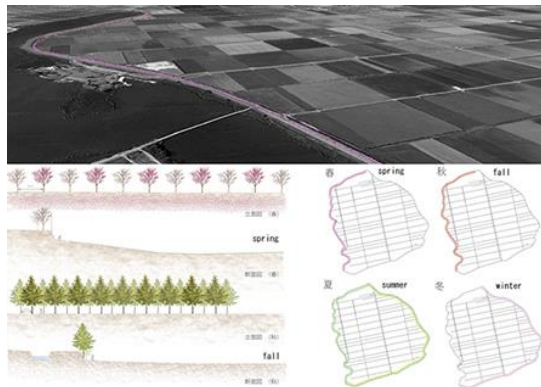


Fig. 12. Work by Miki Okamura

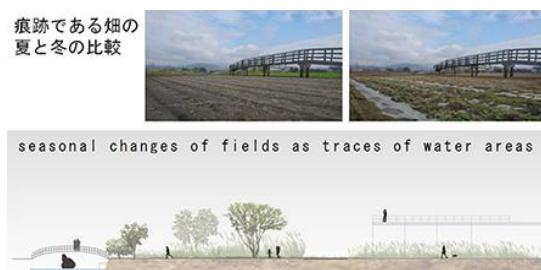


Fig. 13. Work by Takayuki Suzuki

who visit can observe the seasonal changes of the fields (Fig. 13).

4.3.2 Regenerating the Water Area

A lagoon will be regenerated by flooding the reclaimed land. The area of an existing pear orchard will be expanded as well. The site will be developed into a park, a core space where people can enjoy boat rides and harvest pears (Fig. 14).

A sports park is located on a lagoon-reclaimed land. The view of the lagoon from the castle adjacent to the park is one of the important elements contributing to the historical value of the castle. After the big event closing, the coastal environment of the lagoon will be reproduced in the park and its surroundings. The sports park will become a legacy of the event in the midst of the wetland, thereby contributing to the castle's historical legacy (Fig. 15).



Fig. 14. Work by Saki Endo

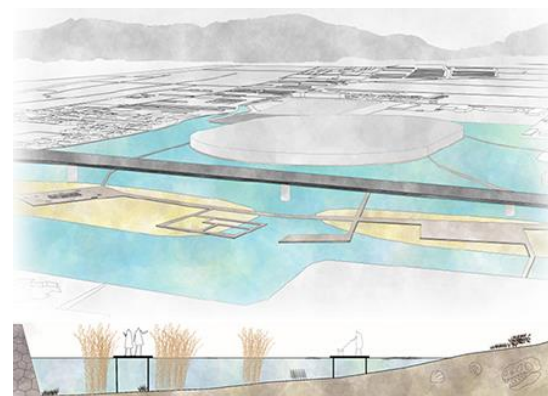


Fig. 15. Work by Yoshiki Esaka

4.3.3 Applying a New Program to the Element and Use it as a Space

The creek that flowed in the middle of a coastal village appears as a winding road. Ripple-like terrains will be built at various locations as an activity base for the residents, and covered pergolas that reflect the former water surface will be included throughout the area (Fig. 16).

A space for an exchange base in this region will be constructed on a wedge-shaped piece of land that exists between the outer edge of the reclaimed lagoon and the main road. By manipulating the wall, frame, roof, floor, and void in-between variables, possibilities of the



Fig. 16. Work by Shigeki Nishimura

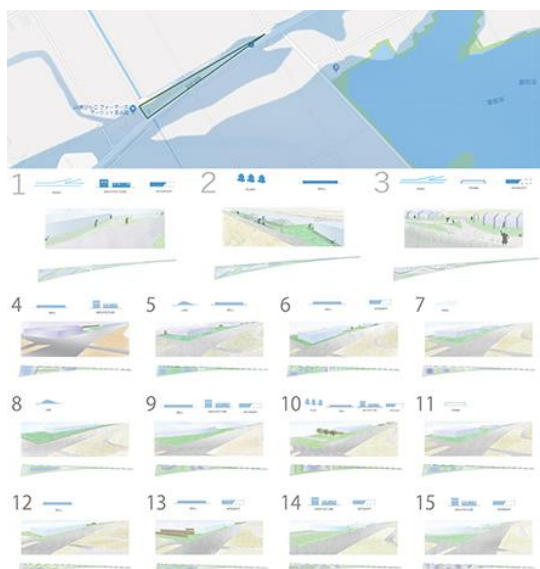


Fig. 17. Work by Kazuki Yanagisawa

forms in the space that inherited the trace of the lagoon will be explored (Fig. 17).

A center for education and landscape design research will be built on a lagoon-reclaimed land. The site will be subdivided by the size of the field that once existed. In each lot, infinite possibilities of the six element parameters, such as landform, water, surface, planting, circulation, and building, will be explored (Fig. 18).

5. Conclusions

Field survey based on a comprehensive map analysis of the water areas that changed into land areas showed elements that are likely water traces. Such elements include 1) height differences in the ground matching linearity of former shorelines, 2) outlines of

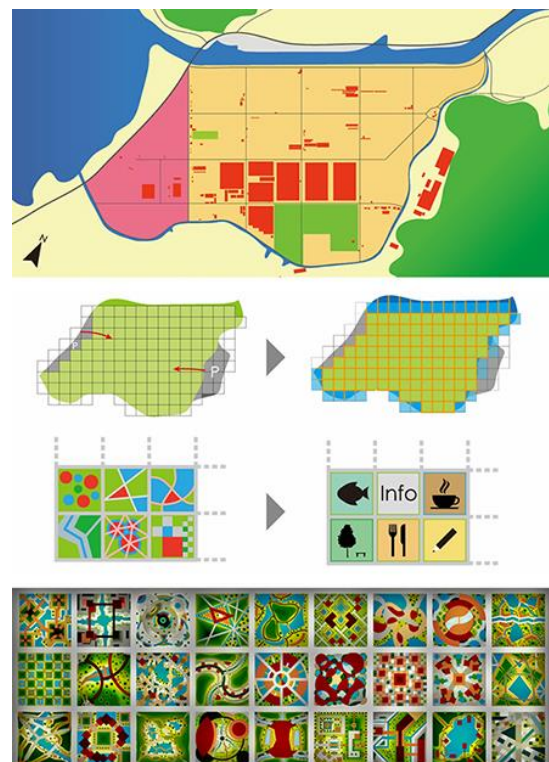


Fig. 18. Work by Yosuke Iguchi

land surfaces matching the recesses of former shorelines, 3) outlines of land surfaces matching the linearity of former creeks, and 4) height differences of the ground matching the outlines of former lagoons. To identify these elements as water traces, the details about the formation of these elements must be investigated. In addition, the existence of elements with a high risk of extinction

emerged. A student-led study of ideas for incorporating these elements into the land history resulted in three methods to use and pass on the elements. These methods were 1) to make it easier for people to recognize the element, 2) to regenerate the water area, and 3) to apply a new program to the element and use it as a space.

Acknowledgments

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[FEATURED SESSION SPEAKERS]

DAY 2 TIME: 14:00 – 14:20

Why Designing for Neighbourhood Landscapes Matter - Overview of Research Project

Professor Tan Puay Yok
National University of Singapore
Singapore

Synopsis:

Neighbourhood landscapes are the quintessential forms of landscapes in most cities. These are the green spaces that buildings and infrastructures are embedded in – the myriad interstitial spaces between buildings, peripheral plantings at edge of residential plots, and increasingly, vegetated areas on buildings. Despite their small individual sizes, neighbourhood landscapes collectively constitute a rather large proportion of cities' vegetative cover. As landscapes, they have the potential to influence the ecology and quality of the urban environment, improve the well-being urban dwellers, and forge identity, sense of place and care for the environment. This potential increases markedly for neighbourhood landscapes because of their large land uptake and proximity to the large majority of urban dwellers. But because of their mundaneness and small size, they are seldom the attention of designers compared to large gardens or green infrastructure projects. There is scant literature in the world on conceptual framework, approaches and design guidelines for the planning and design of neighbourhood landscapes, especially in the context of high-density estates which will increasingly need to house more people in the rapidly urbanising regions of Asia and elsewhere in the world. This talk presents highlights of the project undertaken in collaboration with the Housing and Development Board, National Parks Board and Urban Redevelopment Authority on development of a conceptual framework and guidelines that could maximize the potential of neighbourhood landscapes through urban ecosystem services.

DAY 2 TIME: 15:45 – 16:00

Designing FOR Nature

Leonard Ng
Ramboll Dreistl Studio
Singapore

Synopsis:

Remember that famous landscape book by Ian McHarg – Designing with Nature? Much of modern cities has evolved beyond Ian's compelling design philosophy. Many of our cities are urban jungles where nature is but a remnant of its former glory; almost an afterthought in this highly engineered environment. Nature must be more than bits of greenery draped onto buildings. Nature must play an equal role in the health of our urban environments so that future generations will stay rooted in their origins. This presentation will show some recent projects of efforts at reclaiming spaces for nature within our cities.

DAY 2 TIME: 15:45 – 16:00

Standing on the Ground: Respecting the original topography

GyoungTak Park

Dongsimwon Design Corp
Republic of Korea

Synopsis:

The project title, standing on the ground is a poetic statement that denies the conventional design practice of flattening the original topography to build high-rise structures, which has been creating a typical landscape with similar appearance of blocks all over the city and substantially damaging the existing ecosystem and unique heritages of the site. The proposed design solution argues that the development of high-rise structures based on the respect of the existing topography and inherent natural characteristics is not only feasible but also the key to strengthening the identity of the site. The existing hills and low-valley area that are important natural assets of the site to be preserved, together with the proposed linear Park system described below, establish a strong interconnectivity for both human and nature throughout the site and becomes a framework for a new development plan.

Design Concept - Linear Parks

A series of long and narrow parks are designed to overcome the weakness of the conventional satellite park system of Singapore. The separated parks in the satellite park system does not only degrade the biodiversity of the region leaving each green patch isolated, but also weaken the bond among the communities neighboring each park. However, the proposed linear park system enhances the interconnectivity among the parks and communities of the region by creating a matrix of green corridors in various types and scales which include Main, Secondary, and Tertiary Linear Park and Green Necklace. The four ranks of Linear Park as green arteries, connecting important natural assets and running all over the site, maximize the extent of opportunity for people to access to all the parks, open spaces, amenities, and programmed spaces.

Preservation Parks – Hills, Mountains and Low-Valley Area

It is suggested that the most important natural assets of the site are to be the Preservation Park and become the core part of the entire green network system of the site. Hills and mountains from 35m to 50m in elevation are one of such important natural assets of the site in terms of its rarity value in Singapore landscape. In addition, building HDB high-rise residential blocks in such high-elevation areas requires substantial destroy of the rare landscape. Hence, the design solution proposes that the hills and mountains are to be the Preservation Park surrounded by various buffer greens such as apiary, community farm, forest playground and etc. The Preservation Park together with the contiguous buffer greens around becomes a neighborhood park located at the center of a residential block. Within the residential block, School, hospital, and community center are located closer to the neighborhood park to more actively appreciate and utilize the natural resources.

Low-valley area is another important natural asset of the site due to its ecological value, rich nutrients and humid micro-climate. Hence, the design solution proposes the low-valley area with less than 5% degree slope to be Preservation Park. Two low-valley areas of the site designated as Preservation Park function not only as the ecologically important aquatic corridors but also as the waterways of the two watersheds for the western region of Singapore. Two large detention reservoirs are also suggested to mitigate flood risk and to support various water related leisure activities. These reservoirs are located at the boundary of the site, being used as water source for the waterfront of the suggested commercial area.

DAY 2 TIME: 16:15 – 16:30

The Wenshan Oasis Project: Neighbourhood Landscape Design along the Waterway

Liu Po-Hung

Chairman

Classic Landscape Design and Planning, Ltd

Synopsis:

Singapore developed the Neighbourhood Landscape Planning and Design Framework (NLPDF) that guiding the design of neighbourhood landscapes nestled among residential buildings in the high-density, high-rise public residential estates. Taipei city is conducting similar projects that transform abandoned spaces into sustainable community shared space throughout residents' cooperation.

Wenshan district is located in the suburbs of Taipei city and surrounded by several small hills. This topology brings abundance of ecological resources to Wenshan district. On the other hand, it also causes humidity and frequent flooding during rapid storm runoff. In order to ease the storm runoff, we conducted some field research to Wenshan district. We discovered that there used to be 4 main irrigation systems in Wenshan district, Liugong canal, Xingfu sub-canal, Wulixue canal, and Wansheng River. However, as Taipei city developed, the irrigation systems are covered in the underground. This not only limits its potential to adapt to climate change, but also left a lot of hidden back-alley ran zigzag between buildings.

The concept of "Wenshan Oasis" is to remodel these abandoned spaces into Rain Gardens and Bioswales that help absorbing the water runoff and lower the probability of flooding. Moreover, we intend to transform these spaces into community shared spaces that engage the residents and enhance community cohesion. The Wenshan Oasis Project aims to create community spaces that are ecological, flood- detaining and with local vibe.

Before remodeling the actual space, we held several residents' networking events for everyone to interact face to face. There was a participatory activity of space-planning that used 1:1 scaled scenario props. There was an outdoor exhibition and a workshop about making models of urban design. There were community dinner parties that everyone was invited to, and we gave short talks at the dinner parties. We installed a playful "Water Wall" for children to have fun. We even designed a scavenger hunt – "To Find The Home of River God". This game linked with local historic story and made the waterway issue entertaining.

We applied varies strategies in these events to make participants experienced how a vacant space could be transformed. Local residents started associating with the community environment through the activities. They discovered the correlation of their environment and its drainage systems, and they recognize the importance of this relationship. As local residents gradually care more about their environment, they are motivate to take action. They started to improve community shared space, creating an ecological , flood-detaining, and leisure environment.

Wenshan Oasis project echos to the concept of Neighbourhood Landscape Planning and Design Framework (NLPDF). The project focused on the topic of "disappearance of the waterway", and remodeled the abandoned spaces into community space that are beneficial both ecologically and culturally.

DAY 2 TIME: 16:30 – 16:45

Landscape Design with Ecosystem Services in High-Density Cities

Professor Liao Kuei-Hsien
National Taipei University

Synopsis:

In recent years, the concept of ecosystem services has become popular in the discipline of landscape architecture, which has increasingly applied ecology to open space design as sustainable design becomes a norm. However, how ecosystem services can be explicitly integrated into landscape design is still an area of early development, in both research and practice. Most existing literature on ecosystem services focuses on natural ecosystems. While it helps landscape architecture professionals understand the concept and basic science of ecosystem services, it provides little guidance to how to design with ecosystem services. The research on ecosystem services in the urban context, or urban ecosystem services, is highly relevant to landscape architecture. However, existing literature is still rather limited. The operationalization of the concept of ecosystem services requires a clear guidance to how to design with ecosystem services. Developed by an interdisciplinary research team, the Neighbourhood Landscape Design Guidelines (NLDG) provides a concrete methodology to explicitly design for multiple ecosystem services in neighbourhood landscapes in the context of high-density cities, where humans and nature intensively interact. Neighbourhood landscapes, or residential landscapes, refer to the open space in residential neighbourhoods. While they are a relatively underappreciated type of open space in landscape architecture, they account for a substantial amount of the total green areas in the city. Neighbourhood landscapes therefore can be considered the most common form of urban ecosystems, to which urban dwellers are exposed on a daily basis and which should be capable of providing multiple ecosystem services. The omnipresence of neighbourhood landscapes suggests that they can significantly affect the well-beings of the urban dwellers and the overall ecological quality of the city through the ecosystem services they provide. How neighbourhood landscapes are designed, used, and maintained would determine the quantities and qualities of their ecosystem services. Therefore, it is important that the design and management of neighbourhood landscapes are guided to optimize the provision of ecosystem services. As an example of how to design with ecosystem services, NLDG addresses seventeen urban ecosystem services that are identified to be more relevant in neighbourhood landscapes in high-density cities. For each ecosystem service, there is a suite of integrated design strategies for conserving, enhancing, or creating the service; targets for optimizing the service; and performance indicators for assessing the effectiveness of design. The details of NLDG is documented in a recently published volume titled "Nature, Place & People" authored by the research team (Tan et al., 2018). The objective of this presentation is to further explain the methodology behind NLDG. I will discuss the systematic approach to developing NLDG based on best available natural and social sciences. How to explicitly consider the tradeoffs between different ecosystem services will also be explored.

DAY 2 TIME: 16:45 – 17:00

The Role of Green Spaces in Community Formation Depends on the Urban Context

Dr. Vincent Chua

National University of Singapore
Singapore

Synopsis:

There is growing recognition among scholars that green spaces are an important facilitator of community ties, but the specific conditions undergirding this link are less well understood. This study adds contextualization by asking when and for whom green spaces matter. Examining two neighbourhoods in Singapore, Punggol and Toa Payoh, our study finds an overall positive correlation between green spaces and neighbourly ties, yet uncovers some contingent effects. Singapore makes an interesting and relevant case given its high-rise and high-density residential contexts, its strong emphasis on greening, and its interspersing of urban and natural forms. We adopt the perspective that green spaces are simply one amenity among a broader range of other amenities (e.g., playgrounds, markets, shops, and the like) that coexist alongside green spaces to affect community formation.

Importantly, urban neighbourhoods incorporate both cultural and natural forms. On one hand, they are socio-ecological systems hosting a variety of commercial, industrial, and residential entities. On the other hand, they also host large swathes of vegetation cover and biodiversity, especially in biophilic neighbourhoods. The term garden city applied to Singapore captures the idea that urban and natural elements are interspersed. This being the case, the analysis of green spaces should be conducted while taking into account the broader socio-ecological mix within urban neighbourhoods, including their amenity mix and provisioning of other services. Depending on surrounding conditions and pre-existing provisions, green spaces can add to the provision of values and services to residents or be more contingent. This suggests a need for contextualized analysis.

We consider the following two possibilities: First, we venture that the positive relationship between green spaces and community formation might be attenuated among residents who already have strong place attachments to the neighbourhood. Second, this impact of green spaces (on community formation) might be less influential among residents who live in neighbourhoods characterized by a long-established network of amenities (such as provision shops, markets, food centres, libraries and the like) that already do a good job bringing residents together. Our findings justify our analysis and underscore a contingent view of the role of green spaces in community formation. First, we find that if residents are already well entrenched and have strong place attachments to their neighbourhoods, additional green spaces will do less, comparatively speaking, to strengthen their ties with neighbours. This is especially so if residents are part of neighbourhoods that are older, with a well-established network of social amenities that already do a thorough job bringing residents together. Second, analysing green spaces against a broader canvas of the neighbourhood as constituted by a range of amenities and pre-existing conditions allows us to determine the limits of what green spaces can be expected to achieve for neighbourhood communities. It is the mix, the interfacing of the man-made and natural structures that requires theoretical attention, not just one or the other.

DAY 2 TIME: 17:00 – 17:15

Window View and the Brain: Can Floor Level and Amount of Green within the View Have an Effect on Mental Health and Well-Being?

Dr. Agnieszka O. Guizzo
National University of Singapore
Singapore

Synopsis:

Landscape views are a pervasive feature of urban areas which can restorative effect on mental health and well-being of urban dwellers. The quality of these landscapes and the visual connection with the nature elements (like greenness of the vegetation) constitute an important factor in the aesthetic values of a landscape - one of the landscape services in the socio-cultural (or People) category. In the high-rise, high-density context of residential estates, like Singaporean HDB, the window view provides to its residents, the most immediate and easily accessible way of connection with the neighbourhood landscape. This can potentially influence their quality of life, mental health and well-being, and it was important to us to explore to what extent this can happen through modulation of the brainwave rhythms. Evidence-based design emphasizes the use of data collected through various experimental techniques, including methods of neuroscience, to provide the scientific basis for designs of the built environment; it has emerged as an important study area. In this presentation we show the findings from the explorative study on how different window views may affect the pattern of brain activity of HDB residents who are passively exposed to them, depending on the floor level and the green cover within the view. To measure the brain response, we designed a simple passive-task experiment where 29 participants, in the controlled lab environment, were exposed to set of 36 photographs of different window views, while simultaneously the electroencephalography (EEG) signal was recorded, using the 14-channel Emotiv device installed on their scalp. Participants, HDB estate residents, viewed photographs taken from different floors (3rd, 6th, 12th and 24th floor) of a high-rise housing block, with varying extents of green cover within each view (minimal, medium and high green cover). The results showed that amount of green cover within the view captured at different floor levels had significant effect on the frontal alpha and temporal beta brain oscillations recorded while participants viewed photographs. These results suggest that the brainwave patterns commonly associated with positive emotional states, motivation and visual attention mechanisms are increased by the extent of green cover within the view. This phenomenon seems more pronounced on the higher than lower floors. However, window views from the highest floor studied (24th) appeared to stimulate the brain in a less positive way, but this was partially negated by increased levels of green cover within the view. Our results emphasize the importance of considering the quality of window views in the planning and design of urban high-rise neighbourhoods. Simply having a view of greenery can contribute to the mental well-being of urban dwellers.

THE RESTORATIVE VALUE OF NATURE IN SINGAPORE'S LANDSCAPES

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Abstract

In the 1980s, Rachel and Stephen Kaplan conducted extensive research on the correlations between spending time in nature and mental concentration. The product of the Kaplan's work formed the Attention Restoration Theory, a primary source of reference for landscape architects in creating Biophilic Cities. The Kaplan's Attention Restoration Theory states that a physiologically restorative environment is made up of four components: 'fascination', 'extent', 'being away' and 'compatibility'. This paper presents three case study projects within Singapore's Biophilic context distinctly created with aspects of the Attention Restoration Theory: Jurong Lake Gardens West, Sungei Buloh Wetland Reserve and Jurong Eco-Garden.

Jurong Lake Gardens West (JLGW) is a new national gardens planned to open by 2019 located in the island's western heartland community. JLGW embodies two dimensions of attention restoration: 'fascination' & 'extent'. The Kaplans' describe the value of 'soft fascination' (clouds, leaves in the wind, sunsets) in nature as able to hold attention while leaving the opportunity to think. Within the design of JLGW, 'fascination' is invited through the careful composition of plant groupings with consideration of views to the surroundings, along with targeted visual relationships between birdlife zone and the spatial experience of park visitors. The mental restoration component of 'extent' can refer to the experience of interacting with a historic artifact and gaining a connection to the past. JLGW was originally dominated by freshwater swamp forest with flora adapted to the unique intertidal habitats that characterized this area. Visitors will draw upon the restorative aspect of 'extent' as plant species of the park were specifically selected based on historical association with Jurong's tropical lowland freshwater forest. Through the components of 'fascination' & 'extent', Jurong Lake Gardens West serves as a case study for the Biophilic values of psychological restoration.

Within Kaplan's theory of Attention Restoration, the components of 'being away' refers to the value of releasing the everyday worries and stress of life through the feeling of getting away. These destinations are often natural environments such as shoreline beaches or alpine mountaintops. While Singapore has a highly urban population, Sungei Buloh Wetland Reserve provides an escape to a mangrove hinterland along the country's northern shore. Here visitors can leave behind the burdens of city life and immerse themselves in a rich native tropical environment with Smooth Otters and numerous migratory birds.

The Jurong-Eco Garden provides a case study to the last component of Attention Restoration Theory: 'compatibility'. Anchored by the overarching vision of the Jurong-Eco Garden as the first business park in a tropical rainforest, the central core was designed as the lungs and heart of the unique ecology of the site, a tranquil breathing space for visitors and office dwellers. Here

‘compatibility’ is achieved by providing the compatible setting to human inclinations towards roles such as locomotion through trekking or observation through bird watching.

These three Singapore landscapes showcase the city’s Biophilic context through the four components of the Attention Restoration Theory.

Keywords: Attention Restoration Theory; Directed Attention Fatigue; Restorative Environments; Singapore; Biophilia

1. Introduction

Compared to 30 years ago, our contemporary lives receive five times the amount of daily information due to advances such as the internet, 24-hour television, and smartphones. This figure is a fraction of the amount of information we produce through email, social media and text messaging. In the late 1980's, the average person created approximately two and a half pages of information a day. Now our daily information output could fill six newspapers, which is a 200-fold increase [1]. As a result, more mental attention is required to process this massive amount of daily information. The increase of effort to manage more data comes at a psychological cost. Mental fatigue often sets in when we exceed the amount of direct attention we can provide on a given day [2].

This form of mental exhaustion is called Directed Attention Fatigue. It is most frequently caused by periods of intense or prolonged work. Directed Attention Fatigue can affect one’s ability to perform common tasks such as *Selection, Inhibition & Affect, Fragility, Perception, Thought, Action, and Feeling* [3]. While sleep provides one approach to Direct Attention Fatigue recovery, it can be insufficient as insomnia may develop before a full recovery is gained. Based on Kaplan and Kaplan's research, a restorative experience within the natural

environment can provide an alternative mode for directed attention restoration.

1.1. Attention Restoration Theory

In the 1980’s & 1990’s an abundance of research was developed regarding the psychological benefits of nature. Natural environments were further understood to be specifically equipped with the robust values necessary for both attention restorative experiences and stress reduction [4]. At that time, the focus of environmental psychological research had situated the study of attention restoration apart from stress reduction [5]. Attention Restoration Theory sought to address the theoretical divide and shift towards an outlook on nature’s benefits to both stress and attention fatigue. Through this framework, an analysis was provided of experiences which led to recovery from directed attention fatigue [3].

The concept of restorative experience arose in the context of a research program in the wilderness by Kaplan and Kaplan in 1989. Several value traits were discovered through the study. The premise developed stated that attention restoration may be obtained through the experience of specific properties within the natural setting [2]. Four key components defined the restorative environment which may reduce the mental fatigue caused by directed attention [6]. These four characteristics are *‘fascination’, ‘extent’, ‘being away’* and *‘compatibility’*. These traits of a restorative environment will

be described in detail through the following pages.

1.2. Singapore's Biophilic Context

While the Kaplans were developing the basis for attention restoration theory, a book by Edward O. Wilson was published titled *Biophilia*. He is widely recognized as the first to coin the term *Biophilia* and described it as the inherited connection between humans and nature. Wilson describes our evolutionary history within the natural world as the cause for a human need to interact with nature [7].

The city of Singapore provides several case studies for how a Biophilic approach may be integrated into a major metropolitan area. The initial motivation behind Singapore's nature integrated development began in 1963 when Prime Minister Lee Kuan Yew launched his vision for a 'clean and green' city. The campaign was conceived as a tree-planting initiative to improve air quality and brand Singapore as a 'garden city' [8]. Lee Kuan Yew felt deeply driven to create a garden city model within the Asian context. To exemplify his commitment to urban nature, Lee created the National Parks Board within the Ministry of National Development as a key agenda for the nation's political focus. After Singapore's major industrial development, the Prime Minister Lee Hsien Loong reaffirmed the commitment to nature in the city: 'in the next phase, our aim is to build a "City in a Garden"', to bring green spaces and biodiversity to our doorsteps' [9].

2. 'Fascination' – 1st Trait of Attention Restoration Theory

The first of the four characteristics of Attention Restoration Theory as outlined by the Kaplan's is 'fascination'. Nature inherently hold several engrossing aspects of 'fascination' through both objects and processes. Examples of objects of 'fascination' in nature are flora, fauna, water or even a play of light. The processes of nature in which 'fascination' is held are elements of growth and succession along with the sequences of predation and survival. A prime example of process-based 'fascination' in nature is bird watching. These processes may be experienced in a variety of natural settings, such as clouds in the sky, sunsets on the horizon, snow patterns over the ground, or leaves moving in the wind [3]. Since these natural patterns seem effortless, they leave a certain room for the mind to wonder.

Fascination can be considered "hard" in the form of watching a car chase, which demands one's full attention. While "soft" fascination allows the opportunity for reflection in the possible form of a nature walk, which requires only partial attention. 'Soft fascination' holds one's attention, although not in a dramatic fashion. In the mental state of 'soft fascination,' the mind is allowed to recover from direct attention fatigue through the processes of thinking, doing and pondering [2]. While 'Fascination' is a key component to providing restorative experiences, it does not guarantee rest or recovery without other characteristics of Attention Restoration Theory.

2.1. Singapore Case Study for 'Fascination': Jurong Lake Gardens West

Singapore's new Jurong Lake Gardens is an excellent case study for 'soft fascination' within a natural setting. Along the western portion of the gardens, Jurong Lake Gardens West (JLGW), vegetation frames views towards elements of nature such as fauna habitats, birdlife feeding areas and the greater Jurong Lake. Benches provide viewing moments under mature shade trees to create resting spaces ideal for processes of thinking and reflection. Mental restoration through 'fascination' may occur through active processes such as: walking, running and even people watching. At JLGW, primary and secondary pedestrian routes are woven throughout the gardens to provide a diversity of experiences within nature. [10] People watching is welcomed at plazas near a variety of natural settings such as woodlands, grasslands and wetlands.

'Soft fascination' may occur in Jurong Lake's rich ecological systems of native flora and dynamic fauna. While the history of the Singapore's Jurong Lake landscape has experienced many transformations, it remains a vibrant sanctuary for birdlife [10]. Several biodiversity hotspots are concentrated along the banks of Jurong Lake. These natural areas are densely vegetated, comprising of large banyan trees and other plants which support a diversity of fauna such as small mammals, insects, and birds. The tall, dense crowns of the banyan trees serve as important resting sites for birds such as the black-crowned night heron, grey heron, and various species of egrets. Birdwatchers may visit to see the grey heron, a bird considered nationally threatened,

nesting among the tall casuarina trees within Jurong Lake Gardens. The lake itself also adds an ecological niche to the terrestrial habitat, with aquatic and semi-aquatic species of fauna depending on the water body for survival. This range of habitats offers a vast range of potential opportunities for mental restoration through 'fascination' within the natural setting of Jurong Lake Gardens West.

3. 'Extent' – 2nd Trait of Attention Restoration Theory

The Kaplans' second characteristic of Attention Restoration Theory is 'extent'. While the element of 'fascination' relates to human engagement, 'extent' is in reference to more qualitative aspects of the natural environment. The most typical example of a space with 'extent' is a vast and remote wilderness. Although, to achieve the experience of 'extent' the size of the natural landscape and its proximity to urbanity is irrelevant. The spatial quality of 'extent' must provide the sense of a completely different world through environmental factors of richness, dynamics, and coherence. Watching a streaming video or even engaging in augmented reality is only a collection of impressions which may not provide enough for a full restorative experience. To gain the sensation of 'extent' a complete environment must be experienced to sufficiently preoccupy a better portion of the mind [2]. Three characteristics of an 'extent' experience are 1) its boundaries are not evident, 2) it has atypical properties from those of daily life and 3) it offers the

feeling of a real completely immersive environment.

It is not required to travel to a faraway wilderness in order to receive the mental restoration of 'extent'. This may be created through a manipulation of scale such as miniaturization, an approach often used in Japanese garden design. Here landscape elements are intentionally dwarfed in size to create the perception of a larger space. 'Extent' may also be a conceptual idea through the interaction with historical artifacts or even reading a fantasy story [3]. These means of engagement can allow the mind to casually wander to a place where the stresses and fatigue of daily life recede away.

3.1. Singapore Case Study for 'Extent': Jurong Lake Gardens West

Jurong Lake Gardens West serves as an additional case study for the Attention Restoration Theory's characteristic of 'Extent'. Over an area of 53 hectares, JLGW is of a size which may engage the mind in a fully immersive environment. Also, by referencing the Jurong Lake's historical context the experience of 'extent' may provide an authentic interaction with the fresh water swamp landscape which once occupied the site.

Jurong's primeval ecosystem was rich in tropical lowland flora and diverse fauna. The first director of the Singapore Botanic Gardens, Henry Nicholas Ridley and his successor, Isaac Henry Burkill collected extensively from the area between the late 1800s to early-mid 1900s. From herbarium records, Jurong was covered with tracts of mangrove and freshwater swamp

forests, comprised of a diverse palette of species. Trees with stilt roots that sit in intertidal areas, giant Pandanus that reach beyond 10m tall, pitcher plants that capture insects in their leafy cups, to myriads of orchid species that thrive epiphytically on the trees were all once part of the natural Jurong landscape [11]. Edred John Henry Corner conducted a botanical survey of the original freshwater swamp forest along Jurong Road 15th Mile right before the felling began in 1932. Within a tiny two-acre tract of the original freshwater swamp forest left, he identified 15 species which distinguished the Jurong freshwater swamp forest from the ones in Mandai, along with Pontian and Sedili in Peninsular Malaysia [12]. By June 1933 the whole swamp forest had been transformed into a pineapple estate.

Jurong's historic freshwater swamp forest is comprised of plant life which has adapted to thrive in a unique intertidal habitat. The present-day Jurong Lake functions as a detention reservoir for storm water from the greater Jurong catchment via Sungei Lanchar and Sungei Jurong. This lake has an average fluctuation of about 500mm in weekly water levels. This presented an opportunity to use the changing water levels to mimic the intertidal effect necessary for the successful establishment of a shoreline character similar to the historic freshwater swamp. The plant groups were selected as part of a larger flora collection found within the lowland freshwater forest ecosystem. By using these plant species at various locations in JLGW the visitors are given a degree of 'extent' combined with 'fascination' to provide an environment suitable for mental restoration.

4. 'Being Away' – 3rd Trait of Attention Restoration Theory

The third characteristic of The Kaplans' Attention Restoration Theory is 'being away'. The experience of 'being away' is desired when one states "I need to get away for a few days". This expression is used when travelling to a place of restoration. These 'get away' destinations are typically within the natural setting, such as beaches, mountains, lakes, forests, rivers or even meadows. When 'getting away' is mentioned it infers mental fatigue. In order to seek restoration from the fatigue, this need is stated as a desire to be away from the everyday task which is the source of exhaustion. When 'being away' is achieved, one is free from direct attention

activities and is allowed to recover mentally [3].

While the desire of 'being away' often refers to a beach vacation, travelling to a faraway destination may not be possible or even necessary. The state of 'being away' may either be physical or conceptual. In the case of physical, one is required to physically be away from the setting and tasks which causes the need for mental restoration. The state of conceptually 'being away' may be obtained by simply pausing to peer out a window to receive a mental moment of feeling 'away' [2]. Since a majority of the world's population lives and works in the urban context, close proximity to parks and gardens allows physical access to natural spaces for mental restoration. While conceptual access to 'being away' may be obtained through viewing a common space in a new way by shifting the position of perspective.

4.1. Singapore Case Study for 'Being Away': Sungei Buloh Wetland Reserve

As a resource for urban dwellers seeking the experience of 'being away' Sungei Buloh Wetland Reserve (SBWR) is a 202-hectare robust wetland sanctuary of mangroves, mudflats, ponds and secondary forest located at the Northwest corner of Singapore along the Johor Straits. The wetland reserve of mangrove species is particularly important as Singapore ranked 6th, out of 94 countries, for the richest number of mangrove species globally. Along with the rich range of mangroves, Sungei Buloh is also a key stop-over area for the international network of migratory shorebirds. SBWR has local and migratory birds with a range of nationally and

internationally endangered species [13]. The diversity of wildlife species, beyond numerous shorebirds, include Smooth Otters, monitor lizards and a range of aquatic marine life adapted to the reserves unique landscape character [14].

Since it's opening in 1993, Sungei Buloh has played a significant role as a 'being away' destination within Singapore. Sungei Buloh Wetland Reserves has been created with the opportunity for visitors to experience distinctive trails showcasing the dynamics and diverse aspects of the wetland park [14]. SBWR provides visitors with the immersion into a unique natural environment conducive to mental restoration within the urban lifestyle of Singapore.

5. 'Compatibility' – 4th Trait of Attention Restoration Theory

'Compatibility' is the fourth and final characteristic of the Kaplans' Attention Restoration Theory. The physical setting is a critical factor in one's ability to carry out a given task. An environment's suitability for an intended purpose defines its level of 'compatibility'. In a highly 'compatible' setting, an activity may be carried out comfortably with little to no obstruction [15].

The natural environment has an inherent capacity to be experienced in general as 'compatible'. When performing typical functions people tend to prefer a more natural setting over an urban, even when the city condition is familiar, as tasks seem to require less effort in a natural environment [16]. When a setting is not

'compatible' it adds to mental fatigue. Elements of 'non-compatibility' may be an obstruction in the environment, a desire to be in another setting, or a critical element missing from the present space. Within the natural environment, several activities tend to feel highly 'compatible' such as hunting, fishing, gardening, caring for pets, bird watching and even visiting zoos [2]. By engaging in these nature-based programs, mental fatigue may be restored through the experience of 'compatibility'.

5.1. Singapore Case Study for 'Compatibility': Jurong-Eco Garden

Singapore's Jurong Eco-Garden (JEG) is a valuable reference for the trait of 'Compatibility'. JEG was the first business park in a tropical rainforest designed for the site's unique ecology and as a tranquil space for both visitors and office workers [17]. Here employees may take breaks to reconnect with nature as every building has a natural forested front on at least one side [18]. Underlying the holistic approach of JEG is a drive to work with a deep respect for nature. Through a host of surveys and studies, including topographic, geological, hydrological, botanical and zoological, the site in its original condition is fully considered in the Eco-Garden's layout. Through allowing a close proximity to natural spaces, JEG creates a 'compatible' environment for nearby office workers to gain moments of mental restoration through activities such as nature walks and bird watching while taking a break on a typical workday.

6. Conclusion

In the midst of the information age, Singapore is driven by strong growth and continued prosperity. This trend towards development often creates an intense life of 24/7 communication, stressful deadlines, and a seemingly endless pursuit towards progress. The repercussion of this constant effort is mental fatigue. Contemporary cities often look for elements of sustainability and sky rise greenery to create a more "natural" and healthy urban setting. These efforts to increased greenery and sustainable building

credentials do not always address the social need for mental restoration. To provide psychological recovery from daily stresses, Biophilic cities should specifically create nature spaces with traits of *'fascination'*, *'extent'*, *'being away'* and *'compatibility'* throughout the urban context.

In Singapore's urban evolution towards a Biophilic City, a new chapter is possible by developing into a 'city in a natural ecosystem'. Here urban escapes into the tropical wilderness can continue to be embedded throughout the city. A focus on creating increased human-to-nature interactions with traits of Attention Restoration Theory at the city's heart may expand. This authentic daily interaction with natural objects and processes is a valuable investment to advance Singapore's health and mental restoration.

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Growing fast and staying green – Vienna’s green space strategies

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Abstract

More than 50% of the Vienna city area are green spaces. This high share the city owes to its historic development. Large wood-areas and imperial parks were spared from urbanisation and clearance. In 1905, when Vienna’s population nearly has reached its peak, **Vienna’s Wood and Meadow Belt** was put under protection by the city council.

Today, more than a 100 years later, the generous green spaces are considered as one of the main factors for Vienna frequently being ranked amongst the most liveable cities worldwide. However, in the next decades Vienna again will face significant population growth. Recognising Vienna’s urban landscapes building the core of this city’s character and (life) quality, one of the city planner’s trickiest tasks is to still maintain natural areas and improve green space quality for all – existing and future – inhabitants.

Therefore recently a new set of instruments has been developed and implemented: **Vienna’s Open Space Network** now defines the city’s linear green connections to enable access of recreation areas for undersupplied quarters. The future goal is that every Viennese will be able to reach this network within a distance of 250 m. Balancing out the green space supply throughout the whole city area and all popular strata, the densification of the green infrastructure aims in a “**green space equity**”. Also, this close mesh ensures the networks accessibility for people of limited mobility. Furthermore the network links to the environs of the city and provides essential ecosystem services in the city.

Another new instrument, the “**Local Green Plan**” serves as a standardized planning tool for urban development areas to outline the green space demands for the master plan level and land use planning. Therefore 12 open space types can be used to define the required qualities of the new quarter whereas “green and open space standards” provide calculation methods to specify the amount of green space needed per future inhabitant or workplace.

In the tradition of Vienna’s “Wood- and Meadow Belt” from 1905, but equipped with these new instruments and the knowledge of today’s and future requirements and probable circumstances, on the large scale Vienna’s city planners currently are developing a new model and guideline for the entire city’s green space system, which aims in preserving Vienna’s high quality green spaces despite the predicted population growth.

To provide the city with an instrument strong enough to withstand the expected building pressure in the next decades, the model will rest on two solid pillars: On one side, the determination of green areas is based on a multi-layered GIS database of already approved

existing framework conditions (e.g. nature protected areas, agricultural zones, climate-relevant areas ...). On the other hand Vienna is redefining its inviolable historic, functional and identity-establishing green space category “**Vienna green belt**” as interconnected major green areas of the whole city region.

The conclusively justified database and the transparency in decision result in an indisputable, legally sustainable and widely accepted instrument suitable to preserve Vienna’s green character for the upcoming decades.

Keywords: Green space equity; city region; population growth; urban green space; green infrastructure; life quality

1. Introduction

More than 50% of the Vienna city area are green spaces. This high share the city owes to its historic development. Large wood-areas and imperial parks were spared from urbanisation and clearance. In 1905, when Vienna’s population nearly has reached its peak, Vienna’s Wood and Meadow Belt was put under protection by the city council.

Today, more than a 100 years later, the generous green spaces are considered as one of the main factors for Vienna frequently being ranked amongst the most livable cities worldwide. However, in the next decades Vienna again will face significant population growth and many other challenges in terms of climate, energy and mobility. Recognizing Vienna’s urban landscapes building the core of this city’s character and (life) quality, one of the city planner’s trickiest tasks is to still maintain natural areas and improve green space quality for all – existing and future – inhabitants.

2. A brief history of Vienna’s green space development

Situated right at the junction of the Vienna Woods (“Wienerwald” - the eastern alpine foothills) and the riparian forests of the Danube, Vienna is naturally blessed with large greenspace-systems surrounding the city. Still, in the last 200 years Vienna’s green and open spaces took a huge development in terms of ownership, accessibility and functionality.

2.1. Imperial Vienna

Up to the 18th century the mayor green spaces around the historic city center have been strictly reserved for the aristocracy as representative gardens or imperial hunting grounds. [4] The opening of the Vienna Prater area (a large riparian forest area) to the public in 1766 was the starting point of a development of conversion of the green spaces to large leisure- and recreational areas for the Viennese citizens.

2.2. Industrialization and new recreation and health necessities

Like in many other western capitals industrialization in the 19th century and the rapid population growth brought about

urban densification, followed up by catastrophic living conditions and health standards. Between 1850 and 1910 the Vienna population nearly quadruplicated from about 500.000 to over 2 mio. inhabitants. Due to the large amount of energy and space needed, Vienna's green spaces and especially the Vienna Woods more and more were considered as endangered and this development soon called for counteraction.

Adapting an initial plan from architect Eugen Fassbender from 1898 [5] [7], in 1905 the peripheral "Vienna Wood and Meadow Belt" was defined by the city government for the "durable protection for the health conditions in our city as well as for the preservation of the attractive natural frame conditions". So, the preservation of these large green areas mainly was founded on health considerations. This included the need to secure fresh air supply into the city, considering the heavily polluting industries at those times. Also, this peripheral green belt fitted within a concentric city development

2.3. 20th century: the century's catastrophes and stagnation in population growth

Soon after the beginning of the 20th century, the "endless city"-like growth came to a preliminary end with this century's mayor catastrophes – World War I and World War II, which – together with the iron curtain – led to an overall stagnation in Vienna's population growth until the end of the century.

model, promoted e.g. by the famous Viennese architect and city planner Otto WAGNER, which basically allowed an "unlimited" city growth (see Fig.1).

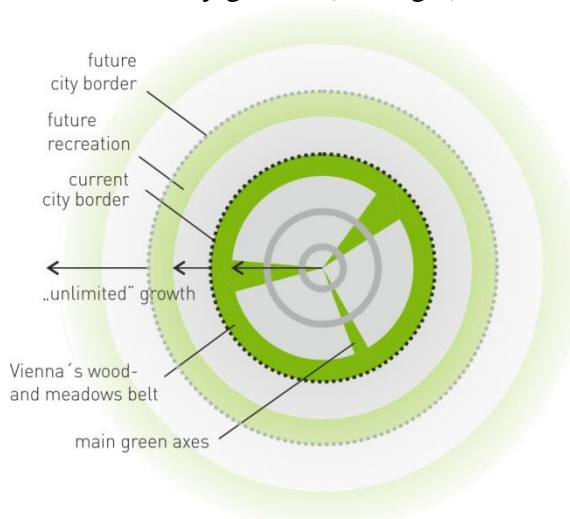


Fig. 1. 1905: Concept of the "unlimited" city growth with concentric green belts

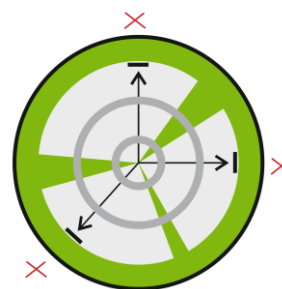


Fig. 2. 1955 to 1990 – Vienna green belt as ultimate city limit

Unlike its initial function as one of many recreational ring structures, to allow practically unlimited city expansion, now the Viennese green belt for the city planes

became like the green border, the ultimate lines for city development (Fig.2). Apart from traffic infrastructure, the areas surrounding Vienna, all of them within the province of Lower Austria, hardly were taken into consideration in terms of city planning and green space development. There was hardly any population growth and every infrastructural requirement should have been covered within the city borders.

With the Yugoslavian wars, after the fall of the Iron Curtain and with the European eastern countries applying for EU Membership, Vienna's population started to increase again, mainly from immigration.

The city development concepts from that time (1995, 2005) accordingly show stronger reflection on the landscape outside of Vienna's borders, the green- and open space concept from 2005 even shows Vienna's green belt as a part of the 5 surrounding mayor landscape types (Fig. 3). Nevertheless, apart from the Vienna Woods (UNESCO biosphere park, founded 2005) and the Donau-Auen National Park (1996) there has been no real collaboration between Vienna and surrounding Lower Austria to commonly develop those shared green spaces.



Fig. 3. 2005: First glance beyond the city borders: "Landscapes of the urban region"

3. Recreation and health – human needs that don't really change through times

In modern city planning green and open spaces are considered equally important as other infrastructural necessities like mobility or energy supply. One of the core functions of those green spaces is to provide health promoting features. Green and open spaces contribute to the health of the citizens in different physical, psychological and social ways. Vienna's city structure is strongly shaped by the 1905 established "Wood and Meadow Belt", which to preserve was a decision basically for public health reasons. Today, the supply of public health and welfare services still is one of the main function of city green space infrastructure and needs to be adapted to challenges like fast population growth, overaging and climate change [2].

4. Green space equity

Vienna has a total of more than 50% green space. This high share of green space will be maintained in the future, which makes green space equity a vital issue: all citizens have the same right to high-quality provision of green and open space. However the green spaces of course are not equally spread over the entire city area. Some quarters are undersupplied with green spaces and some are extremely fortunate. The appropriate connecting elements should safeguard a consistent infrastructural supply with green and open spaces to the best possible extent. By developing a robust open space system and safeguarding the required areas, future generations will be provided with continuous access to high-quality green and open spaces in a growing city [1]. “Green space equity” is one of the main goals for Vienna’s green space development planning.

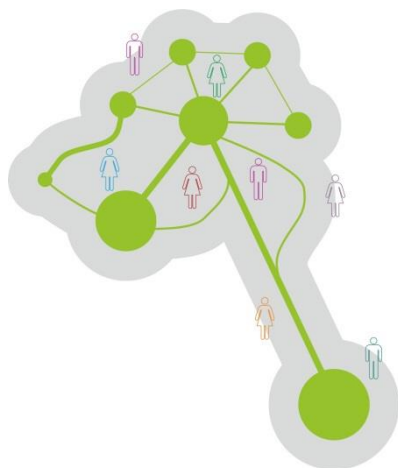


Fig. 4. Green space equity [1]

5. “Vienna City Region”: taking a new perspective on city growth

Green space equity as well as the preservation and improvement of green space qualities are the keys to better the availability of recreation possibilities and life quality for undersupplied city quarters. However with continuous population growth and densification potentials slowly coming to an end, there comes the point where the solution has to be broken down into one aspect: space.

Unlike in imperial times, when the empire’s capital just took the space it needed from its surroundings, today the administrative borders between the two equitable territorial entities Vienna and Lower Austria, are indisputable. Still, there is a traditional certain rivalry between the most (Vienna) and second most (Lower Austria) inhabited Austrian provincial states. It’s based on the common rivalry between urban and rural, different predominant ideologies and therefore traditional rivaling political parties leading the governments. So, the in many aspects vital collaboration between those provinces never has been completely frictionless.

Within today’s city region, administrative borders have lost their practical meaning in the people’s everyday life. Starting along the infrastructural axes the city slowly has blended into its surroundings and the region’s inhabitants care less and less whether they live in Vienna itself or just in the wider city region.

However, although it seems like the most logical and obvious way to address those

issues from the technical point of view – in a highly structured and organized western democracy like Austria, where each province has their own spatial planning authorities (and even laws), for local planners a collaborative approach to develop shared green spaces together appears groundbreaking.

For networking and coordinating common projects, in 2006 the joint platform “Stadt-Umland-Management” (SUM) was founded by the city of Vienna, the surrounding municipalities and the province of Lower Austria. Based on that platform many “cross-border” projects have been implemented but still there is need for general regional development policies.

So, Vienna’s green space planning department today wants to pick up that ball and aims in letting commonly developed regional green spaces be the first substantial collaboration in spatial planning between the Provinces of Vienna and Lower Austria.

6. New tools for Vienna’s green space planners

The Vienna city administration currently is developing the toolset for providing the necessary amount and qualities of urban green spaces for the future Vienna of 2 million citizens. Therefore, in 2014’s Thematic Concept “Green and open spaces” with methodical tools like the “Local green plan”, the 12 open space types and the green- and open space standards the basics have been set for quality assuring green space planning.

Being equipped with those tools and having gained experience on the local and district level, now Vienna’s city planners aim in setting up spatial tools to define Vienna’s green space development on a city-wide – or even wider – level.

Methodical tools

6.1. Local Green Plan

[6] The “Local Green Plan” is a planning method in which different types of open spaces are worked out, defined and assessed regarding their supply efficiency for the citizens. The “Local Green Plan” is a standardized tool for urban development planning which serves the collection of basic information for quality assuring procedures (competitions, cooperative planning procedures) and the design of land use plans.

Local Green Plans are based on 12 open space types: Open spaces in Vienna range from linear pedestrian zones to green axes to wide open, semi-public green spaces to protected areas. [6]

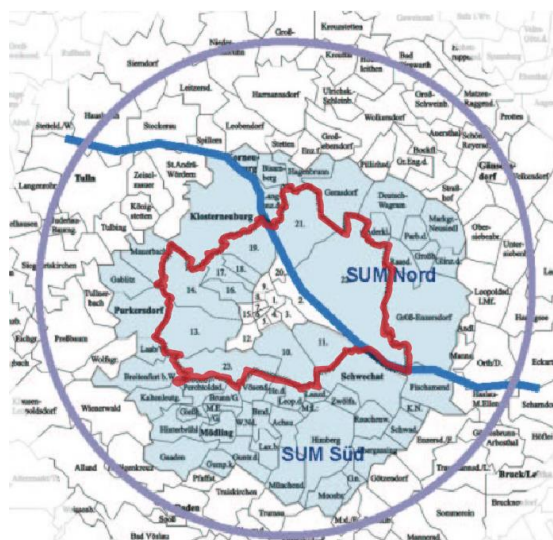


Fig. 5. Vienna City Region ([3] SUM, 2018)

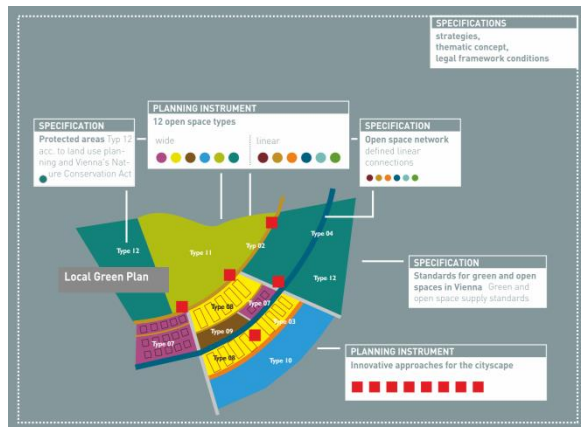


Fig. 6. Design of a Local Green Plan [6]

6.2. 12 open space types

6 linear and 6 wide open space types build the basis for green and open space planning of the city.

The types of open spaces are described regarding their form and functionality. If a space or a linear segment of the open space network has been defined as a particular type of open space, it has to fulfill certain functions.

The following functions are differentiated [1]:

- Function for everyday life and recreation
- Function for the structuring of the urban fabric
- Function for ecosystem services
- Function for nature conservation

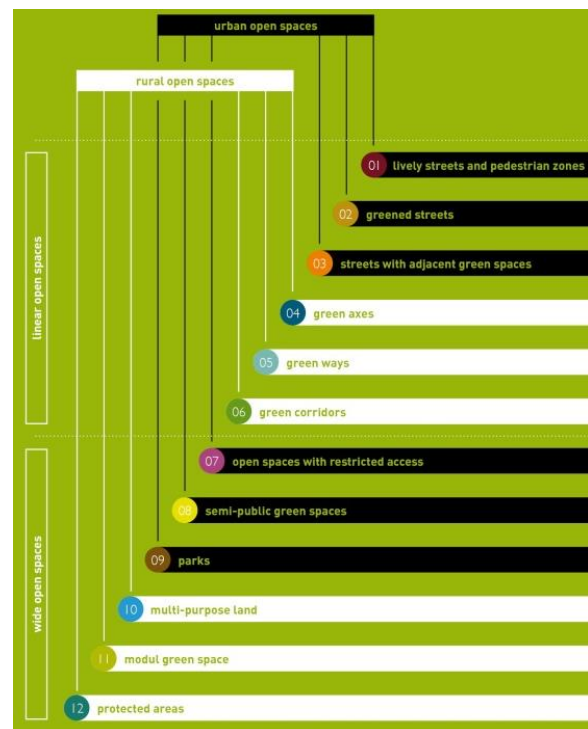


Fig. 7. Open space types for Vienna [6]

The 12 open space types provide a uniform tool for green and open space planning in Vienna for expert departments, planning offices and politicians. They currently are mainly being used as the basic elements of Local Green Plans (6.1.) and the Vienna Open Space Network (6.4.).

6.3. Green and open space standards

[6] The development of new urban quarters requires the securing of green infrastructure such as parks in the neighborhood. These green and open spaces are anticipatorily secured in urban development competitions, in master plans and in the course of land use and development plans. The new standards regarding the supply of green space contribute to quality assurance in new urban

development areas. They contain minimum dimensions, as well as catchment areas.

Especially children and older people need recreation areas close to their homes, such as parks and attractively designed public spaces. They are the basis for social cohesion in the neighborhood and are crucial in making an active and self-determined life possible in their own urban quarters.

GREEN AND OPEN SPACES	CATCHMENT AREA (m)	SIZES (hectare)	m ² per inhabitant	
Neighbourhood	250	< 1	3.5	
Residential area	500	1-3	4.0	13.0
Urban quarter	1,000	3-10	8.0	
	1,500	10-50	4.0	
Region	6,000	> 50	5.0	
+ sports ground			3.5	
+ green spaces per working place (catchment area 250 m)			2.0	

Fig. 8. Green and open space standards for Vienna [6]

Together with the 12 open space types, the green and open space standards build the basic planning elements of Local Green Plans (chapter 6.1.)

Spatial tools

6.4. Vienna Open Space Network

To address the aim of “green space equity” (chapter 4), the city planner’s future goal is that every Viennese will be able to reach the closest segment of the open space network within a distance of approx. 250 m. The idea behind this is to build a network of high-quality green and open spaces of different characteristics. Large-scale green

spaces, parks, smaller spaces of ecological importance, streets with green elements – they all will be connected to each other.

This network brings about many benefits, e.g. attractive thoroughfares which can be used on foot or by bike, an improvement of amenity and recreation quality in the close environs of residential areas or working places and a positive impact on the urban climate, as well as on the fauna and flora.

The close mesh of green and open space connections ensures that people of limited mobility also have access to high-quality spaces of leisure and exercise in their closest vicinity.

The network concept also includes linking and connecting Vienna’s open space network to the environs of the city.

For determine the form and functionality of each green connection, the 6 linear Open Space Types are being used. [1, 6]

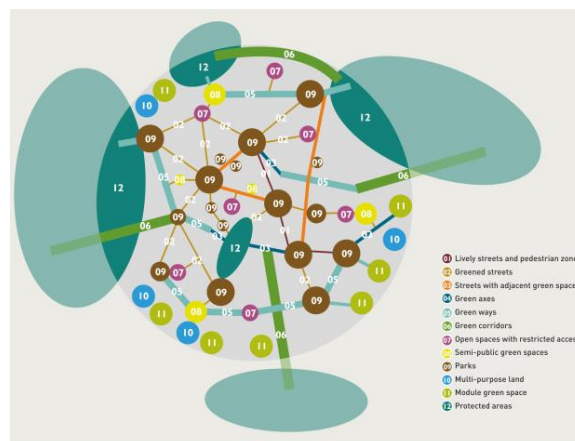


Fig. 9. Schematic scheme of Vienna’s open space network (open space types 0-6) connecting the wide open space types 7-12 [6]

6.5. 16 functional zones

For the development of the new city-wide green space model, the determination of green areas will be based on a multi-layered GIS database of already approved existing green infrastructure functionalities (e.g. nature protected areas, agricultural zones, climate-relevant areas ...) (see Fig. 10).

This also includes city structural functions like the city's green space department redefining an inviolable green space category "Vienna green belt" which founds in the historic, functional and identity-establishing city-wide importance of the interconnected major Vienna green areas.

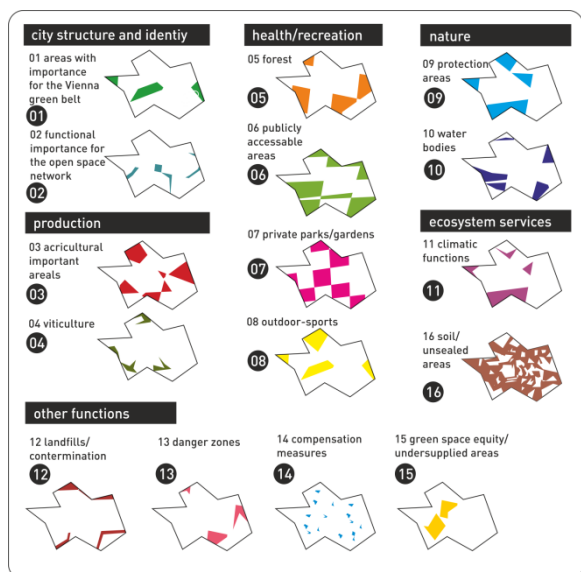


Fig. 10. 16 functional zones (schematic illustrations)

Each of the 16 green-infrastructure functions provides the green planners with arguments to preserve those areas. Overlaying all 16 maps, some areas will serve with a couple of functions, some with

only one. The amount and the types of functions of each area will lead to a certain assertion of the green space development department how to proceed with it within the Vienna's redefined green- and open space system (see chapter 7).

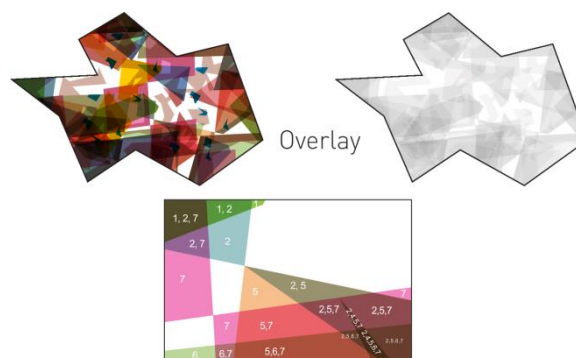


Fig. 11. Overlaying the 16 functional zones (schematic illustration)

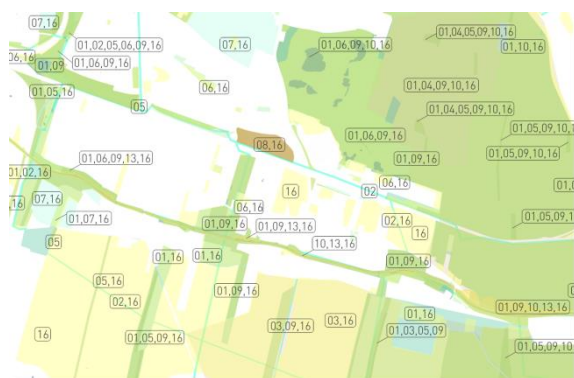


Fig. 12. Overlaying the 16 functional zones (schematic draft)

7. The new Vienna green and open space system (2020)

Given the proper toolset the city planners now are able to define and conclusively justify Vienna's green- and open space system for the next decades. It consists of

only 4 clearly defined, easy to understand and to communicate categories. Based on the amount and type of green infrastructural functions, one of the following categories will apply to each area:

1. Green spaces of the city region

These large green areas are the commonly developed nature- and recreational areas in the city region. The areas crossing the administration border consist of “Vienna Green Belt”-areas and the bordering areas of the neighboring municipalities. Altogether they build up to a wide green ring structure around the city independently from the official city borders and beneficiary for both – Viennese and Lower Austrians.

2. Open Space Network

The network of green infrastructure provides green mobility and green space equity for the whole city population, balancing out inequities between unequally equipped parts of the city. In many parts the Open Space Network already exists, in some measures are still required to increase their functionality according to their open space type.

3. Vienna’s Gardens and Parks

Vienna’s publicly accessible historic and contemporary gardens and parks are used for recreation within the city in minor distances to the residential quarters. They also incomparably shape the face and the identity of Vienna.

4. Vienna Landscapes – Next Generation

City planning is the process of continuously adapting the city to the

current challenges. Therefore planning-reserves are needed. With the „Next Generation“-areas, the city preserves planning possibilities for its future (presently unknown) goals. So, the decision if those areas will host agriculture, recreation areas, residential or commercial zones is to be made by future generations.

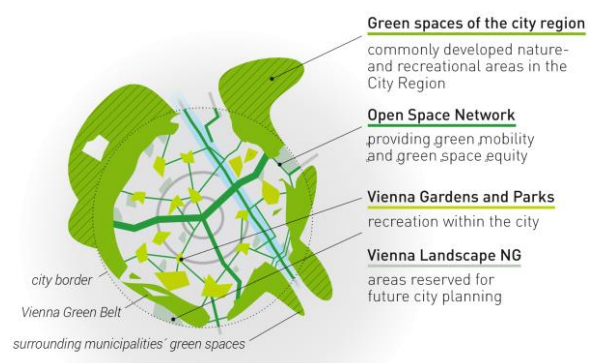


Fig. 13. Vienna’s open and green space planning model for 2020+

The conclusively justified 4 green space categories and the transparency in decision result in an indisputable, legally sustainable and widely accepted instrument suitable to preserve Vienna’s green character and the life quality in the city region for the upcoming decades.

8. Conclusion

Vienna’s worldwide acknowledged life quality to a large extent origins in its historic green spaces and the decisions and plans being made over 100 years ago to preserve and maintain them.

With the foundation on its green heritage, with the overall goal of “green space equity”, with a sophisticated quality preserving toolset, with the awareness of a city development not ending at the administrative border, and conclusively – with the acknowledgment and integration of green infrastructure functionality equal to all the other urban infrastructural needs, Vienna sets up the framework for a strong and consistent green- and open space system for the 21st century. – Good thing, knowing that many of the answers to today’s and tomorrow’s challenges like climate-change, energy revolution, changes in urban mobility, city population growth and -aging can be found in the urban green and open spaces.

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Embracing Nature through the Green Infrastructure Network of Extensive Urban Parks System, Park Connectors and Suburban Forest Parks: Fuzhou, A Case Study of the Emerging Biophilic City in China

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Abstract

Influenced by trends like Landscape Urbanism and Biophilic City, landscape architects find themselves playing more vital roles in reshaping cities nowadays. With the deepening of the study on Biophilic City by Timothy Beatley, Peter Newman, Angela Reeve, Ruth A. Rae and others, its definition, contents, characteristics and practice approaches are gradually clear. However, these researches mostly focus on cities in Europe, Oceania and North America. Asian cities, especially those in China are seldom mentioned. Actually, some Chinese cities are potential emerging biophilic cities. In this paper, we select Fuzhou, the capital of Fujian Province in the southeast of China, as the object of study. Fuzhou is a dense and land-scarce central city which is home to some 7.57 million people. Its good expression as a biophilic city in the coastal valley plain makes it worth studying. Benefiting from the superior natural environment, eco-friendly philosophy of living, widespread introduction of green development concept and successful landscape architecture practice, an increasingly complete green infrastructure network lead by landscape architecture has been gradually constructed. Nature can be found everywhere in Fuzhou. Citizens benefit a lot in daily life. In order to clarify its biophilic features and spatial framework as a biophilic city, we disassemble its green infrastructure network into the following three parts: extensive urban parks system, park connectors and suburban forest parks. Extensive urban parks system consists of some 150 all kinds of urban parks in various types and scales, occupying a total area of some 21.25km². Attached to many low hills with lush vegetation as well as lots of urban rivers, lakes and other water resources, these parks make it possible for all citizens to enjoy the benefits of nature after a some 15 to 25 minutes' walk from every corner in this city. Among them, the West Lake Park is the typical representative. Several park connectors, providing elevated canopy walk to offer dramatic perspectives of the city, express another particular characteristic of biophilic Fuzhou. Awarded the International Architecture Awards 2017, the Fudao Park Connector designed by LOOK Architects is the most impressive one. This totally 19 kilometres long signature connector that provides public accessibility to indigenous hinterland

stretching north-east of Fudao signifies an awakened consciousness to improve lives of city dwellers by bringing nature within closer reach. Some 15 suburban forest parks of all kinds, total area of about 574.95km², are surrounding Fuzhou within a 30 minutes' drive from downtown. Qishan National Forest Park and Fuzhou National Forest Park, as typical representatives, are of high biological diversity and have nice therapeutic function to the visitors. The study of Fuzhou's success as a Chinese biophilic city may help us understanding the leading role of landscape architecture in improving our urban and natural environment in the context of a biophilic city.

Keywords: Landscape Architecture ; Chinese Biophilic Cities ; Green Infrastructure Network ; Extensive Urban Parks System ; Park Connectors ; Suburban Forest Parks

1. Introduction

Influenced by trends like Landscape Urbanism, Biophilic City and so on, landscape architects find themselves playing more vital roles in reshaping cities nowadays. Especially after the publication of two remarkable books which are *Biophilic Cities: Integrating Nature into Urban Design and Planning* and *Handbook of Biophilic City Planning and Design* by Timothy Beatley in the aspect of Biophilic City, we become more conscious in rethinking our discipline and the practice of landscape architecture in the context of rapidly growing cities.

With the deepening of the study on Biophilic City by Timothy Beatley [1-3], Angela Reeve [4], Ruth A. Rae [5], Emmanuel L. M. Wolfs [6], Sue Ruddick [7], CO Ryan [8], Peter Newman [1, 9], Jules Prettya [10], J Honey-Rosés [11], Germán I. Andrade [12] and others, its definition, contents, characteristics and practice approaches are gradually clear. "Biophilic Cities are sustainable and resilient cities. It provides close and daily contact with nature, nearby nature, but also seek to foster an awareness of and caring for this nature. It helps to foster social and landscape resilience, in the face of climate change, natural disasters and economic uncertainty and various other shocks that cities will face in the future [1]."

However, these researches mostly focus on cities in Europe, Oceania and North America. Asian cities, especially those in China are seldom mentioned. Only Chengdu and Tianjin were found in correlational research with brief and short introduction. As Timothy Beatley puts it, "The view of cities as spaces for cohabitation, shared spaces, is growing stronger, but much more needs to be done. We see these sensibilities and priorities expressed in cities in many other ways [3]." Actually, some Chinese cities are potential emerging biophilic cities. They are indeed worth studying.

2. Fuzhou as a Case Study in China

In this paper, we select Fuzhou, the capital city of Fujian Province in the southeast of China, as the object of study, Fig.1. It is in harmony with nature and seems to be a typical emerging biophilic cities in China. Its good expression as a biophilic city in the coastal valley plain makes it worth studying.



Fig. 1. The location of Fuzhou, Fujian Province.

2.1. City Profile

Fuzhou lays on coastal hilly plain areas of Minjiang River estuary, Fig.2. It is a dense and land-scarce central city which is home to some 7.57 million people.

Its rainy and moist subtropical marine monsoon climate, rich water resources, abundant flora and fauna together with plenty of low hills inside and outside the city construct an ideal foundation for the natural environment as a typical biophilic city, Fig.3.



Fig. 2. Fuzhou.



Fig. 3. Natural environment of Fuzhou.

2.2. From a traditional “Shanshui City” to a modern biophilic city

Ancient Fuzhou is one of the best example of widely accepted Chinese traditional “Shanshui City” under the strong influence of “Shanshui Culture” which is one of the most vital traditional Chinese culture emphasizing reaching harmony with nature in the living environment, Fig.4.

Nowadays, Fuzhou inherited this tradition very well and has achieved a further development as a biophilic city under a balanced concept combining traditional ideas with modern theories of urban planning and landscape architecture.

Benefiting from the superior natural environment, eco-friendly philosophy of living, widespread introduction of green development concept and successful landscape architecture practice, an increasingly complete green infrastructure network lead by landscape architecture has been gradually constructed. Nature can be found everywhere in Fuzhou. Citizens benefit a lot in their daily life.

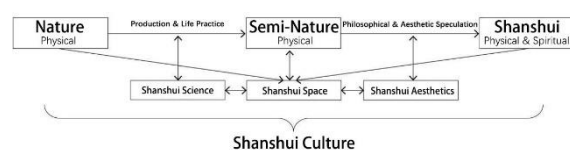


Fig. 4. The definition of “Shanshui Culture”.

3. Biophilic features and spatial framework of Fuzhou as a biophilic city

In order to clarify the biophilic features and spatial framework of Fuzhou as a biophilic city, we disassemble its green infrastructure network into the following three parts: extensive urban parks system, park connectors and suburban forest parks.

3.1. Extensive urban parks system

Extensive urban parks system consists of some 150 all kinds of urban parks in various types and scales, occupying a total area of some 21.25km². Attached to many low hills with lush vegetation as well as lots of urban rivers, lakes and other water resources, these parks make it possible for all citizens to enjoy the benefits of nature after a some 15 to 25 minutes' walk from every corner in this city. Among them, the West Lake Park is the typical representative.

West Lake Park, located in the central area of Fuzhou, has a history of more than 1,700 years and is the most complete classical garden in Fuzhou, Fig.5. Nowadays, it covers an area of 42.51 hectares, of which 12.21 hectares of land area, water area of 30.3 hectares. Liu causeway, Kaihua Island, Lagerstroemia Hall, Kaihua Temple, Wanzai Hall, Dressing Pavilion, Fujian Museum, West Lake Academy and so on are the main traditional and modern attractions. The local citizens treat it as a treasure of the city and will always pay a visit to enjoy their leisure time with friends and family in the park.



Fig. 5. West Lake Park.

Source:

<http://www.nipic.com/show/4884947.html>.

What's more, the ambitious project which is called Fuzhou Beaded Ecological Park, just like the Emerald Necklace in Boston, are ongoing. The first batch of Fuzhou Beaded Ecological Park which consist of 28 parks are already Open to the public in 2017. They become vital green infrastructure as well as robust city sponge along side the city rivers.

Numerous parks occupying urban low hills with lush vegetation scattered in the city. Varying from traditional parks with a long history like Wushan Park, Yushan Park and Pingshan Park to modern parks like Jinniushan Park and Feifengshan Park, these parks take advantages of hilly areas and enlarge the urban green space network as well as the welfare of the public.

3.2. Park connectors

Several park connectors, such as Fudao Park Connector, Jinjishan Park Connector and so on, providing elevated canopy walk to offer dramatic perspectives of the city, express another particular characteristic of biophilic Fuzhou. The Fudao Park Connector designed by LOOK Architects, which is awarded the International Architecture Awards 2017, is the most impressive one, Fig.6.

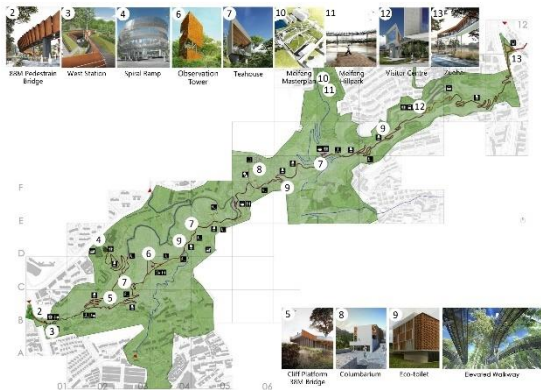


Fig. 6. Overall site plan of Fudao Park Connector.
 Source:
https://images.adsttc.com/media/images/595d/d9e6/b22e/38d8/8b00/013c/large_jpg/Location_map_rev.jpg?1499322839.

The Fudao Park Connector is the first-of-its kind elevated steel pedestrian walkway system weaving through forested areas in China [13]. This totally 19 kilometres long signature connector that provides public accessibility to indigenous hinterland stretching north-east of Fudao signifies an awakened consciousness to improve lives of city dwellers by bringing nature within closer reach [14].

There are about 10 entrances of the Fudao Park Connector in total around the Jinniushan Hill, constructing an easy and accessible networks of conversion points from weary urban life to the embrace of nature. Several rest shelters, viewing decks, observation towers and teahouses are sited evenly and reasonably throughout the route. Use of steel grating for the walkway decks serves to bring natural light down to the ground plane, encouraging low-lying plants to thrive, Fig.7-8, [14].

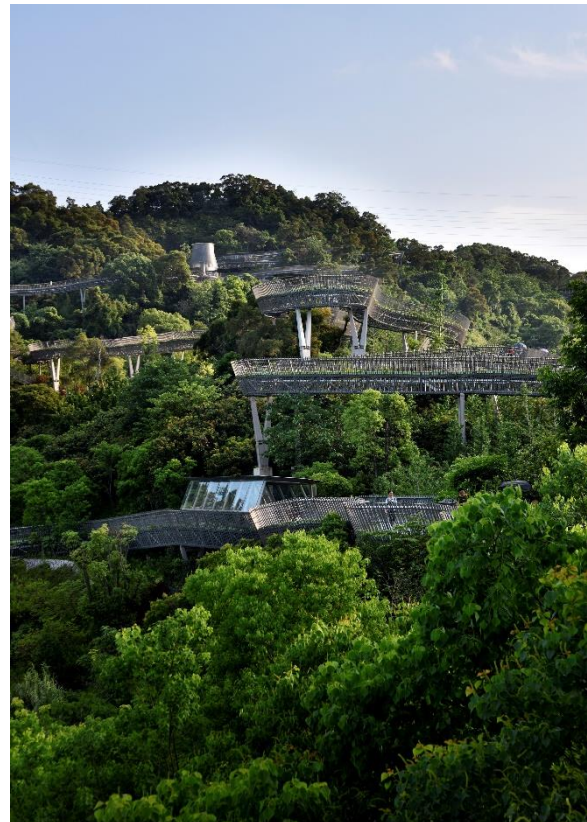


Fig. 7. Fudao Park Connector.
 Source:
https://images.adsttc.com/media/images/595d/d8a5/b22e/38d8/8b00/0134/large_jpg/Fuzhou_02.jpg?1499322497.

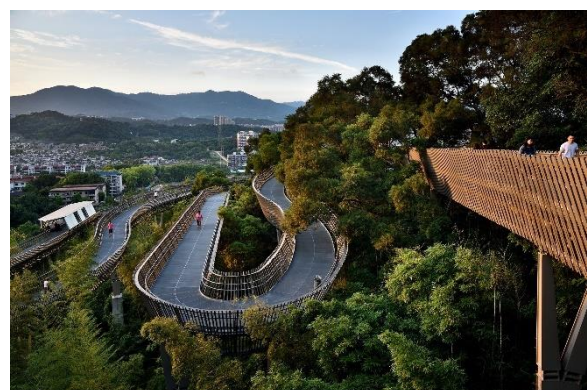


Fig. 8. Fudao Park Connector.
 Source:
https://images.adsttc.com/media/images/595d/d9d1/b22e/3853/7c00/008a/large_jpg/Fuzhou_17.jpg?1499322826.

Jinjishan Park Connector, another famous park connector which is situated in the north of the city, is a 2500-meter-long elevated pedestrian walkway stretching upon the Jinjishan Hill, Fig.9. Its other name is “Lancheng Walkway”, which means a park connector of embracing the city because of its shape and nice view of overlooking the city.



Fig. 9. Jinjishan Park Connector.
 Source:
http://tieba.baidu.com/photo/p?kw=%E7%A6%8F%E5%B7%9E&ie=utf-8&flux=1&tid=4532320599&pic_id=47982f2eb9389b50d54da6ab8235e5dde6116e66&pn=1&fp=2&see_lz=1.

3.3. Suburban forest parks

Some 15 suburban forest parks of all kinds, total area of about 574.95km², are surrounding Fuzhou within a 30 minutes’ drive from downtown. Among them, 5 are national forest parks and the other 10 are provincial forest parks. Fuzhou National Forest Park and Qishan National Forest Park, as typical representatives, are of high biological diversity and have nice therapeutic function to the visitors.

Fuzhou National Forest Park with an area of 859.33 hectares, which was founded in

1960, is the first national forest park in Fujian Province and one of the top ten forest parks in China, Fig.10. It is divided into 5 sections: forest area, nursery, greenhouse, special park, and rest area. Due to the geographical environment and the protective effect of forests, a unique microclimate is formed in the park. It is warm in winter and cool in summer. The average temperature in summer is 3-5 degrees Celsius lower than inside the city. The forest releases a large amount of oxygen and negative oxygen ions, attracting many people to experience the “forest bathing” and is known as “the largest natural oxygen bar in Fuzhou” [15].



Fig. 10. Fuzhou National Forest Park.
 Source:
<http://you.ctrip.com/sight/fuzhou164/8797-dianping.html>.

Qishan National Forest Park, occupying an area of 35.87km², is located in the southwest, only 25 kilometers away from the downtown. In 2007, Qishan Forest Park officially launched the Forest People's Tourism Project. It is a new type of leisure tourism which is based on its good forest ecological resources and environment. It uses local forest farmers and large households as the main business and integrates forest culture and folk customs as one of the cities [16]. Besides, hot springs, Shisong Temple, Wanfo Temple, Shuixiang

Ancient Road and others are the main attractions there.

4. Conclusions

The research of biophilic city is especially important and urgent now, as Timothy Beatley puts it in his latest book: “As Planet Earth lunges forward toward a higher and higher percentage of world population living in cities, it is timely to rethink how these cities function and feel to those living in them ... nature is not something optional, but, rather, absolutely essential to living healthy, interesting, and meaningful lives [3].”

In this paper, we select Fuzhou as a typical emerging biophilic city in the southeast of China and conduct a brief research of Fuzhou’s natural and cultural conditions to analyze its inheritance and development from a traditional “Shanshui City” to a modern biophilic city. Its biophilic features and spatial framework are mainly expressed as a comprehensive, ecological and robust green infrastructure network consisting of extensive urban parks system, park connectors and suburban forest parks.

The study of Fuzhou’s success as a Chinese biophilic city may arouse more scholars' attention and research on Chinese cities and help us understanding the leading role of landscape architecture in improving our urban and natural environment in the context of a biophilic city.

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Greening Chóngqìng: Creating a Green City on the Yangzi (Cháng Jiāng) towards Enhancing ‘Double Happiness’

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Abstract

Now hosting 32.4 million residents, Chóngqìng is the fastest growing inland city in China, and the most populous of the Chinese municipalities. Located at the confluence of the Yangze (Cháng Jiāng) and Jialing (Jiǎlíng Jiāng) rivers, originally named Jiangzhou in 316 BCE, Chóngqìng has historically served as a key economic node and centre of governance in China. The ancient city of Chóngqìng exists within the ‘mother town’ inside Yuzhong District today home to some 639,000 residents. The District offers unique archaeological records spanning over 3,000 years, and has experienced four distinct city wall construction movements that uniquely created a city analogous to the medieval walled cities of Europe. The first three wall-building movements resulted in a gradual expansion of the city’s footprint, while the latter wall-building movement was highly influenced by a Fengshui (Compass school) theory. The city’s urban tapestry is today interlaced and characterised by a unique semi-grid system of human and trade-movement mountain trails, possibly linking port gates on the Yangze and Jialing River edges. These rivers provided important water trade passageways and potable drinking water supplies for residents prior to the construction of a reticulated water supply. Once physically constrained within these walls, contemporary urbanisation has witnessed extensive industrialization and suburbanization on both sides of the rivers and in the larger valley, and massive urban rejuvenation projects within Yuzhong District. Considerable portions of this historic Yuzhong District tapestry exists today, and uniquely characterises Chóngqìng from other cities in China.

This paper considers the vision and planning process being taken in Chóngqìng to craft a unique greening strategy termed ‘Green Cultural Belt’. The overarching aim of this vision and planning process is to formulate a Greening Strategy and Master Plan focused upon the central Yudong District; for the ‘mother town’ area of Chóngqìng. Key elements of this vision include greening the image and character of the city; respecting and revealing cultural heritage values; mitigating the urban heat island effect and the occasional fog that veils the city; re-capturing and responding to the villages and mountain trails that interlace the ancient city; exploring and emphasizing pedestrianisation in the ancient city; and positioning Chóngqìng as a prospective Ecocity exemplar in China.

Involving a joint applied landscape planning research partnership between Chóngqìng University and Deakin University. The partnership is seeking to apply ecological

determinism theory and practice to inform the development of a strategy for Chóngqìng having regard to its historic and topographical characteristics. The research points to the potency of formulating a green city strategy unique for a city highly constrained and morphologically structured by its topography, as distinct from many urban cities. The findings demonstrate that an ancient-city-wide greening strategy can offer a successful ecological deterministic strategy for other Chinese cities. This Chóngqìng example confronts major challenges in addressing growth and its negative consequences, while crafting a strategy for a highly topographic and constrained city that will provide an enduring landscape planning legacy reflecting international best practice.

Keywords: City greening; Chóngqìng; Landscape architecture

1. Introduction

In translating human values to nature using Chóngqìng in China as the case study venue, this paper discusses urban ecological theory and archetypes, having regard to the current issues and potential ecological strategies for Yuzhong District in Chóngqìng -- the urbanized old town area of Chongqing. This investigation examines the cultural traditions and fabric of the District, and the existing human movement circulation system embodied in a unique ‘mountain-trail’ walking network. Both aspects are increasingly being negatively affected by over-sized infrastructure to service vehicle accessibility and movement needs despite District policy changes towards increasing walkability and the provision of green infrastructure. This contextual setting prompts a relevant and timely discussion about the position and contribution of the ICOMOS-authored Historic Urban Landscape (HUL) [1] approach and current discussions about biophilic design informing policy and design strategies that could aid the future conservation and greening of Chóngqìng and in particular, Yuzhong District.

In China, the number of people living in urban areas has now surpassed the number of people living in rural areas; this pattern is also replicable globally. In this context, the 21st century has become the ‘Urban Era’ reinforcing the potency of the built

environment as the central domain for human activity and habitation.

Biophilic city design and planning indicators have been extensively canvassed [2], and there is a growing emergent body of biophilic city design case studies to inform and guide this shift in city design and planning [3, 4]. But such case studies are biased towards developed nation exemplars, retrofitting new and or old developed cities, and bear little advice on how to proceed in culturally and historically-rich places in Asia facing rapid changes in culture, place and habitat.

This paper considers the urbanized old town area of Chóngqìng, on Yuzhong Peninsula, in the burgeoning metropolis of Chongqing, in the south-west interior of China.

It offers a review of the town planning history of this landscape through the lens of human relationships to nature, revealed in its current relationship and treatment of nature to ecological development.

The urban ‘mountain trails’ or cultural trails of Yuzhong Peninsula, which used to link its old city gates and the water edges and mountains of the District, is a unique Historic Urban Landscape (HUL) [1] representing successive layers of meanings of this urban area. The landscape is also a significant potential venue for the creative

implementation of biophilic design and activities strategies.

For many historic cities, their origin and typology is based upon a deep respect and understanding of nature and the landscape that inform the physical siting of the village (now town or city).

This line of argument leads us to discuss the relationship between the increasingly dynamic cultural landscape conservation approach to Asian urban contexts and biophilic city design – an aspect missing in all the latter’s discussions and writings to date.

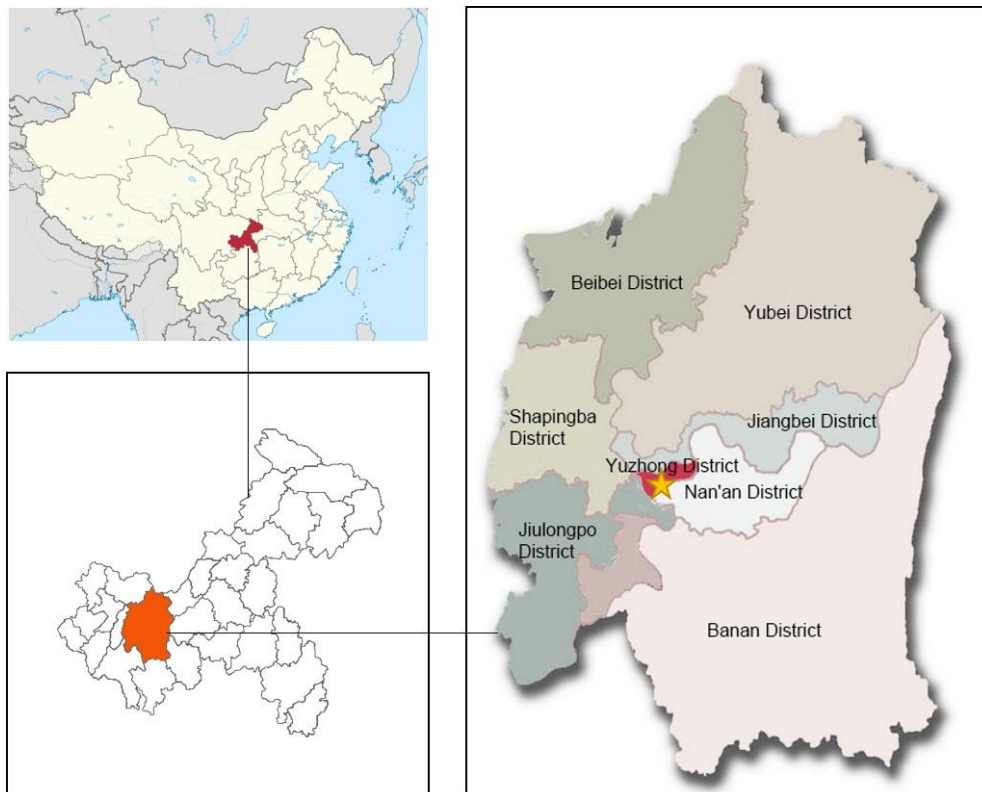


Figure 1: The location of Chongqing and Yuzhong District. (Source: the authors).

2. Biophilic Cities and Oneness with Nature

What is a biophilic city? As Beatley articulates it is:

... a city that puts nature first in its design, planning, and management; it recognizes the essential need for daily human contact with nature as well as the many environmental and economic values provided by nature and natural systems [2].

Included in this definition are indicators that include consideration of ‘biophilic condition and infrastructure’, ‘biophilic activities’, ‘biophilic attitude and knowledge’, ‘Institution and governance’ [2].

From our perspective as researchers and city participants, the nature of our practice involves two aspirations:

1. to embrace and insert more natural elements into the human environment, thereby increasing human contact with nature, and to intentionally re-share these spaces with other species; and
2. to improve integrations of human environments within larger natural systems, to improve cross-species habitat venues, ecological security and green infrastructure.

As a point of definition, our use of ‘natural’ recognises the definition that all aspects of the Earth have been modified by human activity, and that ‘natural’ in its true applied science sense does not exist today [5]. Instead, we reside within culturally modified environments and novel ecosystems.

For some ancient cities in China, the philosophy of town construction and

landscape arrangement embodied a strong reverence of nature and subsequent adaptation to it. This action reflected the central theme of traditional Chinese philosophy that accentuates the relationship between nature and humans [6, 7]. This philosophy includes an “Oneness with nature”, requiring human beings to keep harmony and unity with nature, and for human beings and other species and elements in the natural world to share an ethical equality with each other [8]. This philosophy responds well to both sides of our understanding of biophilic design.

Interestingly, the evolution of Chóngqìng as a village on the Peninsula is very much informed by this historical ‘oneness’ philosophy, as well as the more recent Fengshui. Fengshui theory is a representation of this historical philosophy, seeking to achieve harmonisation amongst heaven, earth and human beings by providing equilibrium amongst nature, building(s) and people [9]. Figure 2 below shows a Form-school Fengshui concept on the ideal siting consideration template for town location and construction, demonstrating the ideal relationship between humans and the natural environment.

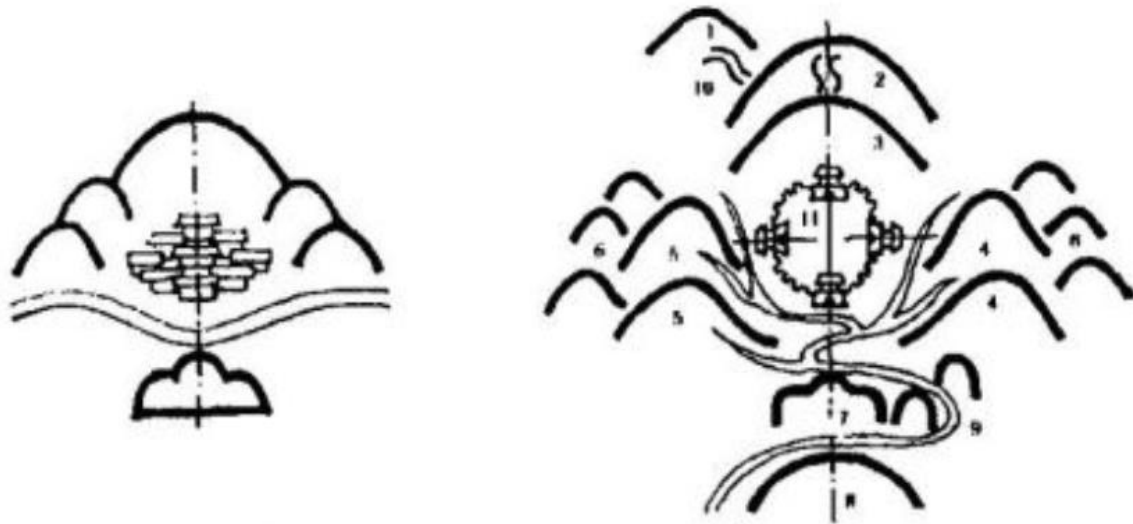


Figure 2: The ideal Fengshui mode for village and town construction. Source: [10].

3. Chóngqìng and its Yuzhong Peninsula

Chóngqìng, formerly known as Chungking, is located in southwest China, is the largest city in central China. With a history of more than 2,000 years, Chóngqìng has functioned as the economic and financial hub of the upper Yangtze River catchment in China since the Qing Dynasty. Chóngqìng’s pivotal status in China continues today because Chóngqìng is one of only 4 direct-controlled municipal cities of China (the other 3 being Beijing, Shanghai and Tianjin). It is also the only municipality in China located away from the coast.

The urban area of Chóngqìng is known as Central Chóngqìng and covers approximately 5,473 km². Chóngqìng. The Yuzhong District (“Central Chóngqìng

District”), with an area of 23.71 km², is the geographically central, historically oldest, and most densely populated district of Chóngqìng. As the original site of the metropolis of Chóngqìng, it is located on a peninsula confined by the major trade navigation routes of the Yangtze and the Jialing Rivers.

4. Reverence and adaption of nature

The major part of today’s Yuzhong Peninsula was where the ancient Chóngqìng city was originally sited. Built on a mountainous landform, and as a port city confined by two rivers (the Yangtze and the Jialing), the urban planning philosophy of old Chóngqìng city embodied a strong sense of reverence to nature.

4.1 The gate structure with Fengshui meaning

Historically, there are 4 periods of ancient town construction of old Chóngqìng. The core historical period resulted in a town finally characterised by 9 water gates and 8 fire gates. The reference to water and fire alludes to this reverence embedded in

Chóngqìng’s city structure (Figure 3). As part of this design theory, the symbolic role of ‘water’ is to control ‘fire’, (only 9 water gates can be opened and each links to water; the 8 fire gates complete the Fengshui urban structure theory).



Figure 3: The 17 gates of old Chongqing (map of Chongqing, 1891). (Source: http://cq.cqnews.net/shxw/2015-07/02/content_34646846.htm ; accessed 1 July 2017).

Fire is a key archetypal value because historically Chóngqìng governance and citizens were always concerned with fire due to the predominance of bamboo and wood materials in building fabrication, and the close proximity of the buildings on the Peninsula. Similarly, the numbers 8 and 9 represent ‘9 palaces and 8 diagrams’, drawing reference to traditional Chinese philosophy, while also demonstrating defensive integrity and capability at the key juncture of two rivers. Further, the stilted timber buildings erected on the Peninsula

followed the contours, accentuating the geographical character of the landform (Figures 4 and 5).



Figure 4: stilted buildings and old Chongqing
 Source:

<http://Itsxr2008.blog.163.com/blog/static/48157980201161232942426/> , accessed 5 April 2018.

4.2 Self-adaptive trails

To cater for this unique geographical context, the trails historically evolved interlacing through this mountainous topography. The way these streets adapted to this uneven and often steep topography nonetheless resulted in the creation of flexible public spaces (Figures 4, 5 and 6), making these streets not only a space for transportation, but also venues and stages for social activities including small businesses, playing Majiang and chatting. This natural geographical environment historically formed the unique built environment space that is Chóngqìng today, which also historically informed the nature of Chóngqìng’s social activities and collective culture.

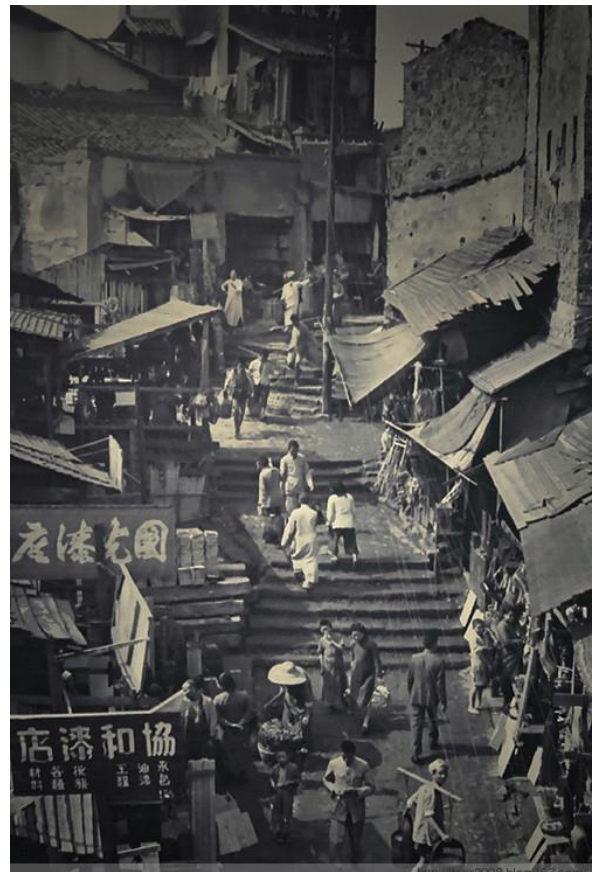


Figure 5: the self-adaptive trails one hundred years ago. Source:

<http://Itsxr2008.blog.163.com/blog/static/48157980201161232942426/>; accessed 4 April 2018)

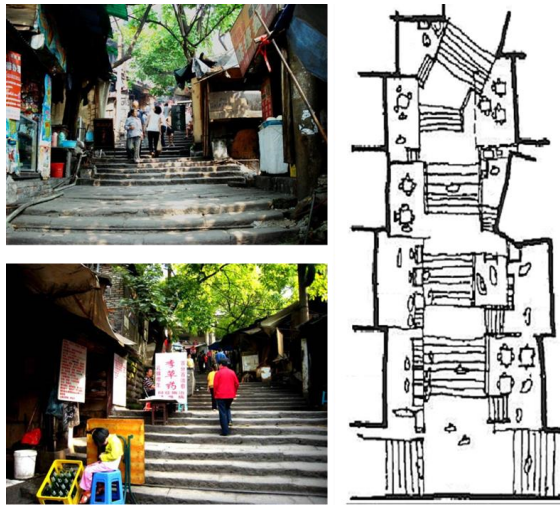


Figure 6: Self-adaptive trails and public space. Source: the authors and Zhao (2003)

4.3 To ‘overcome’ nature

The contemporary emergence of high-rise buildings symbolizes Chinese people’s effort to overcome nature in Chóngqing. Symbolically these new towers are seeking to break the historical limitations of vertical development and spatial capacity. As a mountainous city, Chóngqing’s contemporary construction regulations have demonstrated softer requirements upon distances between buildings. In contrast, flat regions in China have a relatively strict requirement on the provision of daylighting and distance between new buildings. Instead, Yuzhong Peninsula, as a continuing Central Business District of Chóngqing, has become filled up with candle-like skyscrapers (Figure 7). These towers not only destroy the harmonious visual relationship between mountain, river and built environment, but also are leading to a convoluted and vast mosaic of grey infrastructure and construction that is changing the original walking-based culture and main circulation structure of Chóngqing.

This vehicle road construction is resulting in separated and imbalanced functions and social infrastructures. The first new vehicle road construction can be traced back to the 1920s when demolition of the original city wall defences commenced to facilitate city expansion. In recent decades, the process of vehicular road construction has increased, not only because of increasing population, but also due to imbalanced strategic planning.

For clarification, the City of Chongqing and Yuzhong District, have their own five-year plans as official urban developmental strategies. In the *13th Five-Year Plan* (2016-2020) [11] of the City of Chóngqing, a requirement has been placed on the need to balance the functional development of city and to apply a cluster town planning model. This Plan emphasizes a cluster-node urban spatial layout and the need to balance working and living functions in each cluster, to reduce the unnecessary movement between clusters.

The development strategy for Yuzhong District, however, as the most significant central portion of Chóngqing and its core function as a port area, highly emphasizes its commercial and business functions, which is increasingly breaking the balance of the historical functions of living and working harmoniously in the District.

This argument is evidenced in the *Yuzhong Image Design Planning and Control Regulations* [12]. Articles 6 and 7 of these *Regulations* are stated in Appendix A.

Further, the yearbook of Chóngqìng statistically evidences the practical application of these strategies that have resulted in a continuous reduction in the residential population of Yuzhong District in 2005, 2010 and 2015 (Appendix C).

4.4 To compromise with nature

Over the last 20 years Chóngqìng has experienced considerable growth in the construction of large-scale buildings to accommodate commercial, office or cultural

activities. Figure 7 quantifies the construction of skyscrapers above 100m in height from 1998 to 2020, of which there are 79 buildings from 2005-2015 alone. Prior to this, only 15 such skyscrapers were built in 1998-2004. Among these new 79 skyscrapers, 26 were built in Yuzhong District, comprising a building footprint area of 0.4% of the Chóngqìng metropolitan area.

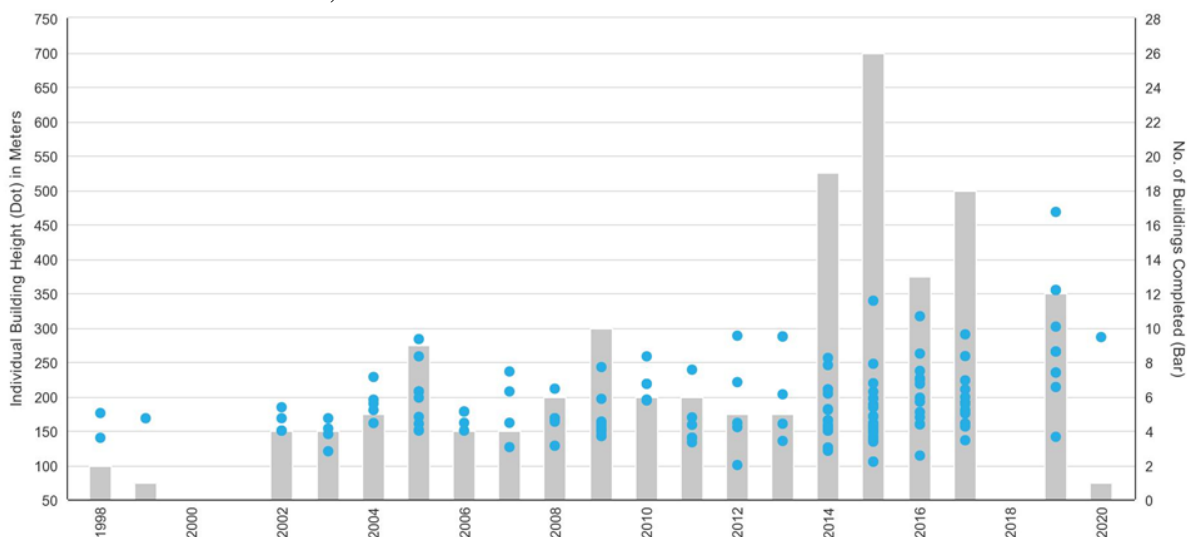


Figure 7: Skyscrapers being built in Chongqing (source: <http://www.skyscrapercenter.com/city/chongqing>); accessed 5 April, 2018).

Vehicle infrastructure construction has been an immediate outcome of this building construction to service and support this rapid and imbalanced development. Thus, vast new traffic infrastructure are needed to transport people from residential areas to Yuzhong for work and shopping, as well as to transport supplies of goods and materials for business and commercial activities. A substantial period of construction was legitimatised in traffic infrastructure

planning heralded in the *11th 5-Year Plan* (2006-2010) [13] of Yuzhong District aim is set out in Appendix B.

This vehicular infrastructure involves the construction of roads to surround the peninsula to stimulate the productivity of the District, and to supposedly increase the economic vitality of Yuzhong. However, many places in the District that previously supported local social activities have

vanished, especially along the waterfront area (Figure 7).



Figure 7: Layers of vehicle roads along Yuzhong waterfront have compromised access and social opportunities

Source:

<http://www.tukuchina.cn/r/photo/view/id/2323827471/>, accessed 6 April 2018.

5. To compromise with nature

Despite this change, there continues to be human inconvenience due to vehicle use and parking inside the mountainous landscape of the Peninsula. This is why successive Plans for the District have sought to include the revitalization of the extant walking system through Yuzhong Peninsula (Figure 8).

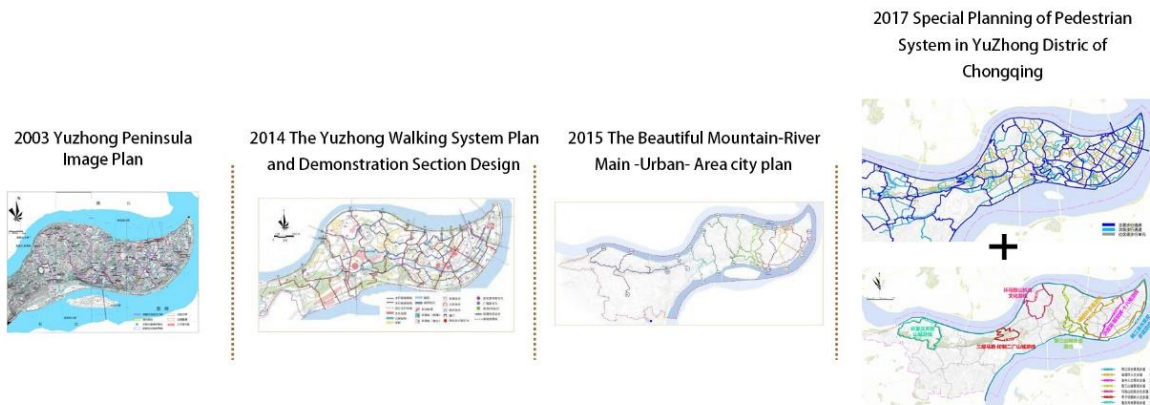


Figure 8: Walking elements included in four plans. Sources: authors edited from the special planning of pedestrian system in Yuzhong District of Chongqing

Of these Plans, the most well-known one is the *Yuzhong Image Design* [14]. This plan recognised 9 mountain-city trails (山城步道) as forming the key urban design framework for this landscape with an aim of seeking to utilize the traditional linear corridors and networks for both conserving the character of Yuzhong as well as to relieve the congestion of north south vehicle transportation across the Peninsula. However, from data analysis through Chinese social media platform weibo.com, only a few of these extant mountain-city trails have been well recognized by tourists and local residents [15].

Special urban planning of the pedestrian system in *Yuzhong District Plan* (2017) [17] has separated up the walking system into two layers:

1. the fundamental walking system plan with pedestrian-transportation considerations; and,

2. walking trails plan with leisure and tourism considerations.

The 2017 plan has considerable modified this approach, seeking to appropriate spontaneous formed leisure trails by local organizations and peoples. But there is still a need to respond to and use and respect the natural and cultural environmental context of Yuzhong.

6. Understanding nature and people connections

The notion of a ‘cultural landscape’ represents a combination of human and natural values. The term ‘cultural landscape’ was recognized as a subclass of ‘cultural heritage’ by UNESCO through ICOMOS to better incorporate places that demonstrate ‘significant interaction between people and the natural environment’ [1]. ‘Cultural Landscape, in the associative sense, can exist at almost any scale’ [17]. Because

urban places are gathering venues for large populations of human beings, and often represent physical manifestations of human aspirations through space and time, there is an increasing recognition that cities also reflect or embody the interactions between nature and humans, making them a new type of a cultural landscape [18].

The Historic Urban Landscape (HUL) concept was proposed by ICOMOS to address a city-level systems context, thereby enabling the recognition of both a thing and a process, and their synergistic interactions. The HUL Recommendation [1] defines a historic urban landscape as the ‘layering of cultural and natural values and attributes, extending beyond the notion of ‘historic center’ or ‘ensemble ... [that] include[s] the broader urban context and its geographical setting’’. This definition puts an emphasis upon conservation and land development based upon an integrated pattern appreciation and knowledge of historic town and landscape under consideration, instead of putting strict definitional limitations between a heritage area and a non-heritage area.

Biophilic design requires us to understand and connect to nature. While the logic for many historic cities derives from such a connection and engagement with their natural environments, biophilic design emphasises the need to add green spaces and opportunities to connect with nature, as well as rebalance urban realms within natural environments. Thus, it is better for us to deeply understand the extant urban fabric and social clothes, its resources and its traditional knowledge about an old city area

before proceeding with strategy formulation and practical actions.

In Chóngqìng’s case, to learn from the existing fabric and living culture can be a way to respond to the requirements of formulating a biophilic city model. There are a lot of parallel relationships between the HUL approach and the biophilic design approach for historic urban areas. Inspired by both of these theories, this paper proposes two visions for Yuzhong peninsula:

6.1 To revitalize walking-oriented urban spaces and biophilic activities

Yuzhong District today, as a compact city area framed by its traditional fabric, has good basis for enabling walkability. However, the accessibility of the existing pedestrian system has been reduced by poorly integrated pedestrian and vehicular systems and zig-zag footprint construction of vehicle roads within the Peninsula towards the two rivers. The situation is compounded by the narrow laneways arising from the cessation of a family-oriented cohesive social structure to curate these activities. These issues are reflected in the Yuzhong specific walking system plan [12].

Aside from providing a walkable framework inside the Peninsula, it is equally important to link the walking system to the outside of Yuzhong Peninsula. Secondly, there is a need for an integrated railway and walking trail system that links the recently installed underground metro railway stations and the walking trail system. Provision of a legible trail system from railway stations to

walking trails, and inside each trail corridor, should be developed.

High-rise buildings reduce the legibility of living within mountainous topography. Along with bridges for vehicle transportation, new buildings block many visual and physical connections between people, mountains and rivers. This is why people on Yuzhong Peninsula are increasingly valuing opportunities to view the two rivers, the mountains, and the sky.

Searching the key word “山城步道” (mountain-city trails) in the Chinese social media platform weibo.com many photos has been found taken the mountain and river views of this part of Chóngqing [18]. Many social activities centre around the mature *Ficus virens* specimens (a local tree offering shelter in intense heat of summer), evident in people’s comments (Figure 10) [18]. There is a clear need to conserve traditional lifestyles of peoples residing and or working along these trails – such as small businesses and outdoor activities – to encourage people

to get out of their houses and to continue to partake in historical trail and street use culture.

We argue that strategies should include:

- building an integrated and interconnected railway and walking trail system to reduce vehicle use, with the larger vision of inspiring de-vehiculization of the place;
- prioritise the selection and design enhancement of trails establishing better access and legibility of water and mountain landscapes;
- Promote the conservation and celebration of traditional cultures and lifestyles encouraging outdoor engagement and activation; and
- Conserve local trees as part of Chóngqing’s heritage, as well as identify and implement new tree plantings.



Figure 9: *Ficus virens* and local people. Source: <http://www.cq.xinhuanet.com/jrht/20140514a.htm>, accessed 6, April, 2018

6.2 Possible solutions to building an ecological network after a de-vehicalization process

Continuing use as port area, the old town area of Chóngqìng continues to increase in density, thus presenting limited space for green infrastructure. The recent District Plan strategies seeking to reduce the resident population appears to be trying to alleviate the population density to the detriment of the historic and social fabric. In this high-density area of Chóngqìng, roads appear to have taken too much spatial prominence, to the detriment of provision of green infrastructure.

The ancient maps of Chóngqìng, evidence a network of Fengshui-inspired trails linking gates, water and the city, such a philosophical design strategy can work equally as an innovative culturally-responsive greening strategy, offering shaded and stimulating patches and routes for humans, corridors for animal migrations, and oxygenating air vents and conditioners for the old city of Chóngqìng.

In Chongqing's case, along walking trails, micro-level planting can be undertaken to formulate a pedestrian-inspired greening system. At another level, if a de-vehicalization process works, there are several opportunities to change grey infrastructure into green infrastructure.

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To conclude, strategies for this target include:

- take full use of existing walking trails for micro-level greening, to aid walking and outdoor activities; and
- turn grey infrastructure green, in synergy with or following any de-vehicalization process.

7 Conclusion

The idea that 'Nature benefits humans' is embedded in the subconscious common sense of individual and collective human beings. There are many ways to realize these benefits – new techniques, art and traditional wisdom. To be inclusive to this urbanisation change, it is important that we confront issues being presented by rapid population growth and associated urban structures and infrastructure, and the quietly profoundly emerging diversity of social values.

As human beings we need to respect the past to go forward. The corresponding relationship between these two terminologies tell us a possible truth rather than labelling any idea as a vehicle or policy for action. These include the need to respect diversify in people and context and to be inclusive to change for the betterment of people and their living environment.

Planning Policies and Guidelines outlined in this paper.

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Appendix A

Articles 6 and 7 of the *Yuzhong Image Design Planning and Control Regulations* (2003).

Article	Article text
Article 6:	<i>To enhance the construction of commerce, culture, natural & cultural landscape and the big-middle public facility which support them, while weakening the living and industry function.</i>
Article 7:	<i>To strictly control and gradually reduce the total amount of residential buildings, while reducing the resident population of Yuzhong, forbidding any function transformation of buildings from others to residential</i>

Appendix B

Aim of the 11th 5-Year Plan (2006-2010) of Yuzhong District.

11th 5-Year Plan Yuzhong District aim	
Aim:	<i>To establish the east, west, south and north expressway; to promote the implementation of '6 bridge, 5 road, 3 subway, one tunnel' construction; to finish the construction of Caiyuanba-</i>

Yangzte River Bridge, Jiahua-Jialing River Bridge, Shibampo-Yangzte River Bridge; to begin the plan of Hongyancun Jialing River Bridge, Qiansimen Jialing River Bridge, Dongshuimen–Changjiang Bridge; to finish the Gaojiu Road, Jiabing Road-Dishuiyan section construction; to promote the Changbin Road Caiyuanba-Huangsha section construction and the reconstruction of Dahuang Road and Dashi Road. To promote the construction of No. 1 No. 3 and No. 6 railway stations; begin the plan to construct Chaotian Gate-two river Tunnel. Completing the traffic network system, enhancing the road traffic effectivity... ”.

Appendix C

Total population of Yuzhong 2005, 2010, 2015 (Source: Chongqing Statistical Yearbook 2006, 2011, 2016).

	2005	2010	2015
The total population of Yuzhong (Household register population)	599,400	572,600	530,700

Biophilia and Berlin: how historical conflict establishes progressive biophilic landscape strategies and design.

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Abstract

Biophilic design approaches emerge in the 1980s when advancing eco-philosophies, such as Wilson's Biophilia, Clément's Third Landscape and Kowarik's Fourth Nature, began to manifest in literature and practice. Parc Henri Matisse (Lille 1995) and Natur-Park Schöneberger Südgelände (Berlin 2000), among others, represent some of the first instances where inherent urban systems, existing outside the influence of the designer, manifest in spatial practice.

This paper investigates attitudes towards biophilic projects today with a focus on Berlin, a city considered an exemplar of biophilic policy and design. The paper analyses Berlin's key environmental policy and explores its impact on landscape practice. Additionally, by focusing on acclaimed landscape Park am Nordbahnhof (2009), the research comes to understand the expression of biophilia in contemporary practice. Drawing on a number of interviews, including: a city planner for Berlin's Senate Department of Urban Development and Environment; an urban ecologist central to the creation of Natur-Park Schöneberger Südgelände; and the landscape architect responsible for Park am Nordbahnhof, this paper unveils the complex socio-political and eco-cultural conditions that inspire a positive engagement of urban systems through design.

The research suggests that Berlin's ability to support biophilic practice is closely tied to its recent history. Complex socio-political conditions, in this case post-war recovery, inspire a new engagement of urban ecology in philosophy and landscape architecture. For example, it is suggested that World War 2, as well as the Berlin Wall, are catalysts in the development of a unique, and progressive eco-cultural dynamic that establishes the city as archetypically biophilic.

Keywords: Fourth Nature; wastelands; spontaneous urban ecology; Berlin; ecological philosophy; landscape architecture.

1. Introduction: from ecology to biophilia

The discipline of ecology first emerged in Europe during the 19th century and was

understood as a scientific investigation into the 'relationship of the organism to the environment' [1]. Notably, European scientists, such as Alexander von Humboldt, examined intact ecosystems and focused on, among other themes, how species evolved and adapted within their environments.

The study of ecology diversified in the 20th century as new ecological positions continued to emerge. For example, in 1935 Tansley introduced the term ecosystem; and, in 1953 the Odums published *Fundamentals of Ecology*, a text that combined notions of *systems* operation alongside principles of ecological science. Coming a decade later in 1962, Carson's *Silent Springs* pushed ecological concepts into the mainstream consciousness. Notably, Carson explained how human actions, for instance the application of chemicals such as DDT, had agency to destroy entire ecological communities. Critically, Carson's text introduced a new eco-framework that established associations between ecological and cultural systems. Bateson described this position succinctly, stating 'We are not outside... ecology... we are... a part of it. Herein lies the charm and... terror of ecology - that the ideas of... science are irreversible becoming part of our own ecosocial system' [2]. In this way, Carson and Bateson defined a system whereby cultural and environmental conditions are disparate, yet equal components, of the same system.

Building on these frameworks is Wilson's *Biophilia*, a text that examined the complex interactions between culture and ecology globally. Wilson explored, among other concepts, biophilic associations between different cultures, ecologies and species which led him to conclude that ecological values can shift through time. As Wilson stated, 'What is good... at this moment might easily sour within ten years... That is why any ethic worthy of the name has to encompass the distant future.... Values are time-dependent...' [3]. Wilson identified the inherent complexities of ecological value systems and argued that biophilic relationships may evolve as new systems and perceptions emerge in the future.

1.1 *Biophilia, ecology and design*

Similar to the preceding philosophers, landscape architects, keenly interested in science and ecology, became more sensitive to ecosystems performance in the 1960s. Ian McHarg, for example, aimed to design the landscape as an integrated system composed ecological and cultural processes. As McHarg stated in *Design with Nature* 'the ecological method allows' the landscape architect to 'understand form as an explicit point in the evolutionary process' [4]. Similarly, Ian Laurie's *Nature in Cities* outlined new approaches to urban ecology and landscape practice. The book features Sukopp's essay, 'The Soil, Flora, and Vegetation of Berlin's Waste Lands' which studied the pioneer ecologies of Berlin's wastelands and argued for the retention of ruderal flora through design [5]. Critically, these examples, among others, demonstrate

how landscape architects began to engage dynamic systems as a primary design material in the 1960s and 1970s.

Frameworks of ecology continued to diversify in the 1980s and 1990s with the introduction of *eco-design philosophy* which challenged many ideologies established in the 20th century. Notably, core principles were re-evaluated as the world became increasingly globalised and urbanised. For example, Gilles Clément (a designer) and Ingo Kowarik (an urban ecologist) utilised new theories of urban ecology through philosophy and landscape practice. Clément evolved eco-design thinking through the production of new ecological terms, namely the Planetary Garden, the Garden in Movement and the Third Landscape. While these positions are similar to some scientific principles of ecology (for example dynamism), Clément expanded established beliefs by acknowledging the role of *politics* and *economics* in a globalised ecosystem.

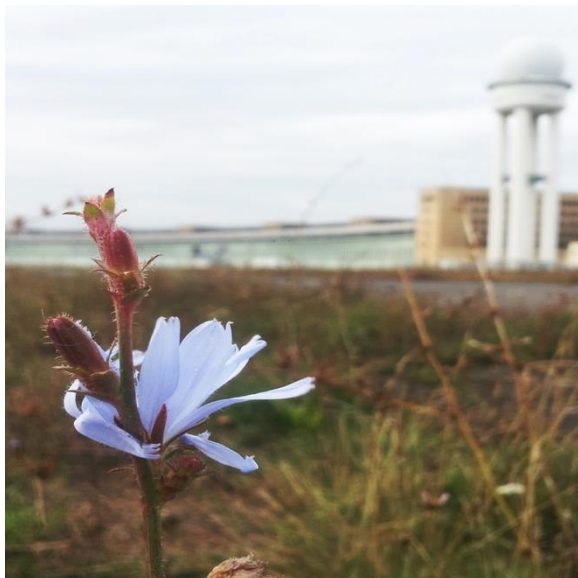


Fig. 1. An example of a Fourth Nature grassland at Tempelhof Feld, an abandoned airport in Berlin.

Similarly, Kowarik's classification of a Fourth Nature ecology within Berlin (figure 1), which he defines as 'spontaneous', 'novel' and 'wild' [6] pushed the classification of species in ecological science beyond binary terms such as native or exotic. Read in conjunction with Clément, the novel philosophies represent another important progression in ecological thinking from the 1980s onwards.

The introduction highlights a shift towards a European acceptance of highly modified urban ecosystems in philosophy and design. The following section discusses the impact of this shift within Berlin. With a focus on Kowarik's philosophy, and the design of Park am Nordbahnhof, this paper clarifies two points: first, how the legacy of World War 2 and the construction of the Berlin Wall produces Fourth Nature philosophy; and second, how Fourth Nature systems enhance biophilic associations through the design of public open space in Berlin.

2. The Berlin Wall and Fourth Nature: the emergence of biophilia in Berlin

In the 1970s and 1980s ecologists practicing in a *divided* Berlin were forced to examine unexplored landscape typologies as their primary sites of research. As Kowarik explains, West Berlin had become 'an island... surrounded by the GDR' following the construction of the Berlin Wall; and, having been denied the opportunity to examine traditional sites of research, such as

the wilderness, ecologists were forced to study urban environments [7]. This pivot from the exterior to the interior of the city shifted the ways in which ecologists perceived and understood natural systems. Critically, urban landscapes, which had been overlooked as valuable research sites [8], became the focus of ecological study in Berlin. As Lachmund notes, ‘ecologists... sought a reconciliation of city and nature...’, an impact he suggests ‘transformed into a more comprehensive view of different types of ecosystems... which had... some value or potential as nature’ [9].

For example, within wasteland spaces numerous ecologists, notably Herbert Sukopp, often discovered (unexpectedly) spontaneously evolved and biodiverse ecosystems. Sukopp’s discoveries were so remarkable that he advocated for the protection and enhancement of wasteland biotopes. As Sukopp wrote, wasteland species would be the ‘prevailing plants of the future’ owing to their abilities to ‘adjust themselves best to man-made sites’ [10]. Similarly, the ecologist wrote about a ‘great protective importance of these plants in cities...’ and argued to ‘preserve spontaneously developing’ systems as they often performed as ‘the last refuge of some species threatened elsewhere with extinction...’ [11]. In this way, Sukopp’s investigation of Berlin’s spontaneous ecosystems, later classified as Fourth Nature by Kowarik, reframed wastelands spaces as valuable ecological resources. Critically, as discussed in the following section, the evolved awareness was the epoch of Berlin’s contemporary biophilic system.

2.1 Contemporary biophilic association in Berlin

The perspectives of Kowarik, landscape architect Herald Fugmann, and Senate Department planner Holee Thierfelder reiterate the inherent biophilic relationship between the Berlin community and the city’s Fourth Nature ecosystem. Critically, Kowarik and Thierfelder refer to the notion of *freedom*, both cultural and ecological, when describing Berlin’s biophilic attributes. Similarly, Fugmann, who also describes a *free* condition, explains how the biophilic system impacts the design of Park am Nordbahnhof.

Kowarik and Thierfelder indicate that Berliners are inherently liberated and believe this attribute is derived from living in close proximity to Fourth Nature. As Kowarik states, ‘...it produces a feeling of being different... a feeling of natural approaches... that provides qualities that make... life richer because you have more direct contact with natural processes...’ [12]. Kowarik references the designed landscape of Park am Gleisdreieck to clarify his position, noting the park is valued ‘because it is a symbol of freedom, of natural processes in the heart of the city’ [13]. In this way, the quote suggests that Fourth Nature ecologies are a significant factor in the production of a liberal society within Berlin.

Likewise, Thierfelder describes a similar biophilic condition, defining the city’s residents as free and diverse. Nevertheless, unlike Kowarik’s viewpoint that the *ecosystem* produces a liberal society, Thierfelder implies the city’s Fourth Nature ecosystem is produced by the community’s

open-minded attitude towards cultural expression. As she clarifies, ‘Berlin had the idea to be such a free town and we have... not only the Fourth Nature, you have the bars and restaurants that are open all night... that’s what makes the people here and that’s what makes the Fourth Nature’ [14]. Critically, Thierfelder suggests that the attributes of liberty existed prior to the emergence of Fourth Nature; and, that Berliners’ inherently liberal attitudes led to the classification of a new type of eco-system in science and philosophy.

2.2 Valuing Fourth Nature in Berlin: protests and policy

Berlin’s biophilic system is supported by the city’s protest culture and numerous government policies that protect Fourth Nature from destruction. In reference to activism Thierfelder states that Berlin is a ‘protest city’ [15] and identifies Park am Gleisdreieck and Tempelhof Feld as two abandoned landscapes that have inspired political responses as a means to save Fourth Nature systems from destruction. Berliners, Thierfelder suggests, remain fiercely



Fig. 2. An example of a Fourth Nature grassland at Natur-Park Schöneberger Südgelände.

protective of abandoned landscapes as these spaces offer a ‘sense of freedom in our well organised world’ [16].

Similarly, multiple levels of government are committed to safeguarding Berlin’s Fourth Nature landscapes from processes such as residential development. For example, the Federal Government, Berlin State and the Senate Department for Development and Environment have a range of policies that safeguard Berlin’s Fourth Nature ecosystems. Notably, Berlin’s *Biodiversity Strategy* highlights ‘the importance of biodiversity for the... society of Berlin’ [17] and references numerous typologies of urban green space that are considered ecologically valuable. Critically, the strategy identifies Fourth Natures, defined as *urban wilderness*, as extremely important to Berlin’s eco-cultural system. As the document clarifies: ‘Current environmental psychological research... prove that city dwellers value urban

wilderness as much as traditional green spaces... For aesthetic reasons, but also for... biotope protection, it... makes sense to allow a permanent development of wilderness in some areas... in the context of species support programs and the biotope network' [18]. Likewise, in *Specially Protected Biotopes in Berlin*, a resource outlining biotopes of principal interest, numerous Fourth Nature conditions are identified, for example; 'gravel, sand and marl pits' [19] and 'lean and dry grasslands' [20]. Notably, the document explains, among other points, how 'rare or endangered plants...' can emerge within wasteland spaces [21] (shown in figure 2) and establishes the ground of legal protection.

The examples of community activism and government protection reiterates the inherent biophilic relationship between the city's ecological and cultural systems. Similarly, landscape architects practicing within Berlin are often driven by an ambition to protect Fourth Nature while foregrounding its ecological attributes through design. The following section discusses Fugmann Janotta's biophilic approach to the design of Park am Nordbahnhof in the borough of Mitte.

3. Biophilia and Design: Park am Nordbahnhof

Park am Nordbahnhof was designed in two phases. The original scheme was the outcome of a 1995 design competition that Fugmann Janotta won in collaboration with architect Romuald Loegler. However, due to the Berlin's constrained economic position

in 1995 the proposal was never implemented.

Six years later the State Department flagged its intention to realise the project with significant design changes; the department had new ambitions which focused principally on the landscape's ecological attributes. Fugmann explains that the Senate thought Nordbahnhof could perform *ecologically* as 'compensation for things that happened in... other parts of the city... where nature and resources are destroyed' [22]. In response, the landscape architects reconfigured the scheme with a strategic focus on the landscape's ecological history.

Fugmann recalls the experiential, structural and ecological attributes of Nordbahnhof's pre-designed landscape. The designer notes that 'it was a very special atmosphere... because you felt to be in the centre of the city... but you didn't hear anything of it...'; similarly, he explains that 'the Berlin Wall' was a principal influence and describes the existing ecological condition being composed of 'small band of scrubs and trees...' and 'very special... meadows... in the centre of the park' [23]. As shown in the conceptual diagram (figure 3), each condition influences the configuration of the final design.

Principally, the landscape architects understand Nordbahnhof as an opportunity to heighten the interface between Berlin's urban ecology and its community. Fugmann explains that 'these kinds of open spaces are very valuable for everyone who is living in the city... especially for children to see what nature in the city is and to visit these types' of environments'; the design, he suggests, is a 'kind of insertion... a director... setting up

an observation' [24]. To promote interaction between the cultural and ecological systems, the designers inserted three islands into the central meadow, a 'very artificial design' that shows the 'big contrast... to the nature' [25] that evolved spontaneously within the landscape.

Within each island, shown in figures 4 and 5, is a disparate programmatic function designed to heighten the interaction between park uses and the surrounding ecology; whereas one island provides opportunities for children's play, another includes spaces for picnicking and nature contemplation. Similarly, the clearly defined boundaries between the *interior* and *exterior* of the islands, constructed in concrete, intensify the visual and spatial distinction between the design and peripheral spontaneous environments.

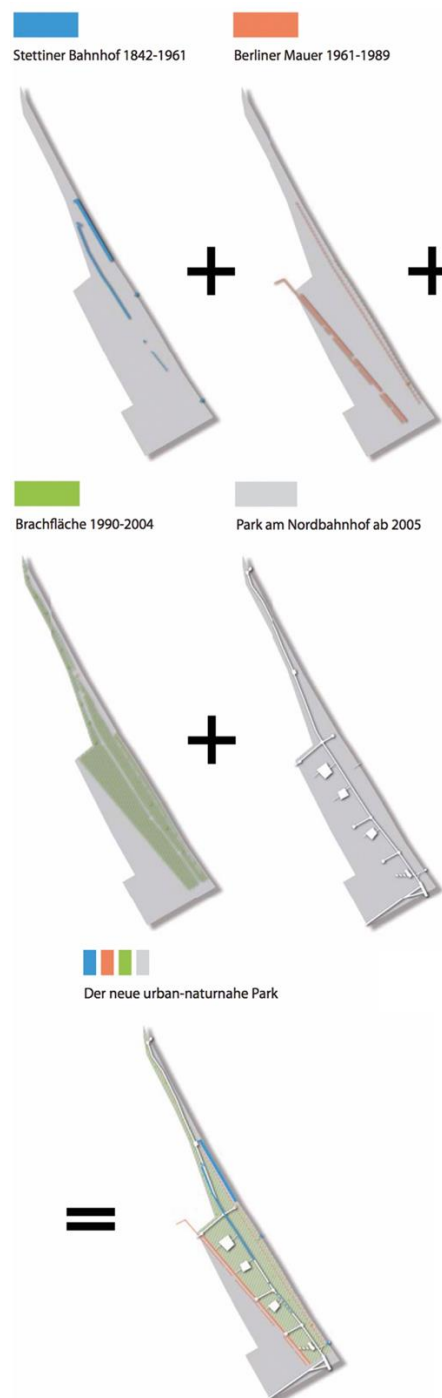


Fig. 3. Nordbahnhof's pre-existing eco-cultural conditions.

The islands are circumnavigated by a linear path system and interceding bridges which establish connections between the meadow islands and remaining landscape. Commenting on the performative capabilities of the path network the designer explains how they are perceived as devices to heighten the interaction between the Fourth Nature system and park users. Fugmann describes the railing as ‘very comfortable to put your hands on the top and to look and the vegetation’, to ‘think about what they... see in the area... to make people sensitive’ to Nordbahnhof’s spontaneous ecology [26].

Equally, the rails act as a barrier system to protect Nordbahnhof’s most valuable species. As Fugmann notes, ‘it was very important to build a line around the meadows’ as a means to limit damage to the environment; however, while *protection* is the design intention, he believes ‘there is no possibility’ to entirely secure the meadow from human encroachment [27].

Notably, several ephemeral tracks, shown in figure 6, are identified within the meadows as the barrier system is easily traversed. However, while the barriers, shown in figure 7, are traversable the designers do not necessarily perceive this as a failure. Alternatively, the landscape architects understand the rails as strategic moments where park users *choose* how they interact with the space and its ecology. Fugmann clarifies that the design encourages users ‘to be open to new experiences, for nature’ and ‘for history... we didn’t want... it to be a teacher or a guide... Everyone should make’ their ‘own experience... and... own

discoveries’ within Nordbahnhof [28]. Principally, Fugmann’s position reinforces



Fig. 4. The inserted island (left) and the pre-existing Fourth Nature system (right).



Fig. 5. Nordbahnhof's path networks and islands.

the liberal approach to Berlin's eco-cultural system previously described by Kowarik and

Thierfelder. In this case, the railings, in addition to the islands, are *loose* design elements that provide park users a platform to contemplate, and interact, with the Fourth Nature system that dominates the landscape.

Nordbahnhof has proven to be a successful addition to Berlin's open space network. It won the German Landscape Architecture Prize in 2011 which celebrated the park for its ability to 'unite the fundamentally competing aspects of ecology and intensive park use in one overall concept' [28]. Reflecting on the reaction to the design Fugmann recalls that Nordbahnhof 'was an experiment', and that he didn't know 'whether the public' would react positively; but 'the reaction was very positive: people... go to Nordbahnhof... looking for' a novel atmospheric experience, 'to see... nature, to hear the birds and the trees' and to seek solace from the city [29]. In this way, Nordbahnhof presents a biophilic design response reflective of a culture that has developed a unique relationship with its spontaneous urban environments.

4. Conclusion

This research highlights how Berlin's recent history establishes new approaches to ecology in design and philosophy. The creation of wasteland spaces through war and spatial division supported the emergence of a spontaneous ecosystem, notably Fourth Nature, which was later

reconceptualised through science, philosophy and landscape practice.



Fig. 6. Ephemeral tracks produce by park users.



Fig. 7. Steel railing surrounding the central meadow.

Critically, the prominence of Fourth Nature in Berlin's eco-cultural system typifies the city's biophilic association. The ecology, among other performative capabilities, reinforces the community's liberal condition; similarly, the freedom of the community supports an ecosystem which is inherently spontaneous.

The systems' liberal attributes are celebrated through environmental policy and landscape architecture practice as a means to protect Fourth Nature for future generations. In the case of Park am Nordbahnhof, the intervention reinforces Berlin's biophilic associations by establishing an interface between designed landscape and spontaneous ecology.

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Figures

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The Landscape Recovery in Small Cities and Towns in China- Based on Liuying, Fengxiang County, Shaanxi

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Abstract

Today, the environmental problems of the city is attracting more and more attention. Generally speaking, the environmental problem in large cities are more likely to cause people's attention. However, the environmental landscape of some small and medium-sized cities is not so optimistic, because the size of the city is smaller and the attention will be less. In small and medium-sized cities and towns, the investment level of the destruction of the environment pollution and the control of polluted productive activities are much less which leads to environmental problems in small towns is more prominent.

A balanced development with human settlement and cultural construction is the primary prerequisite for a city's healthy development. Liuying, a small town famous for its clay sculpture in Fengxiang County, Shaanxi, is the case study in this paper which provide the possible measures for the effective coordinate between the development of local culture and the urban environment in small and medium-size cities and towns.

Keywords: small and medium-size cities and towns, clay sculpture, ecological restoration, sustainable development

1. Brief introduction

In recent years, with the acceleration of urbanization in small and medium-sized cities and the expansion of urban population, environmental problems are becoming more and more seriously. The sharp decline in air quality, water pollution, soil pollution, solid waste pollution and other problems are urgently needed to solve. At present, among

the ten cities with poor air quality, the small and middle-size cities account for six. Sewage and industrial wastewater directly pollute rivers and lakes. Some small and medium-sized cities have serious soil pollution and low environmental quality. The comprehensive utilization rate of solid waste is low, and removing quantity of living garbage is insufficient. The air, water and soil pollution will affect the people's health, and it also restricts the healthy

development of these small and medium-sized cities and towns.

Over disordered exploitation of landscape resources, the land lost capacity of recovery. This brought more serious lack of biodiversity and higher degree of environmental pollution. On the other hand, many environment deteriorated small and middle-size cities and towns will direct radiate its problems to the adjacent rural areas. Besides, small and middle-size cities and towns are less affected by the urbanization process, people's daily life combines more closely with local culture, the deterioration of the environment impact on people's lives are more obvious than in large cities.

Generally speaking, the development of small and medium-sized cities and towns exposes more prominent problems than the large cities, such as the poor quality of urbanization, the decline of the carrying capacity of environment and resources, the phenomenon of "urban disease", especially the lack of urban cultural construction, which has lost the soul of the city's development. With the economy improvement of living standards, people are having an even higher demand for the quality of living environment, especially for cultural aspects. The demand for culture construction is marked by multi-level, divers and multifaceted characteristics. A balanced development with human settlement and cultural construction is the primary prerequisite for a city's healthy development. Liuying, a small town famous for its clay sculpture in Fengxiang County, Shaanxi, is the case study in this paper which provide the possible measures for the effective coordinate between the

development of local culture and the urban environment in small and medium-size cities and towns.

2. The Fengxiang clay sculpture in Liuying, Fengxiang County, Shaanxi



Fig. 2.1 The location of Fengxiang County.

Fengxiang County, is located in Guanzhong Plain, northeast of Baoji, Shaanxi. It is along the Qinling Mountain and has complex terrains. (Fig. 2.1) It is in the warm continental monsoon climate zone, semi humid and semiarid. Fengxiang has an area of 1179 square kilometers. It has 12 towns and 520 thousand population. Fengxiang has a long history of more than two thousand years. It is the famous for many of its folk arts and crafts, such as the folk poses, the clay sculpture, the boarding, the paper-cut, and the shadow puppet, etc. (Fig. 2.2)



Fig. 2.2 The famous folk arts and crafts in Fengxiang county.

Fengxiang clay sculpture is listed in China intangible cultural heritage. It is a kind of traditional folk art with unique local characteristics, and main produced in

Liuying town. The history of clay sculpture making could date back to the Ming Dynasty, which is more than 600 years ago. Local villagers purchase clay sculptures at home, to pray for children, spirits, houses, and good fortune. The making methods are handed down from generations to generations. Liuying is the main productive base for Fengxiang Clay Sculpture. There are a large number of clay making small factories and small workshops scattered in this area.

Fengxiang clay sculpture draws its inspiration from ancient stone carvings, New Year pictures, paper-cut and embroideries, with exaggerated shapes and colorful colors. The Fengxiang clay sculpture is modeled from dozens of processes such as fine blanking, coloring, thread drawing, color loading and glazing. The shape of the sculptures is realistic, rough, exaggerated, concise, generalized, colorful, and white drawn. The form is mainly for animals, birds and other mythological folklore modeling. (Fig. 2.3)



Fig. 2.3 The modeling process of Fengxiang clay sculpture.

2.1. Environmental problems of Fengxiang clay plastic production

For over a decade, the ground soil excavation caused the destruction of vegetation, bare land, and the lack of self-purification ability. This is resulted in the pollution of water resources. The disorder and unrestrained development also leads to less and less high-quality soil resources for Clay Sculpture making and the production quantity is decreasing.

The Liuying clay sculpture is the most representative folk craft product in Fengxiang. The blinding expansion of production leads to serious environmental problems. The raw material of clay sculpture is taken from the nearby Dongfeng reservoir. The large area of unordered soil collection cause serious environmental problem. As the same time, the water in Dongfeng reservoir is polluted by the disordered discharge of industrial waste water and domestic sewage, the scattered solid waste make the situation even worse. The deterioration of the water land environment also leads to the lack of local cultural identity, the neglecting of suitable living spaces creation, and the reduction of people's life quality and happiness. (Fig. 2.4)

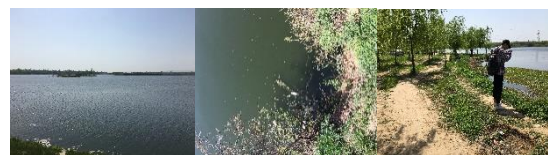


Fig. 2.4 The water pollution of Dongfeng reservoir.

2.2. Soil erosion is caused serious clay figurines

The Liuying clay sculpture is made by six kinds of materials, the local black oil plate, white seal soil, fine cotton and glutinous rice, etc. The black soil is taken from the Dongfeng reservoir. In recent years, the economic benefit of the clay sculpture production has been highlighted. The demands for clay sculpture production has increased year by year, which leads to the unordered rising trend of the excavating of the raw clay material. The model of small workshop production is lack of overall arrangement, and lead to an individual behavior of soil collection. Over excavating

leads to the thinning and narrowing of the soil layer of the reservoir bank. The bank protection is very important in maintaining the ecological balance with soil and water, as well as the eco-environment in the reservoir area. The nudity bank has lost the ability to regulate the soil, and resulting in a large amount of soil erosion. The irreversible destruction trend lead to a serious destruction of the natural environment, the fragmentation of the landscape, the decline of the land productivity, and the limitation of sustainable development.

2.3. The wastewater discharge and solid waste cause serious water pollution.

The supporting sewage pipe network and connection in Liuying, especially in the Dongfeng reservoir area, is lagging behind. There are no sewage pipe network or the existence of plugging and breaking head in the areas of the basin, and a large amount of sewage is directly discharged into the reservoir. Due to the industrial waste water and domestic sewage, the water quality in the reservoir is extremely serious. The polluted water turns brown in dry seasons. There are no fish in the water and no grass growing on the land. The water quality is extremely worse and the local residents are unable to drink. The pollution has caused great inconvenience to local people's life and clay sculpture production. It needs to be improved urgently. (Fig. 2.5)

The shore edge protection of the reservoir is not well managed at all. The solid waste is dumped alongside the shore. After the pollution of the wasted sewage water, the reservoir water is polluted at the second time by the solid waste. The solid waste is

exposed in the open air along the shore and caused chemical changes. The harmful gas is released continuously. The air pollution around the reservoir area is serious and the environmental quality is reduced as well.



Fig. 2.5 The wastewater discharge and solid waste cause serious water pollution.

2.4. Environmental deterioration leads to lack of local cultural identity

For centuries, in Liuying, the clay sculpture makers are basically staying in the traditional family handicraft workshops, with poor equipment. They still use the individually selling model, which is not only the wasting of time, but also limited the quantity of clay sculpture selling. This is greatly restricts the overall development of the regional clay sculpture making industry. The family style workshops lack of overall concept. Their corporative consciousness is weak. And therefore they lack of the initiatives to improving the living environmental quality. Because of the poor reproduction situation, the poor living environment quality, and the lack of local cultural identity, the development of

Fengxiang clay sculpture was once at a bottleneck. The foresight of high environmental quality and effective producing activities embodies the soft strength of the local development. Liuying is in its urgent need of taking effective measures to improve the overall environment quality, both in software and in hardware.

3. The ecological restoration solutions for Fengxiang clay sculpture's environmental impact

3.1. The government intervention to reduce soil erosion and sewage discharge

We are trying to restore the local landscape in three steps. First, is to improve the local laws and regulations. That is to say, we try to reduce the clay excavation along the water areas, improving water quality, reducing water pollution by the ecological restoration of vegetation. The locals are trying to create a multi-layered defense system and ecosystem services in the surrounding landscape areas. We aim to restore the environment's capability of breathing and growth, and then bring back the diversity of the biological improvement of surrounding areas.

Three years ago, the government of Fengxiang county has set up a three layer supervision and service system for environmental restoration of soil and water, specially in the area of Dongfeng reservoir. It is been considered as a pretty effective series of measures in changing the soil erosion and improving the ecological environment, as well as the agricultural production. These measures accelerate the

pace of poverty relief and carry out the local sustainable development going further. The relevant laws and regulations are enacted to prevent the discharge of industrial waste water and domestic sewage been directly released into the reservoir area. A guarding system is established to prevent solid waste disposal which might lead to the second time pollution.

Along the water bank, the locals build a shrub and further a shrub forest in gully slope. They build a silt dam system which could combine the flood control, mud blocking and silt production altogether. This could stop the ditch erosion quite effectively. The local people expand the width of the natural vegetation area of the bank revetment, and carrying out a wide variety of natural species between the farm land and the water bank. Thus, the three layers of reservoir bank protection system is formed. (Fig. 3.1)

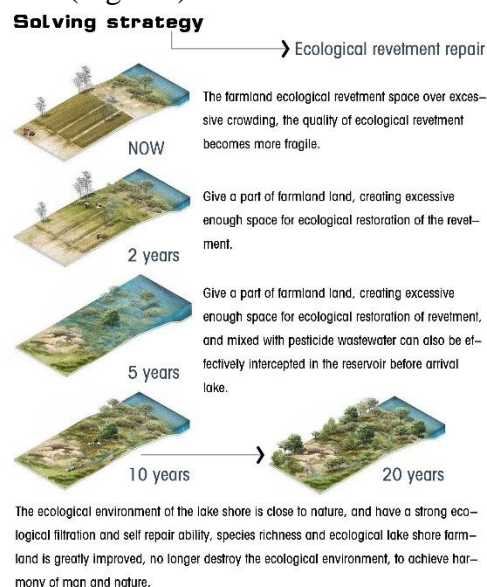


Fig. 3.1 The local people expand the width of the natural vegetation area of the bank revetment.

Other effective measures includes expanding biodiversity, making full use of raw materials and native species with relatively low local maintenance and management costs, improving the current situation of soil and water losses, and gradually set up a comprehensive management and development system for soil and water conservation. (Fig. 3.2)

Through working unit division and classified guidance, the environmental problem Liuying, the water and soil erosion in Dongfeng reservoir can be effectively reduced as well. The ecological environment in the region is improved. After proper management, the advantages of water and soil resources in Liuying will be brought back effectively in the near future, and the rapid development of local economy as well.

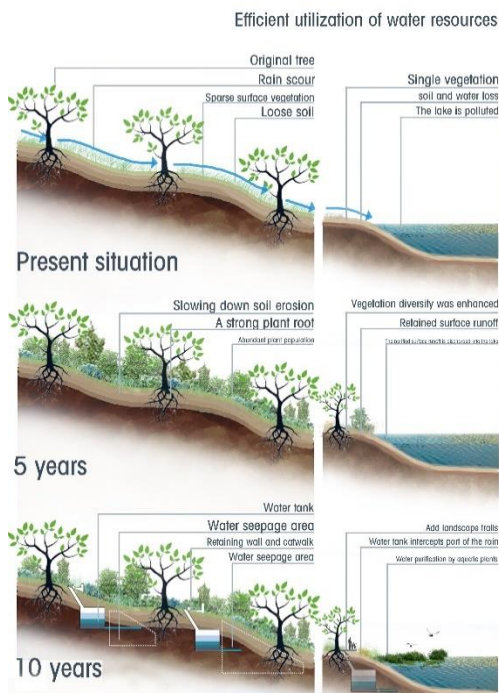


Fig. 3.2 The local people set up a comprehensive management and development system for soil and water

3.2. The process of ecological restoration bring in the promotion of cultural ide

Secondly, we are trying to combine the environment improvement with local culture which could better serve the local people's life and clay sculpture production. (Fig.3.3)

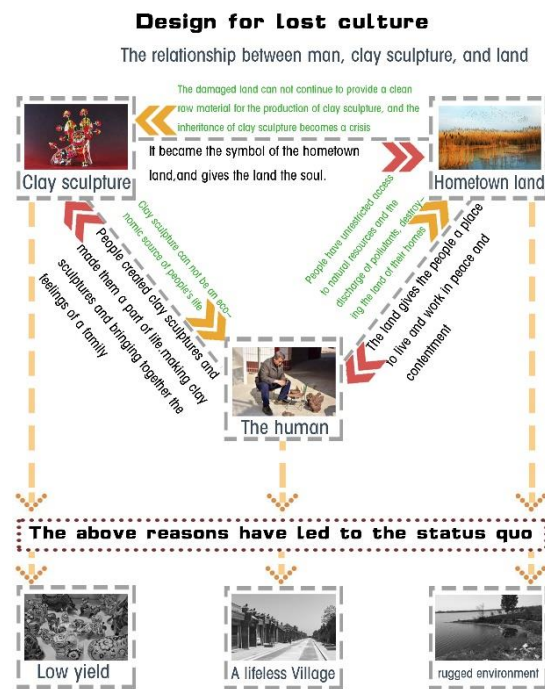


Fig. 3.3 The process of ecological restoration bring in the promotion of cultural ide

The most significant identification for different regions is the cultural difference, which is the unique spiritual and immaterialized wealth retained by every region in its own development. The inspiration from traditional culture and localization should be considered as the key issues to pursue the environmental protection and healthier quality. The Fengxiang clay sculpture in Liuying has its unique charm and connotation. The model making, billet, adhesive forming, fine

throwing, painting, drawing line, coloring, and polishing process of Fengxiang clay sculpture are all taken place in the local people's yard or inside of the house. The clay sculpture making process is a symbol and be a part for local people's daily life.

The purpose for improving the productive environment of the small workshop and build a suitable neighborhood environment is to achieve a better development of Fengxiang clay sculpture production, and then improve the living environmental quality of local people in that area.

3.3. Embedding cultural elements of clay sculpture and building green infrastructure.

Furthermore, the recovered landscape has become a green infrastructure of the town. In the recovering remodeling process of the environmental landscape, creating recreational and cultural spaces, thus strengthen the local characteristics of the area. (Fig. 3.4)

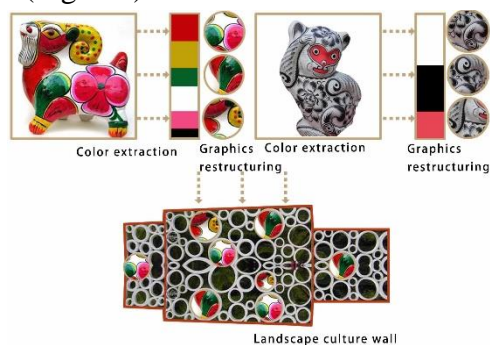


Fig. 3.4 Strengthen the local characteristics by using the clay sculpture cultural elements

In the process of improving clay sculpture making spaces and the living environment qualities of Liuying, all specific problems have to be conducted individually with specific analysis. And the measures being taken have to consider the region's own

characteristics, such as geographical location, natural environment, history and culture, economic situation and so on. The ecological environment protection should be adopted properly. The construction of local green infrastructure also need to be combined with proper environmental management.

The possible measures would be the reforming of the houses' front and back yard, the improvement of open and public spaces alongside the street. In recent years, Liuying has undertaken a series of reforming construction work. The clay sculpture museum has been built, the pedestrian street with the characteristic of clay sculpture was erected, and the folk craft research and development center was opened.

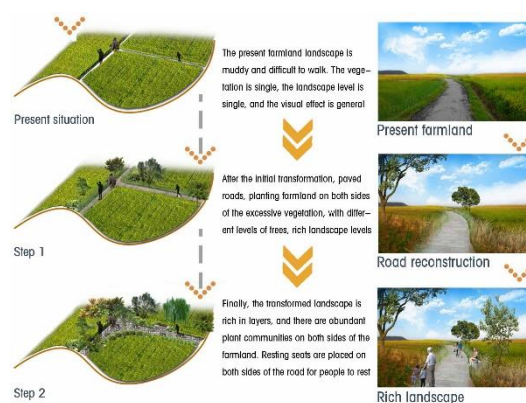


Fig. 3.5 Build the farmland landscape with the function of tourism, leisure and environmental production as a whole.

Other measures include, they build the farmland landscape with the function of tourism, leisure and environmental production as a whole, build the original ecological habitat for animals and plants in water land, and implant clay sculpture cultural elements in a series of

environmental transformation activities, etc. By taking all these measures, the Liuying clay sculpture production can be truly indivisible integrated into the people's every aspect of daily life. (Fig. 3.5, Fig. 3.6)

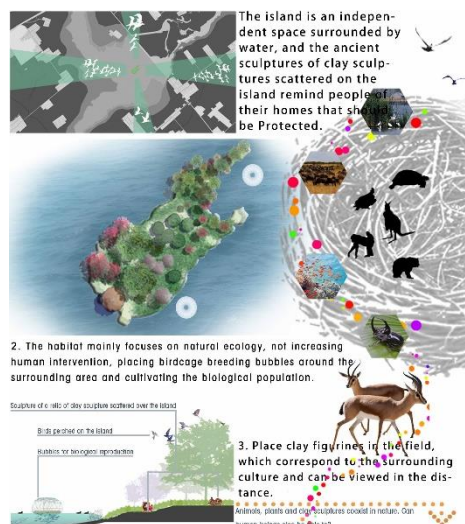


Fig. 3.6 Build the original ecological habitat for animals and plants in water land

4. The conclusion

In Liuying's landscape reformation process, the significance is to draw attention of the marginalized small and medium-size cities and towns while they are facing with environmental pollutions and the destruction of vegetation. (Fig. 4.1)



Fig. 4.1 Building a peaceful environment.

The Liuying and its clay sculpture production is the epitome of hundreds and thousands Chinese small and medium-size cities and towns which has its own cultural characteristics. The study of the environmental, ecological and cultural solutions of Liuying which is aim in building a peaceful environment. Liuying, with its Fengxiang clay sculpture production, are an optimistic example and will provide reference for the refreshment of other small and medium-sized cities and towns with similar environmental and cultural remains to follow.

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History and characteristics of urban parks those have been built on transportation infrastructure

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Abstract

Replacing old infrastructure with urban parks is wide spreading in the world. After the High Line, an elevated park, in New York has achieved success, many cities have proposed a new urban park to succeed. Infrastructure reached its lifespan now become a strategy to revive blighted communities and cities. This strategy which is redevelopment transportation infrastructure into urban parks is not only a fashion in recent but the part of a continued strategy for solving urban issues that have existed since the late twentieth century. Despite the importance of this type redevelopment, research on urban parks are limited. To use this strategy in right place and right type, research related to its characters and history are needed. This study aims to investigate its history and document its typology based on empirical case studies. At the beginning of twenties century, a lid park used to minimize noises from freeways. Since the twenty-first century, elevated parks have emerged as a practical case of landscape urbanism. Recently, a lower park starts to be built under overpass or underground. Type of urban parks built over (or on) a site previously used by transportation infrastructure can be divided into four types: (1) an elevated park, (2) a lower park, (3) a lid park and (4) a recovered park. Then, characteristics of each type and its cases will be explained in this study. This study will contribute to policy makers and urban planners who consider replacing their transportation infrastructure into parks and landscape architects who design urban parks over (or on) transportation infrastructure.

keywords: Urban parks; urban greenways; urban redevelopment; greening strategy; typology of urban park

1. Introduction

A paradigm of the freeway has changed from a way to connect us to a barrier that separates usⁱ. Although mobility, labor inputs and manufacturing outputs are enhanced [2], urban freeways also become urban issues such as air and noise pollution, lack of scenic value and environmental cost [3]. Many freeways which were built around

the 1930s to the 1960s have reached their lifespans and need structural maintenance [4]. Urban freeways have become a subject of urban planning, whether through removal, repair or redevelopment of freeways. In planning, the redevelopment of freeways into urban parks is becoming a global trend around the worldⁱⁱ. This kind of redevelopment project covers not only freeways, but also all transportation

infrastructure such as railways and elevated roads.

To discover the impacts of replacing transportation infrastructure with urban parks, many researchers have investigated three categories: economic, environmental and social benefits. For example, the economic benefits of urban parks represent their impacts on increasing property values [5]–[7], tax revenue and jobs [8], [9]. For social benefits, urban parks contribute to improve health, enhance social interactions and ameliorate social inequity [9], [10], [12], [13]. Lastly, the environmental benefits of urban parks include improving biodiversity, providing wildlife habitat and managing stormwater [6], [10]. The positive impacts of the park over (or on) transportation infrastructure have been largely revealed. However, research on those parks related to their origins, history and features are lacking.

Understanding urban history and features is important to create appropriate proposals for cities. In this regard, this study aims to investigate the history of replacement of infrastructure with urban parks and create a typology based on empirical case studies. This study can be divided into three parts. First the greenway and linear park will be discussed as a theoretical background. Second, since the early 20th century to the present, the history of urban parks over (or on) transportation infrastructure will be investigated. Based on these background and historical reviews, types of parks and features of each type will be addressed. By understanding their origin, history and features, this study can help to find

appropriate types when implementing urban parks over (or on) transportation infrastructure.

2. Background

The theoretical background of replacing transportation infrastructure with parks can be included under the term of greenway in terms of its functions and linear park in form. The parks built over (or on) transportation infrastructure are similar to those of greenways in that nearby residents can access easily and are convenient to use [10]. Looking at the morphological characteristics, this type of urban park is included in one of the types of linear parks [11].

A greenway is an “open space connector linking parks, natural reserves, cultural features, or historic sites with each other and with populated areas [12].” The economic, social and environmental functions of parks built on transportation infrastructure can be included in the same context as these functions of greenways. In particular, from a socio-environmental point of view, the greenway creates a place for leisure activities and alleviates pollution [10]. Especially those who live near a greenway gain more benefits because of greater accessibility [13], [14]. Coutts and Miles (2011) explained that greenways, unlike parks, contribute to neighborhoods' interactions and connections.

Greenway planning in the United States originated at the beginning of the discipline of landscape architecture, and has had three phases in this evolution [15]: 1) the late 19th

century, 2) the early 20th century and 3) post-World War II. Greenway planning in the late 19th century was led by Frederick Law Olmsted and Charles Eliot. In the second phases, the early 20th century, Olmsted and Eliot's works were expanded. During the third phases, Ian McHarg and Phil Lewis led greenway planning [15].

Considering their physical characteristics, urban parks created on transportation infrastructure can be included in the category of linear parks. The linear space in the city is the edge where the most dynamic places in ecosystems occur [16]. It is also a habitat for the birds [17] and a trail for citizens [18]. Karl Kullann (2011) describes linear spaces in urban areas as a by-product of a plethora of cultural processes, and discusses and explains disused railways and freeways as examples. Highlighting connectivity and contextualism as dominant features of linear spaces, he accentuates the connections of adjacent communities and sequential experiences as features of linear parks [11].

3. Urban parks over (or on) transportation infrastructure

3.1 Methods

The study will focus on parks built on sites previously used as transportation infrastructure. From the 1970s to the present, a total of 36 cases in world cities were collected for this study. To identify the typology and compare with each type, three steps were needed: 1) investigating cases for classification, 2) developing a classification framework to define the type,

3) a comparison of each type's features and 4) reviewing the history of each type. A case-study was chosen to capture the complexities of phenomenon and to divide cases into certain categories. From 1960s which a new lid park was completed to 2018, 36 highways have turned into urban parks. From the case study, it was concluded that urban parks on transport infrastructure fall into four categories.

The urban greenway park typology was designed as a way for planners to find an appropriate method to create parks, and for landscape architects to create a design strategy for specific sites. Types of urban greenway parks were divided into four types from the case study: lid parks, elevated parks, recovered parks, and underpass parks. The typological approach to urban greenway parks which was used in the study is not only to serve concrete typology approaches for categorizing urban greenway parks, but also has the potential to assist urban planners and landscape architects who intend to revitalize cities by replacing transportation infrastructure with urban parks. Different types of urban greenway parks were assessed in terms of former usage, replacement construction, and physical characteristics. Fig. 1 outlines various types of urban greenway parks and specific criteria derived from the case study. Four questions were asked to categorize urban greenways: 1) what kind of transportation was its previous usage? 2) what is the elevation of each transportation type? 3) was it torn down before replacing the park? 4) was a lid added for building the park? Each case was categorized in each category which was derived from each

question. Then four types were extracted from each category's construction features (Table 2). After identifying four types, every case in each type was investigated to understand the features of the type.

3. 2 Types and features of urban parks over (or on) transportation infrastructure

Urban greenway parks were divided into four types, lid parks, elevated parks, lower park and recovered parks. These types were defined by four features of their physical characteristics. The lid park is a park that has added a lid or cap upon a highway, so it can link to the ground level. The elevated park is a park which replaces an overpass and has limitations related to. A lower park is a newly emerged park in a compact city, and is a park under an overpass. It is a way to adopt when a city has no vacant area to create a park. The recovered park represents the most significant change among the other types. This type of park builds on the areas where a highway or overpass were torn down, and aims reclaim nature which has been polluted.

The main strengthen of the lid park is its level. Since it is built on the top of a highway, its level can be a connector in the city. When this type originated, it functioned as a noise prevention strategy by covering the highway. It also provides sports facilities for the neighbourhood. Today it can function as a space for festivals in the urban center and improves the livability of a city. The lid park also can link two communities which are divided by a highway.

The elevated park is a famous type of urban greenway park, since it offers not only an extraordinary experience but also contributes to tourism. Generally, an overpass is a long and narrow road that passes through a city. The elevated park which has replaced the overpass also shares the features of the overpass, which include continuity and connectivity.

The lower park is a park under an overpass, and is newly emerged type. Due to its characteristics of underway, the lower park is sometimes covered with concrete, i.e. is shaded. The lower park is used as a skateboard park since the noise from skateboarding is cancelled by road noise. Shade is a limitation of the lower park, but it can also be used to make a unique space in a city. For example, the lower park can be used as a gallery. The underpass park in Toronto is used as a gallery day and night, with lights and site-specific arts. The Lowline in New York City was approved and now funds are being raised for its construction. A lower park is a way to use dead space beneath.

The recovered park is a park that was built on a demolished road. The Südgelände Park in Berlin and the Cheonggyecheon in Seoul are exemplary cases of this type. This type can contribute to recovering its nature which has been polluted by a freeway or a rail road. To commemorate their origins, some parks retain a part of a rail road or overpass and use it as a design metaphor. Among the other types, only the recovered park has no limitations when they plant vegetation. The recovered park, like its title, aims to restore nature in an urban core. People can use this

park as a picnic area and a trail. It also contributes to revive a declined area by increasing visitors. Gyeongui park in Seoul leads the development of small business near the park, and generates revenue from park visitors. The recovered park in an urban core can offer a trail for residents, a picnic area for the citizens and can improve the bio-diversity for all.

3.3 History of urban parks over (or on) transportation infrastructure

The history of parks built on transportation infrastructure can be roughly classified into four phases: 1970s-80s, 1990s, 2000s and 2010s. Each period is a time when a unique approaches appeared to solve urban issues such as noise from transportation infrastructure, the deterioration of the infrastructure and lack of green spaces. The 1970s and 1980s covered highways and made parks on them to mitigate noise. In the 1990s, parks were built on railroads that were shut down. In the 2000s, highways, railways, and overpasses were torn down and parks were built on vacant lots to restore polluted lands. In 2010, parks with an elevated lower section appeared.

For the first phase, during the 1970s – 1980s, planning to cover highways and create the park on them was originated. During this time, urban parks built on transportation infrastructure were used to ameliorate noise and improve the aesthetics of highways. The most prominent example is the Freeway Park in Seattle. Opened in 1976, this park was designed by Lawrence Halprin, and ‘heal the scar’ was used as its vision [19]. Luther Burbank Park on Mercer

Island is also a park built in the same way. Opened in 1985, the Luther Burbank Park has been providing benefits to connect disconnected communities and reduce noise and air pollution. One of the strengthen of this park is its relationship to the east side of Mercer Island as it connects communities to an expanded greenspaces in the future. Covering seven blocks of highway, this park is a typical example of a covered park and is a valuable early attempt.

In the second phase, the 1990s, the lid park continued to be constructed and the elevated park emerged. Due to the transition from rail to automobile, urban patterns changed [20] and surplus infrastructure emerged as a new issue [21]. The Promenade Plantée in Paris was transformed in 1993 from railways to a park. Conversion of disused urban railways to linear parks is a way to the reformatting of disused infrastructure [22]. According to Heathcott (2013), replacing disused urban railways to parks is a brilliant means of producing a new spatial condition in the city’s energy, connectivity and everyday life. At this time, interest in disused transportation infrastructure had begun to concentrate and urban parks emerged as a way to reformat disused urban infrastructure.

In the third phase, during the 2000s, cities have converted sites to parks that were previously used as railways or overpass. A recovered park has two main purposes: one is a restoration of a contaminated site to recover its natural ecosystem, and the other is to provide a green space to blighted area. The Cheonggyecheon Restoration Project in Seoul is an example that is most

representative a recovered park, which is a project to dismantle the overpass and freeway and restore existing rivers. This project has greatly improved the environmental issues of the city. Shiraki, et al. (2006) compared before and after air conditions to verify the effect of the Cheonggyecheon project on the air quality and found the NO₂ level was lower after the city restored the stream [23]. Also Shin, et al. studied the changing in benthic macro invertebrates in Cheonggyecheon and found out some species started to live in the stream [24]. Schöneberg Südgelände Park in Berlin is also one of the example of a recovered park which built on an abandoned railway. This park aims to being a spontaneous nature and making biotope in urban ecology. The idea of the park also aims to prohibit outside intervention and let nature follow its own systems [25]. In addition, it is noteworthy that during this period, parks have become a symbol of the city and the city 's economy has been revitalized. The High Line in New York (2009), the Olympic Sculptor park in Seattle (2007), the Big dig in Boston (2003) and the Cheonggyecheon in Seoul (2005) have been built and revived the cities' vitality.

For the last phase, since the 2010s, replacing transportation infrastructure with urban parks starts to find an appropriate site in the compact city. As a result, a lower park emerged as a new type of urban parks. The Underpass park in Toronto (2012) and the Seart park in New Zealand (2010) were built under the overpass. These parks are built on hidden spaces in the city, and they are mainly used as space for exhibitions and leisure activities. Another feature of this

period is that the park plans for urban regeneration have been announced and completed as learned in the case of the third period.

4. Conclusion

At the time many projects are proposed, this study provides a clue as to what type of strategy is needed in a city by looking at the type, features, and history of the park built on transportation infrastructure. Replacing the transportation infrastructure with urban parks has been developed for a long time as a way of solving problems of cities and give a new vitality to cities. From a lid park designed to reduce noise caused by highways to an elevated park that built on the existing structure, this type of parks changed its strategy according to the demands of the times.

Four types of parks are differentiated based on the physical characteristics of parks. A lid park has the advantage of physically linking disconnected communities to highways, but it is limited in that it is built on artificial ground. An elevated park is meaningful in that they utilize existing structures as they are, but they are limited in that accessibility is low and artificial grounds are used. The advantage of a lower park is that it uses an abandoned elevated lower section. Lastly, a recovered park has the advantage of restoring contaminated sites as a result of their transportation infrastructure.

This study has a limitation in that it did not consider the relation between the park and its surrounding context, although it is

significant in that it distinguishes and characterizes the kind of park constructed in the transportation infrastructure. In future research, we will be able to give some

suggestions about the type of park in which contexts are needed, considering the relationship between each park and surrounding context.

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Table 1. Criteria

Used	Level	Tearing down	Capping	Type
Rail	+1	No	No	Elevated
		Yes	No	Recovered
	0	No	No	Recovered
		Yes	No	Recovered
Freeway	+1	No	No	Elevated
		Yes	No	Recovered
		No	No	Underpass
	0	No	No	Underpass
		Yes	No	Recovered
		Yes	No	Recovered
	-1	No	No	Underpass
		Yes	No	Recovered

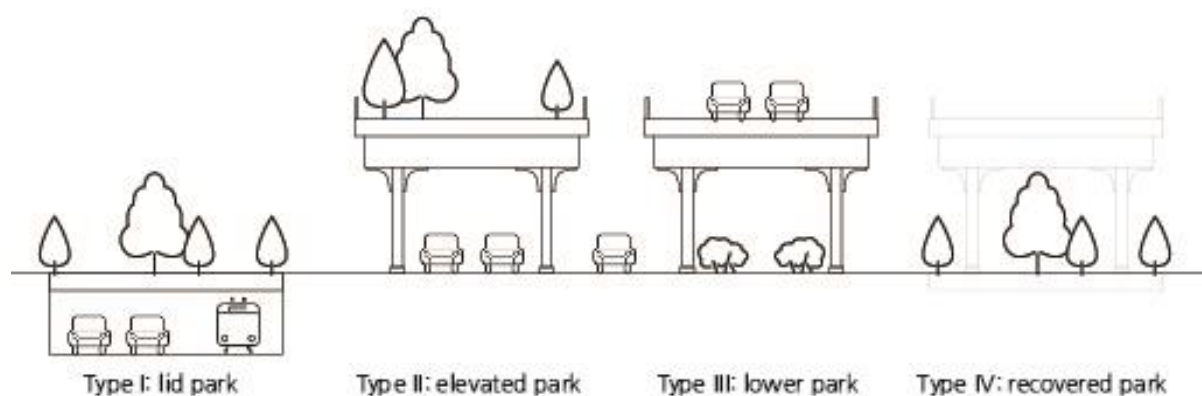


Figure 1. Typology of Urban Greenway Parks

Table 2. Features and Character

	Lid Park	Elevated Park	Lower Park	Recovered Park
Features	<ul style="list-style-type: none"> · roof garden · noise prevention · high accessibility (level=0) 	<ul style="list-style-type: none"> · roof garden · linear park · continuous experience · over-looking · high accessibility 	<ul style="list-style-type: none"> · shaded area · chill and quite · linear park 	<ul style="list-style-type: none"> · reclamation · ecological improvement · linear park

Design and Program	<ul style="list-style-type: none"> · urban oriented program: market, art · sports facilities: soccer field, baseball, tennis court 	<ul style="list-style-type: none"> · walking path · urban oriented program 	<ul style="list-style-type: none"> · sport facilities: skate board · night and light scape 	<ul style="list-style-type: none"> · high density vegetation
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ⁱIn a speech in March 2016, Anthony Foxx, the nation’s top transportation official, said “Instead of connecting us to each other, highway decision makers separated us...We can’t change everything about the past, but we can certainly work as hard as we can today to repair our infrastructure to make it the connective tissue it ought to be [1, pp. 75–80].”

ⁱⁱ More than 50 parks over highways have been built or proposed in the United States [1, p. 76].

Strategies For The Recovery Of Threatened Natural Systems And Their Role In The Mitigation Of Rapid Urban Growth In Montes De Oca, Costa Rica

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Abstract

Costa Rica is well known for its ecological and landscape diversity. Nevertheless, most of its cities have lost their natural richness due to uncontrolled growth in infrastructure. Urban development has caused surface waterproofing, air and water pollution, poorer landscape quality and a major loss of most native forests and the species living within them. This is the case of the county of Montes de Oca, birthplace of the most important university in the country.

The main campus of the University of Costa Rica comprises nearly 87 hectares and has conditioned urban growth in the area. It represents one of the few “green lungs” of the Metropolitan Region and is constantly being threatened by the construction of new buildings. This highlights the urgent need of an urban and landscape development plan. For this reason we made a proposal for its protection, focused on natural continuity, cushioning, ecological compensation and anticipation of future university expansion.

The landscape diagnosis analyzed water resources, slopes, runoff, flora and fauna. In 2017, the effects of “El Niño”, caused prolonged droughts and heavy rainfall in short periods of time, which resulted in flooding, high soil saturation and an increased risk of landslides. Green cover in the county is made up of patches of secondary forests linked to the University and Torres River, urban parks and isolated gardens. At “Finca 3”, the forest fragments represent at least 26% of the land. A detailed survey of its flora allowed us to characterize trees by shape, dimensions, color, as well as detecting the scarce, native, threatened species and the ones at risk of extinction to define the conservation criteria. We identified 209 tree species on 34 hectares, surpassing the records of larger nearby protected areas famous for their biodiversity, such as Cerros de La Carpintera (110 tree species in 2391 hectares).

At a regional level, we propose the integration of a green infrastructure network, through river corridors and landscape connectors associated with the rivers, linking natural spaces. Therefore, creating animal and plant crossings, nurturing ecosystem services such as carbon fixation and water quality improvement, and promoting outdoor recreation and the prevention of floods and landslides.

At the Campus level, the proposal is built upon four pillars: the Articulation System, which solves connectivity issues between the University and its environment considering mobility

factors; the Border System, which analyzes the relationship with the context, adding defined accesses and cushioning fringes; the Functional Units System, which groups homogeneous elements with defined identities; and finally, the Conservation and Ecology System, which promotes ecological and landscape connectivity through two components: water and vegetation. Green infrastructure acts as a natural public health system, favoring physical activity, establishing a bridge that unites forest patches and boosts ecosystem services responsible for preventing climate change. In order to mitigate flooding, there is a chain of lagoons in which water moves by gravity, accompanied by canals and rain gardens that delay water speed, improve its quality and enriches the user experience.

Keywords: Ecosystem services; landscape urbanism; green infrastructure; biodiversity loss; flooding.

1. Introduction

Costa Rica is internationally recognized for its extensive ecological biodiversity, as well for the beauty and variety of its natural and cultural landscapes. Its strategic location as a bridge between North and South America and its altitudinal fringes make it possible to combine landscapes from the humid tropical forest to dry tropical forest. In addition, since the end of the 20th century, the creation of the National System of Conservation Areas (SINAC), has helped recover part of the country's forested area. According to SINAC [1], Costa Rica possesses 26.5% of the continental territory under state protection. However, parallel to the efforts of conservation of the natural patrimony, there has been uncontrolled urban growth in the Great Metropolitan Area (GAM) of the Central Valley that embodies the contradiction between an environmental discourse and a chaotic urban reality.

The county of Montes de Oca in the province of San José is one of the urban territories that has undergone a rapid transformation due to urban growth in recent decades. The county is considered the cradle of education in the country since it is home to a multitude of universities. The sparsely controlled growth and demand for buildable space have caused soils in aquifer recharge zones to become impermeable, increased pollution of streams and rivers; and have contributed to the loss of large quantities of forest.

The Rodrigo Facio headquarters of the University of Costa Rica (UCR) created in the 1940's has also contributed heavily to the urban growth of the area due to its constant expansion with the acquisition of new land (Fig.1). The campus, from its conceptualization in the first overall design, was presented as an ECO-CAMPUS boasting

a high percentage of green areas and protected forests, which is why it represents one of the few urban lungs left east of the GAM, and which in turn has been threatened by the construction of new buildings surrounding university spaces. Users as well as university authorities have made known the urgent need for a territorial urban landscape plan for both the campus and adjacent districts. This is why the proposal for the protection of the Rodrigo Facio headquarters was developed, replicable in other areas of the city, emphasizing the importance of the continuity of "green infrastructure" and of various natural layers superimposed upon urban use. This article presents a diagnosis of the area and proposes strategies for the recovery of threatened natural systems and the mitigation of urban growth within the Campus and the surrounding extent of Montes de Oca.



Fig. 1. Campus and Montes de Oca Context.
 Source: Paul Vega Salas (2017). LANAMME.

2. Methodology

As the first phase, several diagnoses were made that helped to better understand the current saturation of the Campus and its areas of influence. Using a process of

citizen participation with tools including flowcharts or evaluation sheets, it was possible to make a perceptual social diagnosis. Additionally, mobility, spatiality, the landscape and its natural systems were diagnosed along with the new buildings that are intended to be built at the University. For each diagnosis, their current situation and problems were analyzed to produced recommendations and guidelines for planning.

In this article, we will focus on the analysis of landscape and natural systems. For this process it was necessary to conduct field work in transdisciplinary teams. A thorough survey of the campus' vegetation was conducted considering native and exotic species, deforested and newly sown trees, as well plant habitats. Examining historical aerial photographs and previous analyses made it possible to truly grasp the magnitude of the loss of forest cover and predominant urban expansion in the area. On the other hand, maps of the county were created emphasizing the area of the Torres River Biological Corridor according to maps of the Environmental Fragility Index of the National Electric Company (CNF). Finally, the information from the different diagnoses was cross-linked in order to generate mitigation guidelines and a landscape proposal. For this phase two participatory workshops were held: one with university personnel and another with surrounding neighbors and urban groups in the area (Fig. 2). We worked in a variety of scales framing the campus within its respective county, as well as the scale of the Rodrigo Facio headquarters in the University and other specific areas of the Campus.



Fig. 2. Field work and participatory workshops.
 Source: Own elaboration (2017).

3. Territorial framing

3.1. Montes de Oca

The county of Montes de Oca consists of 15,6 km² and is composed of 4 districts, San Pedro (4.82 km²), Sabanilla (1,79 km²), Mercedes (1,39 km²), and San Rafael (7,16 km²). San Pedro occupies 30% of the territory and is the second most densely populated district following Sabanilla, with 52% of the population while San Rafael only has 15.3% of the population and a large part of the protected forest area [2]. The Rodrigo Facio Headquarters of UCR holds nearly 87 hectares, occupying 15.24% of the territory of two of the districts in the county of Montes de Oca (Fig. 3). This county adjoins the northwest with the county of Guadalupe, the Torres River becoming a boundary or “back” instead of a blue infrastructure connector.

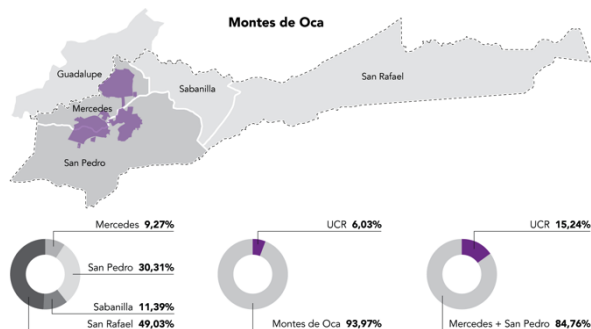


Fig. 3. Location of UCR in Montes de Oca + territorial extension relationship. Source: Own elaboration (2017).

3.2. Impact of the University of Costa Rica in the county

UCR attracts thousands of students, professors and officials from all areas of the country on a daily basis as a meeting point and urban node, which gives the county its identity. University life has functioned like a magnet where internal and external uses establish a range of mutual dependence. Therefore, land uses have been modified as the expansion of the campus has enhanced the creation of services, commercial areas, rental housing for university students and a series of universities and educational institutions that are established nearby, increasing the educational vocation. As result, this has generated increased land value, causing displacement of permanent housing areas, the disappearance of traditional neighborhoods, coffee plantations and the remnants of riparian forests, producing a deterioration in landscape quality.

3.3. The Interurban Biological Corridor

Given the growing demand for built space, the system of green areas in the county has been drastically affected, decreasing urban parks and recreational areas. This is why rivers have reemerged, formerly invisible as an opportunity to protect biodiversity; as a strategy for the articulation of their scope of protection with small green patches, parks or

forests scattered around the city, generating connectors that support continuity throughout the city and allow the transit of populations of flora and fauna established in these sites.

The Interurban Biological Corridor of the Torres River (Fig. 4) is an initiative led by the Hydrographic Basins and Biological Corridors Program of the municipality of San José with the support of other organized groups of neighbors and professionals. This project seeks to rehabilitate the protected areas, protect the urban environment and establish itself as the first urban ecological corridor in the county. Through the initiative, different ecosystem services would be obtained; defined as the benefits that humans obtain from natural ecosystems such as provisioning (obtaining water, food and natural resources); regulation (regulating floods and droughts); cultural (promoting spiritual values); and support [3].

The territory of UCR limits its northwest margin with part of this corridor along 745 m and restricts it to “Finca” 3 and 4 with their margins of 33.667 m² that must be exclusively deemed riparian protection areas. This strip presents a great widening of the vegetal coverage in relation to the context for its vulnerability evidences even more the importance of protecting these tracks inside the university campus.

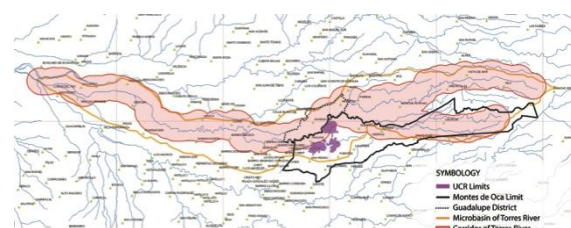


Fig. 4. Torres River Interurban Biological Corridor. Source: Own elaboration, based on maps for Environmental Fragility Index of CNFL (2017).

4. Diagnosis of Landscape and Natural Systems

As we have seen throughout this article, the Torres River Interurban Corridor, still protects an important segment of forest in contrast to the rest of the county and potentially allows the east-west articulation of strategic sites such as the Park of the East, the UCR, the Simon Bolivar Park and the Children's Museum. Within this dynamic UCR holds a relevant role in its consideration as a lung within the urban system for its density of plant cover, a condition that influences the surrounding natural landscape (Fig. 5).



Fig. 5. Location of Montes De Oca. Source: Own elaboration, based on Google Earth photo (2017).

The landscape analysis carried out considered a systemic approach, where the territory is understood as a complex relationship of articulated systems, for its study a superposition of variables combined with the cartography was proposed so that each component analyzed could be reflected in maps and identified within the system. In relation to this diagnosis, the following were analyzed: water resources and runoff, topography, as well as flora and fauna.

4.1. Slopes

At the topographic level, the county presents a very marked difference to the eastern sector, covering the San Rafael district. In this sector the slopes increase, becoming greater than 20% [4], due to the presence of mountains that are extensions to the faults of the Irazú Volcano, also generating the appearance of numerous rivers and streams (Fig. 6). On the other hand, towards the western sector the topography is more consistent except for some river basins that are forming mountains and occupy more depth in the area.

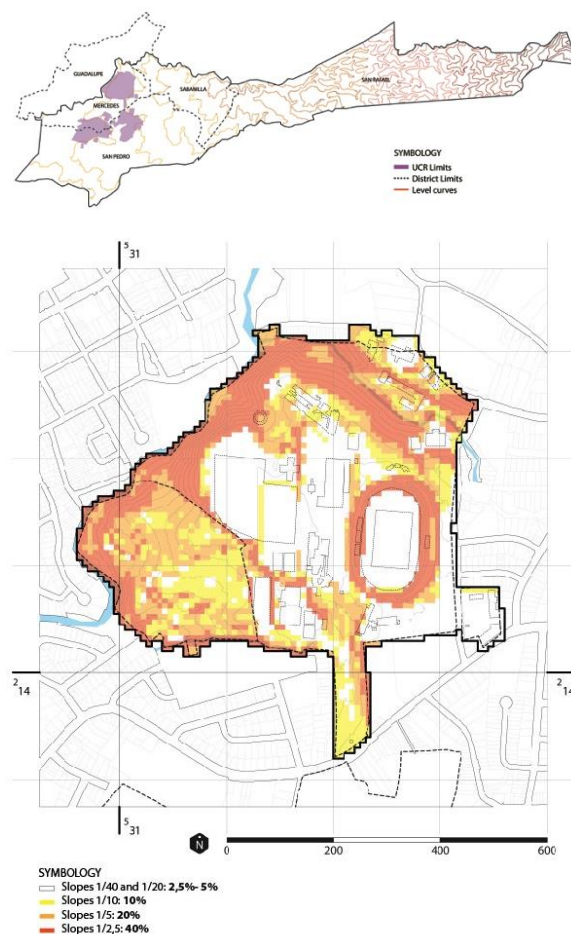


Fig. 6. Slope Maps of the County + Sports Facilities and F4, UCR. Source: Own elaboration (2017).

The central zone of the Sports Facilities and F4 has a more consistent topography with slopes ranging from 2.5 to 5% and up to 10%, where most buildings and infrastructure have been built. As one moves away from this central heart, the topography becomes more irregular responding to the different water channels that cross it, increasing the slopes from 10, 20 and up to 40% in the margins of the rivers. Through certain depressions, visual basins are also formed that allow observing the urban center in the distance (Fig. 6).

4.2. Hydric Resources

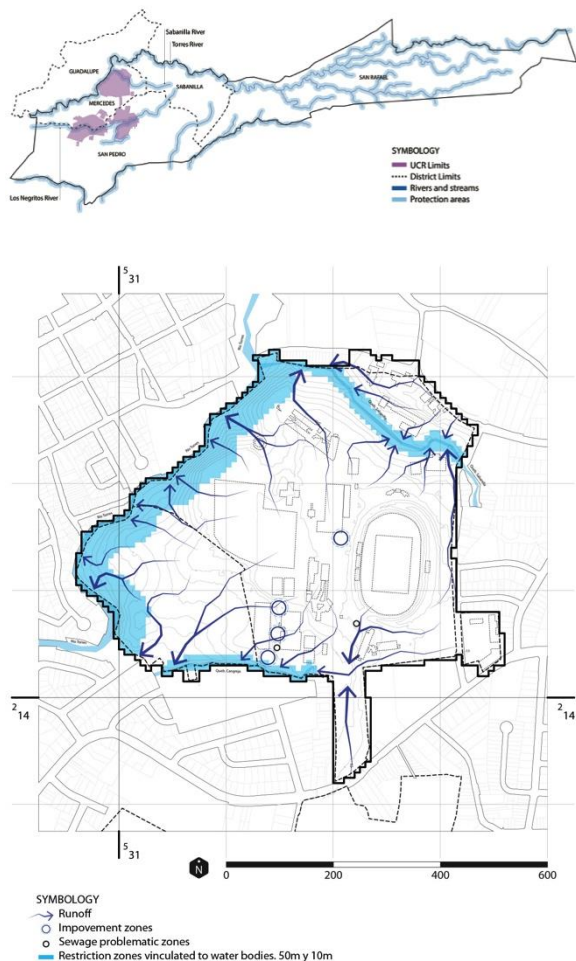


Fig. 7. Maps of the rivers in the county + Sports Facilities and F4, UCR. Source: Own elaboration (2017).

Within Costa Rica in 2017, the El Niño phenomenon generated significant variations in precipitation, causing shortages of rain on the Pacific slope and excess in the Caribbean. Although the fluvial system of the county of Montes de Oca belongs to the Pacific slope, torrential rains occurred, generating serious flood problems. The topography of the county with mountains that descend towards the populated sectors (Fig. 7), added to the loss of vegetation cover, pollution, possible earthquakes and saturation of soils and riverbeds. These factors increase events such as floods and landslides in urban areas.

At the campus scale, a study of directionality of surface runoff from the topography and slopes defined that most of the runoff vents to the surrounding rivers and streams, contributing to considerable water volumes. Some regulatory withdrawals such as those required for rivers that vary from 10m to 50m or the 100m perimeters for the springs restrict the construction of buildings for the protection of these water bodies, however sometimes these containment strips are not enough.

4.3. Wildlife, vegetation and forest cover

As for the system of life zones, Montes de Oca is composed of the Very Humid Premontane Forest in the eastern regions and the Montane Low Humid Forest in the middle section. The districts of San Pedro, Mercedes and Sabanita are mostly part of the Premontane Humid Forest (Fig. 8), which has been reduced to small representative patches within the city due to deforestation and urban growth.

The few patches of significant vegetation cover, especially secondary forests, are associated with the Campus

and the Torres River (Fig. 8). In the high zones of San Rafael the intervened forests abound and throughout the county exist various urban parks, vacant lots and isolated gardens, with certain vegetative wealth.

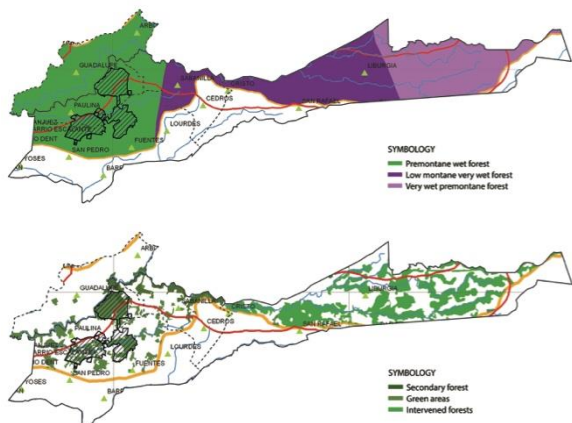


Fig. 8. Life Zones + Forest and green areas Maps. Source: Own elaboration, based on maps of Fragility Index (2017).

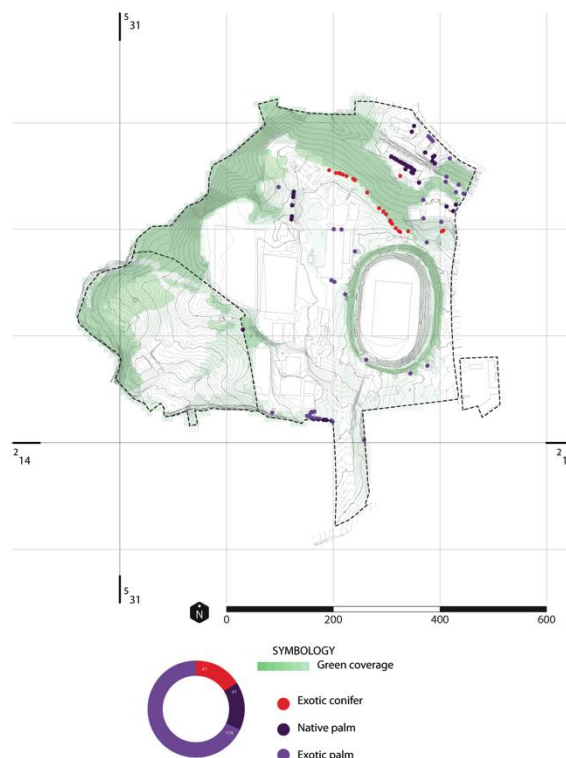
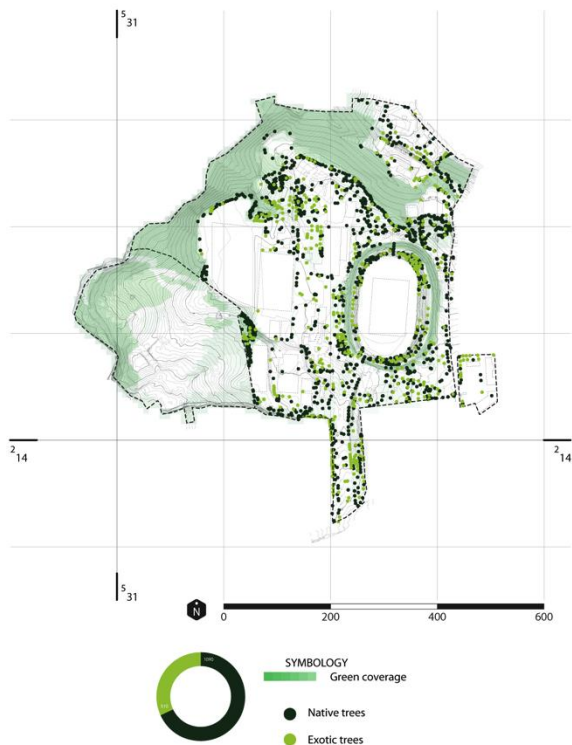


Fig. 9. Maps of native and exotic trees + conifers and palms. Source: Own elaboration (2017).



The Campus density study shows areas of high plant density correlate with bodies of water. The Campus has protected areas and a botanical garden in Plot 1. In “Finca” 3, for example, the forest patch represents 26% of the land. A detailed study of the flora of the site was made, categorizing the outstanding trees by form, monumental size, those possessing striking color, as well as native and exotic species. In addition, a meticulous survey of scarce and native trees, as well as threatened and endangered trees, clarified the conservation criteria of the species, detecting logging without planning in recent years. We identified 1,090 (59%) native trees and 510 (27%) exotic trees (Fig. 9). Of the native trees, 123 different species were identified in “Finca” 3 and 209 species throughout the Campus (34 ha), surpassing areas of greater extension

and recognized for their biodiversity, such as La Carpintera (2.391 ha with 110 species). While the native trees predominate in the election of zingiberals, conifers and shrubs, exotic species prevail, a frequent phenomenon in the selection of urban species within the city. From the point of view of fauna, more than 120 species of birds were identified, as well as a diversity number of insects and mammals. According to studies by CIGN (Institutional Carbon Neutrality Commission), the Campus represents an important contribution in CO₂ capture, emitting 4,538 tons and capturing 56,219 [5]. In addition, the high level of appreciation that the community has regarding its natural areas is evident with participatory tools.

4.4. Conclusions and Issue

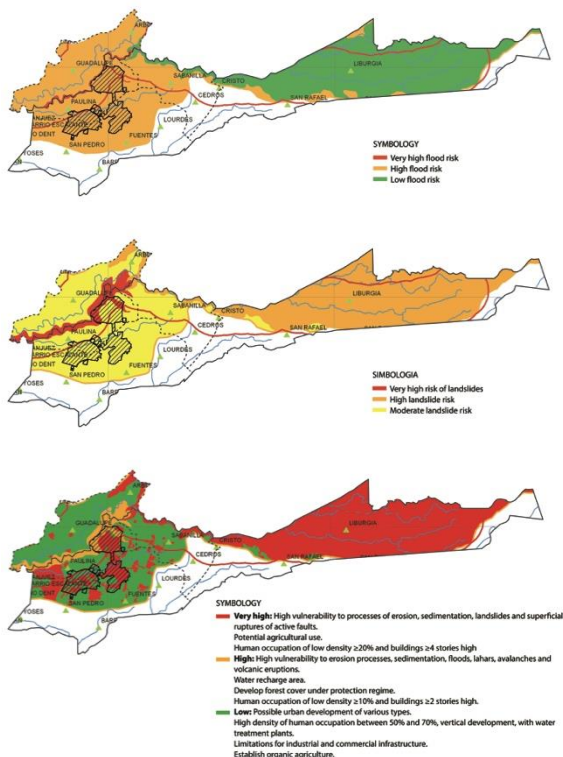


Fig. 10. Maps of flood risks + landslides. Below: Maps of integrated IFA's, zones of vulnerability. Source: Own elaboration, based on maps from the Environmental Fragility Index of CNFL (2017).

The irregular topographic condition of the county, with steeper slopes, produces numerous river channels that descend into urban areas. The pressure on its protection margins added to the loss of coverage, waterproofing and direct outflows increase risk conditions (Fig. 10). It was discovered that the different existing natural and water systems have degraded over time and continued urban expansion is generating natural dilemmas within the city. The need to produce new systems that are more strongly integrated with nature is imperative.

5. Results: Strategies for recovery

Biophilia is the deep-seated need of humans to connect with nature [6]. A biophilic city is at its heart a biodiverse city, a city full of nature, a place where in the normal course of work and play and life residents feel, see, and experience rich nature-plants, trees, animals [7].

For this project a proposal for environmental protection and urban landscape development is made where nature is the advocate supported by principles of biophilic design. One of the fundamental objectives was to anticipate the urban growth requirements of the campus and its immediate surroundings, based on principles of cushioning and ecological compensation. In this sense, Biophilic cities cherish what already exists (and there is much, as we have already seen) but also work hard to restore and repair what has been lost or degraded and to integrate new forms of nature into the design of every new structure or built project [7].

At the regional scale, the protection of water resources and the incorporation of green infrastructure that connects urban parks and the area's most important green spaces are proposed. Emphasis is placed on the protection of aquifers located in elevated areas. Likewise, different green and landscape corridors are established along the two main rivers: the Torres and María Aguilar rivers, creating several linear parks, as well as regeneration parks that make up a large metropolitan river corridor. These corridors that act as pathways for animal and plant life, also provide ecological services such as carbon capture, water quality control, prevention of floods and landslides, recreation and sports areas, among others. The metropolitan park, La Sabana, and the University Campus function as excellent articulators between these two rivers (Fig. 11).

From the Campus scale, prototypes are proposed on a smaller scale that can serve as an example in the management and protection of corridors incorporating water sanitation, articulation of green patches and landscape and ecological integration within the urban context; schemes replicable in other potential sectors along the corridors.



Fig. 11. Macro proposal maps. Source: Own elaboration based on Google Earth, Torres River Biological Park Articulator (Laura Chaverri), Rutas Naturbanas and (2017).

5.1. Proposed systems

The proposal is based on four different systems vital to the Campus, which are interdependent, focused on achieving a balance between the current condition and the

future development of buildings complemented by green areas to minimize their vulnerability.

The first, the Articulation System; resolves the connection of the Campus with its surroundings taking into account the pedestrian, cyclist, public transportation lines and private vehicles in a balanced system for each user. The Edge System studies the relationship of the Campus with the environment, incorporating well-defined access in some areas and incorporating a buffer layer in others. The system of Functional Units corresponds to the configuration of spaces with defined identities that group buildings and green areas producing small sets linked by the "articulator" system. Finally, the backbone of the proposal is formed by the Protection and Ecology System focused on facilitating ecological and passive connectivity through the reinforcement of the "green and blue infrastructure" (Fig. 12).

The Protection and Ecology System is composed of two components that complement and coexist: the hydraulic and the vegetative (Fig. 13). The green infrastructure becomes a natural public health system since as it is interwoven with the mobility system, boosting physical and recreational activity (Fig. 14,16). Thus, establishing a corridor that highlighting the various forest areas and patches of regeneration and generating diverse ecosystem services capable of preventing climate change (Fig. 15). Some biophilic design patterns are enhanced by visual and non visual connection with nature. The latter is characterized by auditory, haptic, olfactory, or gustatory stimuli that engender a positive reference to nature [6]. Some expected results are the reduction of

runoff caused by storms and the generation of increased biodiversity. Likewise, trees with high maintenance and conservation priority are defined, according to the diagnostic criteria.

To compensate for the serious problem of flooding both on the campus and in the surrounding areas, an interconnected water system consisting of channels, compensation and macrophyte ponds, and rain gardens is proposed, which delays the speed of water evacuation and thus the pollution of the rivers by means of oils and hydrocarbons that were not previously treated. A new evacuation system is proposed with a succession of ponds that circulate by gravity towards the river, thus improving water quality and the experience of visitors.

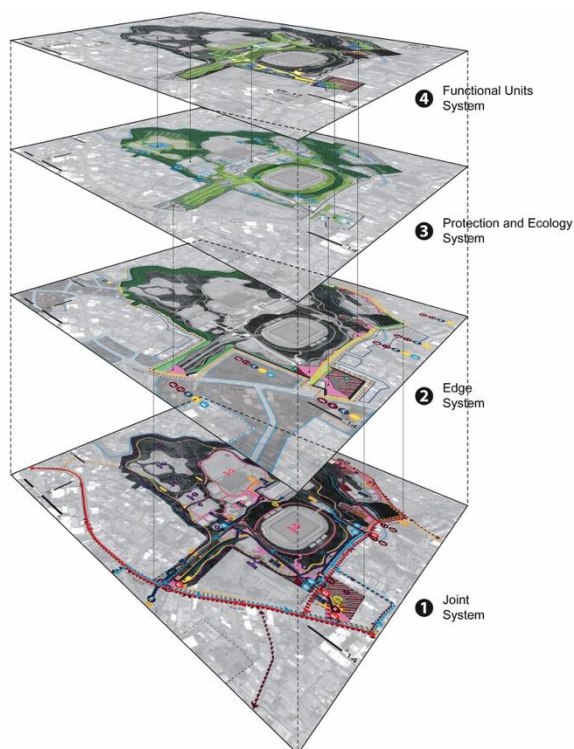


Fig. 12. Layers structure diagram. Source: Own elaboration (2017).



Fig. 13. Green and blue Infrastructure diagram. Source: Own elaboration (2017).



Fig. 14. Proposed urban section showing F3 UCR and integration with Cartaga public street. Source: Own elaboration (2017).



Fig. 15. Protection and Ecology System in the Campus. Source: Own elaboration (2017).

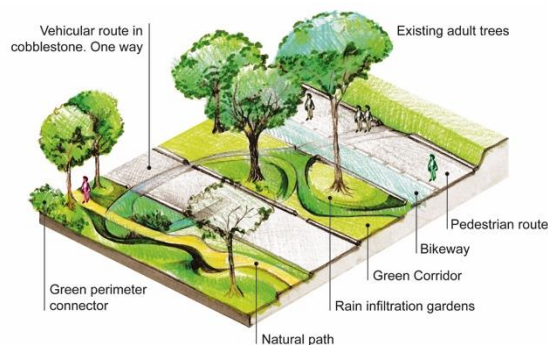


Fig. 16. Proposed Boulevard in Finca 3. Source: Own elaboration (2017).

6. Conclusion

Throughout the article it was possible to observe the enormous landscape and ecological potential possessed by Montes de Oca, however we also detect many problems that must be solved. For the proposal, different design principles were used, where connectivity, education and diversity stand out, as well as biophilic design patterns as visual and non visual connections with nature and the presence of water. The proposal focused on ensuring a sense of identity by strengthening the ecological vision and demonstrating that it provides enormous benefits to the human population, such as offering an ideal environment for relaxation or providing water purification services. Biophilic design patterns have the potential to re-position the environmental quality conversation to give the individual's needs equal consideration alongside conventional parameters for building performance that have historically excluded health and well-being [6].

Although this work has been well accepted by university authorities and neighbors who were invited to both workshops and the presentation of results, it is essential to be able to execute some of these proposals in order to generate a real user impact. It is imperative to involve local governments and communities in order for concrete actions to be carried out in our cities.

Acknowledgments

It must be recognized that the extended research and design work was carried out by a multidisciplinary team consisting of: Arch. Laura Chaverri (project director), Arch. Guillermo Chaves, Arch. Luis Solano, Arch. Nancy Corrales, Arch. Fernanda Barquero,

Bio. Carlos Bolaños, Luis Fuentes, Sigrith Solera, Karen Badilla and Roberto Hidalgo.

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SMART NATION



[FEATURED SESSION SPEAKERS]

DAY 1 TIME: 14:00 – 14:20

Cooling Singapore - Scientific Knowledge for Decision-Makers

Dr. Conrad Phillip

Singapore-ETH Centre, Cooling Singapore
Singapore

Synopsis:

The UHI has become a matter for increasing concern because of its many, mainly negative, effects upon the quality of urban life. These include reduced thermal comfort for urban dwellers, and increased noise, air pollutants and greenhouse gas emissions. In tropical Singapore, increased temperatures due to UHI negatively affects the liveability and thermal comfort of residents. Many of these problems are likely to become more severe in the future, partly because of urban growth but also of the impacts of climate change upon cities.

Reducing the UHI effect will bring considerable benefits to Singapore, measurable not only in economic terms but also in the improved health and wellbeing of citizens. Achieving a substantial and lasting reduction, however, will be a complex undertaking that necessitates an all-of-government approach, since it will have implications for planning, transportation and construction, as well as patterns of individual consumption. Such an undertaking must be based upon the best scientific information, and new research will also be needed in areas where existing knowledge is insufficient. It will require a consistent commitment over an extended period and close coordination among stakeholders in government, the research community and private sector. Finally, addressing the issue of UHI will directly contribute to two of Singapore's policy goals concerned with thermal comfort and meeting the COP21 goals to the reduction of greenhouse gases.

For all these reasons, Cooling Singapore project aims to develop a roadmap to guide the emerging strategy.

DAY 1 TIME: 14:20 – 14:40

Green Intelligence - the future of plants and people!

Veera Sekaran

Founder, Managing Director
Greenology
Singapore

Synopsis:

Mr Veera Sekaran would be exploring GI (Green Intelligence), a term he coined for the application of smart solutions on urban greening integrated with science and technology.

During his sharing, Veera will borrow from his own work that connects bio-sensors and softwares to urban greening and agricultural systems to showcase how we can get these micro natural habitats to 'speak' to us through data analytics and algorithms, and in turn receive regular checks on their well-being. He would also be addressing the pivotal roles played by architects, designers, practitioners and institutions in placing GI at the core of each project, as early as the conceptual and design stages, to realize built environments that are in better connection with nature.

DAY 1 TIME: 14:40 – 15:00

Punggol Digital District - A New Approach to Designing Singapore's Next Generation Business and University District

Aaron Tham

Director
JTC Corporation
Singapore

Synopsis:

Punggol Digital District (PDD) is the first district in Singapore to adopt a one integrated masterplan approach where we co-locate a business park and a university, which are supported by community facilities and public spaces from the planning stage. Such a holistic planning approach creates a vibrant and inclusive district to potentially transform the way we work, live, learn and play in the future.

The co-location of the Singapore Institute of Technology's (SIT) new campus with JTC's business park buildings will facilitate greater industry academia collaboration, through the cross-fertilisation of ideas and knowledge among students, faculty and industry professionals. New technological or business ideas conceived in SIT could be prototyped, tested and adopted by businesses in PDD, contributing to a higher rate of commercialisation success. Innovative enterprises affiliated with SIT's strengths in applied programmes such as digital & cyber security, design, engineering, food technology, can also tap on SIT's research capabilities for R&D and student pool for talent.

Housing key growth sectors of the digital economy such as cyber security and IoT, PDD will bring approximately 28,000 exciting jobs closer to residents in Punggol and the north-east region. Through the clustering of these growth sectors, we aim to create an ecosystem of open innovation and a conducive test-bed environment that will enable our businesses and community to thrive in a digital economy.

The District will not only be about technology and infrastructure, but an inclusive and green district for the community. The District is also planned to include green links to the waterfront and also more public spaces for the community to relax and unwind. For instance, the Campus Boulevard is a 800m pedestrianised street which will be a key gathering space that stretches between the SIT campus and JTC's business park buildings. It will be designed for active mobility options such as walking, cycling and PMDs, with various retail and F&B offerings along the boulevard. PDD is also located beside the Serangoon Reservoir and this allows us to plan more community spaces such as a Market Village, which will offer retail and dining options for the community to relax and unwind by the coast.

Estimating leaf area index of urban trees from digital zenith cover photography: A framework on its application for urban practitioners

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Abstract

Urban vegetation is recognised as an important component in cities due to the benefits they provide, such as attenuation of the urban heat island effect; abatement of air and noise pollution; as well as human stress reduction. One method of assessing urban greenery is using the leaf area index (LAI), which is defined as the one-sided green leaf area per unit ground surface area, and is a measure of vegetation density. It is often used to infer various eco-physiological characteristics of plants, which determine their benefits, for example: evapotranspiration rate and shade provision (related to thermal comfort in urban streets, parks and rooftop gardens) and overall greenness (related to tree health or overall attractiveness). These benefits are often important to quantify for practitioners such as researchers, landscape architects, arborists and environmental consultants. Inexpensive, rapid and accurate estimates of LAI in urban areas are important, as often, practitioners' time is scarce. While conventional methods for LAI are accurate they often require expensive equipment or disruptive measurements, and are not suitable for urban trees. Being one of the few studies to apply this method in an urban context, we show how the ground-based cover photography method (used in recent studies to quantify LAI of natural forests) meets the challenges of quantifying LAI in urban areas and present a framework for its application for different practitioners who work with urban greenery.

Key words: Leaf area index, urban, landscape urbanism, green infrastructure, design evaluation, landscape assessments

1. Introduction

The benefits of greenery in urban areas have been long studied and are well documented. Many academics and policy makers recognise that urban greenery and

green structures are important due to their ability to help alleviate the urban heat island effect [1,2], improve air quality [3], reduce noise pollution [4], and aid in storm water management [5]. Urban greenery is also related to human perceived aesthetic

qualities [6] and health benefits of an area [7]. Thus, quantifying the extent and density of urban greenery is necessary for a variety of different application in cities. Urban practitioners need a reliable vegetation density metric to assess the health and success of landscaped areas, and to understand relationships between greenery and their benefits.

At broad spatial scales, landscape ecologists and planning researchers are interested in understanding the relationship between greenery, land use change and ecosystem services [8]. Thus, these urban researchers in cities often require accurate information of either species-specific traits, or individual tree-level measurements to produce accurate models to simulate these predicted benefits. To optimise the benefits provided by greenery, urban planners and developers are interested in increasing urban vegetation cover and density. At the local scale, practitioners working in the design, use and maintenance of green areas are interested in quantifying the foliage area and density of a space as these measurements are related to the general appearance and health of trees.

To date, greenery in urban areas is often quantified from satellite imagery-based canopy cover estimates. However, canopy cover only detects the extent of greenery and assumes that the vegetation is homogeneously distributed. These remotely-sensed vegetation estimates from satellite or air-borne high resolution imagery do not yield suitable results for complex canopies [9,10]. While this may be sufficient for broad-scale analyses, it can be erroneous at smaller scales as it does not capture important species-specific information, such as branching architecture and foliage density, which are important for quantifying urban ecosystem services. The leaf area index (LAI) is a useful parameter that can

be used to classify vegetation density in urban areas and can be suitable at multiple scales.

1.1 Definition of LAI

Leaf Area Index (LAI) is defined as the one-sided green leaf area per unit ground surface area [11]. It is a dimensionless number which characterises plant canopies and is used as a proxy to measure plant attributes such as gas exchange, rainfall interception, radiation interception, and carbon flux [9,12]. These attributes can be linked to ecosystem service provision in natural and urban areas.

LAI is used by forest ecologists to evaluate the health, stress, and productivity of forest stands or individual trees [13,14]. Another application of LAI is in agriculture to determine and model crop cover and yield by quantifying the light interception and potential energy flux balance in crop fields [15,16]. Although traditionally applied in these forest and agricultural settings, there has been a push to utilise LAI to quantify and assess greenery in urban spaces to provide quantification of the aforementioned benefits, and to compare greenery densities between buildings. For example, LAI is used in the calculation of the Green Plot Ratio (GnPR), which is defined as the average LAI of planted landscape in a building plot area [17] and is incorporated in many planning and building policies [18,19].

For these reasons, it is imperative to develop methods to accurately and efficiently measure LAI in urban areas. However, there have been few studies done in this field and conventional methods to quantify LAI are often expensive, laborious and time-consuming. This paper aims to (1) give a brief overview of the importance of LAI as an urban vegetation density metric, (2) detail a comprehensive working method

to acquire LAI from ground-based cover photography in urban areas, (3) develop a framework on the potential of this technique based on the requirements of different urban practitioners, and (4) provide suggestions for future application and improvement of this method.

1.2 Relevance of LAI to practitioners in the urban environment

LAI is measurement of plant canopy attributes and greenery density, both of which can provide benefits to people as previously mentioned. Despite its extensive application in agricultural and forest settings, studies of its use in urban environments are scarce [2,12,20].

Where may quantifying this metric be useful in urban environments? Knowledge on species-specific LAI values, as well as on-site assessments of LAI, could be used by practitioners and planners to strategically plan the spatial configurations of urban trees and shrubs to best capture air pollution, reduce noise pollution, and increase the social and aesthetic value of an area.

It has been found that trees with higher LAI values have more surface area for the deposition of air contaminant particulates [3], with younger trees with dense canopies [21] and coniferous trees [22] performing the most efficiently in this regard. However, although large trees with spreading crowns and high LAI values may effectively capture pollution particulates, they may also limit particulate dispersion and increase local pollutant concentrations at ground-level when densely planted together [23].

Trees with higher LAI and denser canopy structures are also able to filter more solar radiation, reduce solar transmissivity,

and increase shade area, producing more latent heating with their higher evapotranspiration rate [24]. The cooling potential of trees with similar LAI are comparable across species, regardless of species-specific trait differences such as leaf angle, leaf size, or branching architecture [2]. Trees with LAI of at least 3 are able to provide adequate shade and inherent cooling effects, and significantly reduce the probability of overheating occurrences [25]. In temperate regions, Hardin and Jensen [26] found that surface temperatures were reduced by 1.2°C for every unit increase in LAI, and that variation in surface temperatures was significantly related to LAI. In the subtropics and tropics, air temperatures under trees with higher LAI was found to be up to 2.55°C cooler [27,28].

LAI is closely related to perceived benefits and aesthetics of spaces, and this is reflected in property prices in an area. Escobedo et al. [29] found that property values in Florida were positively related to high LAI trees, with every unit increase in LAI raising property values by US\$9,348. Urban LAI is also found to be inversely correlated with household energy consumption [30].

1.3 Quantification of LAI

Evidently, the ability to rapidly and accurately quantify LAI in urban areas could be a valuable asset to practitioners. However, traditionally, LAI is directly measured by destructively harvesting and measuring the foliage area of a tree or shrub. Direct methods are the only measurements that calculate true LAI as only foliage area is included in the calculations [9]. While accurate, these methods are time-consuming, laborious, and are often only suitable for measurements in small areas or of crops due to its destructive nature.

Indirect methods are often used in place of destructive sampling owing to the challenges faced by direct quantifications of LAI. These methods are either based on allometry, radiation transmission theory or gap fraction theory. LAI calculated from allometric models utilise relationships between leaf area and certain measurements of woody plant elements, such as stem or branch diameter, and require a certain degree of disruptive sampling for verification [31].

Recently, remote sensing and light detection and ranging (LiDAR) scanning techniques have been employed successfully by researchers to quantify canopy attributes [32]. However, although these methods may produce precise and accurate results, they are very expensive and require special expertise to manoeuvre and retrieve data for reliable LAI values.

Other indirect methods commonly used rely on optic technology, and these include zenith cover, hemispherical and fisheye photography; and plant canopy analysers (PCAs). These methods are based on the proportion of crown gaps and crown area within the crown [9].

It is important to note that optic methods only quantify plant area index (PAI), or effective leaf area index (LAI_{eff}), as it includes all other physical elements of plant canopies such as stems and other woody elements [9]. For LAI estimates based on fisheye or hemispherical images, true LAI can be estimated by applying a correctional factor α , the ratio of woody area index to plant area index [33]. Conversely, it was found that the LAI estimates derived from disruptive sampling and uncorrected LAI estimates from cover images were comparable [34–36]. This was because the narrow view angle in cover

images meant that the area of woody elements contributing to LAI calculation in cover images are considerably smaller compared to in hemispherical images [37]. For the purposes of this paper, “LAI” refers to both true leaf area index and plant area index.

1.3.1 Zenith cover photography

Cover photography is an optic method which has been successfully used by multiple studies to accurately acquire LAI estimates from forests. Like with other optic methods, it is based on the Beer-Lambert law, which describes and characterises the absorption of light as it passes through a semi-permeable membrane, in this case a forest canopy or tree crown. According to the law, a consistent ratio of light is absorbed as an incident light ray passes successively through foliage layers of a tree crown such that the its absorption rate follows a logarithmic pattern [38]. This law can be applied in optic methods to estimate LAI based on the proportion of gap fraction of the crown but must incorporate a known pattern of leaf inclination angles and an assumption of randomly-distributed foliage. Cover photography has been shown to be able to produce reliable LAI estimates in forest stands [34,39–41] and agricultural plots [36,42–44]. Due to its ease of use and flexible application, it could be a useful method for adoption by urban practitioners who incorporate LAI measurements into their work, or are interested in doing so.

2. Methods

We propose a qualitative assessment framework to determine the feasibility of cover photography as an appropriate method to assess LAI in an urban contexts based on the requirements of different practitioners.

2.1 Assessment framework

Academic literature, industry and government reports were used to identify five key groups of practitioners who work with urban greenery: urban ecologists; urban planners; contractors and developers; landscape architects; and arborists and park managers. These professions' scope of work; and relevance and challenges of LAI application were compiled to understand whether it would be useful for them to use cover photography to assess LAI of urban trees. To enhance the assessment criteria, we also directly discussed these requirements with different practitioners. Based on the literature review and discussions, we created a qualitative assessment framework to determine the feasibility of cover photography to assess LAI for said practitioners (see supplementary materials for the compiled criteria).

During the review and discussions, we found that all practitioners prioritise speed when trying to measure urban vegetation densities. However, not all groups require the use of vegetation density metrics such as LAI. Urban ecologists and researchers prioritise precision and accuracy; whereas the other groups working in urban planning, design and maintenance prioritise ease of use and adoptability. Based on these responses, we measured the time it took for the data collection and analysis procedure, and qualitatively assessed the method's ease of use and accuracy at assessing LAI in different urban scenarios.

2.2 Data collection



Fig. 1. The process of acquiring zenith images: (a) A DSLR camera mounted with a multi-axis spirit level was used to take zenith photographs of tree crowns; (b) Images taken of individual trees were taken when spirit bubble was levelled and the camera was pointing at the zenith angle; (c) An example of a zenith image. Images taken in urban areas will invariably include some urban features within the image, which need to be removed before analysis.

We took zenith cover images of different trees in the urban scenarios identified in the framework across a variety of sky conditions: uniform overcast, clear blue, and scattered clouds. We used a Nikon D7000 digital single-lens reflex camera with an 18-55 mm lens (Fig. 1). All images were taken with an 18 mm zoom to capture a wide angle of view and images were taken in FINE quality JPEG for highest resolution and detail. To ensure that all images are taken at zenith angle, a multi-axis spirit level is mounted on the camera's hotshoe. All images are taken when the spirit bubble is centred within the horizontal plane.

To ensure that all foliage within the image is in focus, one zenith image is taken when the camera is first set to aperture priority mode (aperture $f/9 - f/11$ for a large depth of field) and ISO 400. A second image is taken at the same spot with one-stop underexposure in manual mode by varying the shutter speed while retaining the same f-step. To capture the spatial heterogeneity of foliage distribution, at least four images per tree are taken at various locations beneath its crown.

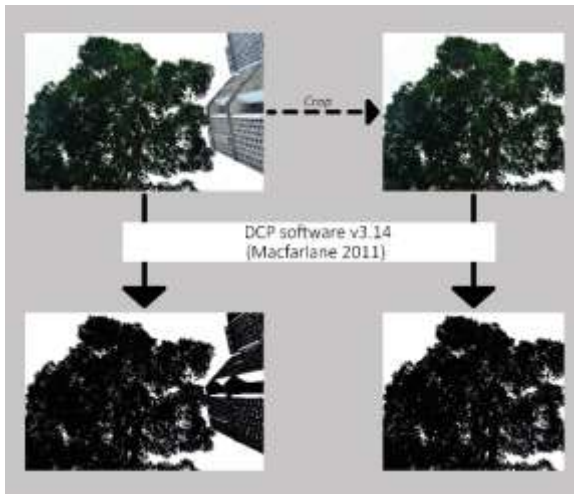


Fig. 2. Images with urban features are cropped prior to input into the DCP software as the software is not sensitive enough to remove urban features.

2.3 Data analysis

We sorted the images and, where needed, cropped them to remove urban features (such as buildings and lamp posts) such that only foliage area is retained in the images (Fig. 2).

Using MATLAB script developed by Macfarlane [45], the cropped images are analysed and the following parameters were calculated: gap fraction, foliage cover, crown cover, crown porosity and LAI. The script separates large between-crown gaps, and smaller within-crown gaps prior to the application of the Beer-Lambert law, which was found by Macfarlane et al. [41] to be able to accurately estimate LAI when compared to destructive sampling. The script requires an assumption randomly arranged foliage and a light extinction coefficient, k , which we have assumed to be 0.85 based on previous studies on leaf inclination angles and photographic image analysis [40,46].

3. Discussion

3.1 Findings

We found that cover photography was able to efficiently estimate LAI across different urban landscapes, provided there was no overlapping urban features or unwanted foliage in the canopy.

The automated image classification threshold is not sensitive enough to accurately distinguish between scattered clouds and blue pixels at times. Images taken in full sun conditions were not useable as the glare and reflection from the sun off the foliage can cause overexposure and an underestimation of foliage cover (Fig. 3).

3.2 Comparison with conventional methods

Zenith cover photography has a considerable advantage compared to other methods for quantifying LAI, owing to its affordability, the speed at which it can be



6 Fig. 3. The DCP software is not able to accurately separate foliage and sky pixels accurately when zenith images are taken in full sun conditions due to the reflection of light off some of the leaves.

executed, and the ease of knowledge transfer. The operator only needs to understand some basic photography concepts (i.e. aperture, shutter speed) and from there, it is as simple as operating a regular point-and-shoot camera. The raw data can be acquired from a single tree within five minutes and post-analysis takes a maximum of 10 minutes per image. This is further expedited by the DCP software's ability to batch process images such that hundreds of images can be analysed within approximately 15 minutes. However, the process is not entirely automated as it still requires the manual removal of urban features through cropping, as well as checking images post-software analysis to ensure that all images have been appropriately thresholded. Nonetheless, the short time taken for the entire process to quantify the LAI of individual trees (~15 minutes) is an asset compared to other methods. Based on reports of other methods, this is significantly less than destructive sampling, PCAs, and other optic methods [47].

Cover photography is a much more affordable option to estimate vegetation density indices compared to other methods. While commercial equipment, such as PCAs and LiDAR scanning equipment, generally cost anywhere between 50,000 USD to upwards of 100,000 USD [48], cover photography only requires a DSLR camera, and a commercial grade computer equipped with photo-editing software such as Adobe Photoshop or GIMP (which is open source). These tools are generally commonplace and readily available.

Cover photography offers a simpler

methodology and enables a wider working window as the operator can acquire suitable images over more varied sky conditions compared to other optic methods. Hemispherical and fisheye images often contain a higher proportion of mixed pixels due to their lower resolution and variable exposure, which may result in underestimation of true LAI [45]. Images can only be taken in overcast conditions to minimise mixed pixels, and this severely restricts the available time for data acquisition. In addition, these images require specific software for post-imaging analyses, which limits their speed and universal accessibility. Due to the wide view angle of these lenses, it is difficult to utilise these methods to estimate the LAI of isolated trees or in urban areas as they may invariably include large expanses of unwanted urban features [49]. PCAs, such as the LiCor LAI-2000, can acquire LAI estimates rapidly, but they possess the same disadvantages as hemispherical images as they rely on similar wide-angle lens technology. In addition, there is no way for the operator to check the accuracy of data collected in-field due to the lack of an interface for quality-checking.

3.3 Limitations of cover photography

The accuracy of LAI estimations from cover photography was compromised in conditions with bright sunlight due to the reflection from shiny foliage elements. This limits the practicality of this method as it only works most optimally in uniform sky conditions without direct sunlight. However, the cover photography method still provides a larger working window and is more tolerable to environmental



FIG. 4. The cover photography method is not suitable for acquiring data from trees under these situations: (a) obstructed sky conditions with urban features dispersed among foliage; (b) large-leaved trees; and (c) mixed canopies with overlapping tree crowns.

conditions compared to other optic methods, where the ideal conditions are only at dawn and at dusk.

The DCP software is not able to accurately detect plant pixels if urban features are dispersed among foliage (Fig. 4a). In these situations, LAI may still be determined through manual analysis as it allows for better control and subjectivity when distinguishing between plant and non-plant pixels [41]. It is not recommended to use zenith cover photography to determine LAI from the canopy of large-leafed trees (Fig. 4b), or of overlapping canopies of different species if the user is only interested in single species values (Fig. 4c). Estimations from cover photography of large-leafed canopies grossly violate the assumption of randomly distributed foliage, and will result in inaccurate estimates of LAI. For overlapping canopies, both automated and manual determination of foliage area of individual trees is near impossible due to the difficulty in discerning between green pixels of different species. In such cases, the overall stand canopy LAI can be determined and used instead.

3.4 *Suggestions for application and improvement*

There are multiple ways the LAI of individual trees can be applied to current industry and research purposes. For example, the total leaf area of individual trees can be acquired by multiplying its LAI by crown area. The total foliage area within a landscaped area can then be calculated by taking the sum of all LAI-weighted crown area. This gives a more robust estimation of the extent of greenery in an area, compared to conventional canopy cover estimates which do not recognise species-specific and individual-specific differences. Millward and Sabir [51] have incorporated LAI

values to evaluate the health and age structure of trees in a landscaped park to determine their ecological and aesthetic benefits, and stressed the importance of utilising individual tree condition to determine accurate estimates of overall greenery benefits.

Accurate LAI estimates can be used together with information on tree location, abundance, spatial clustering, and species-specific traits (e.g. biodiversity-attracting attributes, branch architecture, leaf colour and size) to develop accurate and robust models to determine microclimate and perceived benefits of greenery. Information of total leaf area can be used to perform cost-benefit analyses of urban forests, street vegetation, and parks [29]. LAI can also be used in determining the potential leaf area index (PLAI), which is a measure of the carrying capacity of urban vegetation in an area and is based on the availability and configuration of growing space [52]. This parameter can be used by planners to identify areas that can be further enhanced by vegetation.

While this method is adequate in determining general trends for industry application, it is not robust enough for precise modelling of tree architecture (e.g. in research studies based around an individual or small clusters of trees). For this, we recommend manually determining the light extinction coefficient for more accurate estimates of LAI. We also recognise the limitations of this method with regard to complex urban greenery structures, shrubs and groundcover. We recommend more research to be done to refine and apply the automated cover photography method to estimate LAI of trees in obstructed sky conditions and of understory plants. Macfarlane and Ogden [50] have developed an automated software to detect green pixels to determine foliage

cover in understory plants. This software has been applied to successfully estimate the LAI of forest understory plants [40] and of isolated trees in urban areas with obstructed sky conditions [20]. However, more work needs to be done to fully automate the process.

4. Conclusion

LAI is an important parameter that can be used by a variety of practitioners working in urban areas. It can be used by: urban ecologists to evaluate and model ecosystem services provided by urban vegetation; urban planners, developers and landscape architects to design and assess the extent of greenery in an area; and arborists and park managers to assess the health of trees. For detailed modelling of individual trees, it may be more appropriate to use other methods such as destructive sampling to give more precise estimates. At large landscape scales, LiDAR coupled with remote sensing and spectroscopy are more appropriate LAI quantification methods. Nonetheless, cover photography has the potential to fulfil a specific niche in LAI quantification amongst practitioners that want site-specific greenery density measurements, or rapid inventories of trees. For example, in urban woodlots, landscaped parks, and along streetscapes.

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Tree canopy quantification of street canyons in high-density urban environments using Google Street View

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Abstract

The urban thermal environment has practical implications for energy consumption, human comfort and productivity, air pollution at street level, and urban ecology. Street tree view factor (TVF) is an important parameter of the urban outdoor environment that describe the tree canopy quantification, which plays a key role in the urban thermal environment. However, the previous study areas mainly focus on the cities where streetscape features are relatively simple with well-defined building and street structures. The feasibility and uncertainty of accurately estimating tree canopy at large-scale in such high-density urban areas, with much more complex streetscape structures, are still not clear. A typical street in high-density urban environment is characterized by large overhanging signboards, narrow lanes, heavy traffic, and high-rise buildings that block sunlight and air paths and provide very limited openness to the sky. An effective and accurate method for mapping the tree view factor of street canyons in this urban environment is therefore crucial for studying its urban climate and assessing the relevant outdoor thermal comfort.

This study aims on (1) developing an approach for automatically and accurately deriving tree canopy of street canyons in the high-density urban environments using the publicly available Google Street View (GSV) images and a deep-learning feature extraction algorithm for extraction of tree features; (2) verifying the accuracy of the developed GSV-based method using reference data of hemispheric photography from field survey; and (3) comparing the GSV-based tree view factor estimate of Hong Kong and Singapore, and investigating the impact factors for the discrepancies between them. As a result, TVF maps in high-density urban areas of two subtropical high-density cities are generated. Validation using reference

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data of hemispheric photography from field surveys in compact high-rise and low-rise areas shows that the GSV-based tree view factor estimate has satisfying agreements ($R^2 > 0.95$) with the reference data, suggesting the effectiveness and high accuracy of the developed method. The developed GSV-based method for analysing tree view factor in a 3D street environment makes large-scale tree canopy estimation possible. This will be playing an important role in relating science-based evidence for urban climatic studies and decision making in landscape urban planning and design processes.

Keyword: Sky view factor; Tree canopy; Google Street View; High density; Hong Kong; Singapore.

1. Introduction

The urban thermal environment has practical implications for energy consumption, human comfort and productivity, air pollution at street level, and urban ecology [1]. It is influenced by the geometry of street canyons, street trees, building blocks and impervious ground covers [2]. Street view factor for tree (TVF) is an important parameter of the urban outdoor environment. View factor is a geometric ratio that expresses the fraction of the radiation output from one surface that is intercepted by another [3]. Tree view factor (TVF) is defined as the fractions of the overlying hemisphere as shown in a sky view image that are occupied by the tree canopy. A thorough quantification and understanding of the physical streetscape using view factors, including its features and dynamics, would offer great utility to urban planners and climatologists investigating the urban environment, its physical and social interactions [4], and implications for human well-being.

Street tree canopy, quantified by tree view factor (TVF), has instrumental ecological service functions such as urban heat island mitigation due to its contribution to reduce urban temperature [5], [6]. The thermal comfort benefit of trees that differences due

to trees' aspect ratio affect the physiological equivalent temperature reduction [7]. The trees' cooling effect come from tree shading, which reduces the radiation reaching ground level [8], [9], and evaporative cooling from leaf surfaces [10]. In addition, urban street trees have been found to absorb airborne pollutions and therefore decrease road traffic emissions [11] and improve walkability of streets [12]. Therefore, the proportion of street tree cover can be used to evaluate the benefits from ecosystem service provisions at different areas of a city [13].

The purpose of this study is to develop an approach for estimating and mapping tree view factor (TVF) of street canyons with complex urban living environment context, like the high-density urban areas of Hong Kong. The approach is based on GSV images and a deep-learning technique for street feature extraction, and is validated using hemispheric photography measurements as reference data from field work. This validation is, to our knowledge, the first reported use of hemispheric photography for direct verification of GSV-based streetscape study. The developed approach represents a ground-based perspective of city streetscapes that cover complicated urban contexts, including tree canopy cover, building overhangs, and shade structures.

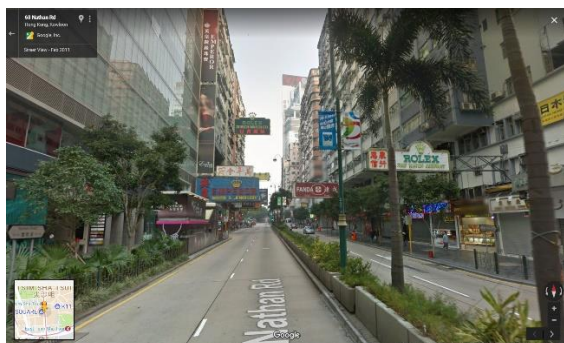


Fig. 1. An example of deep street canyon

in the Tsim Shi Tsui area, one of the typical high-density high-rise urban areas with trees of Hong Kong. (Source: Google Street View, 2016)

2. Methods

2.1. Study area

Hong Kong, situated at the coastline of south-eastern China, is one of the most densely-populated and built-up cities in the world. It has a population of over seven million living in around 262 km² of developed land [14], [15]. The climate of Hong Kong is subtropical maritime, which features hot and humid summers and warm winters [16]. Moreover, high-density urban areas of Hong Kong are characterized by high-rise compact building blocks and deep street canyons with a high H/W ratio. In these areas, tall buildings of some 40-60 stories lining narrow streets of 15-25 m width have been the norm with limited and high fragmentation landscape in built-up area [17]. Serious issues related to human thermal comfort [18], air pollution [19] and the urban heat island effect [20] due to its climate and urban forms have been primary planning concerns. As effective indicators for characterizing urban streetscapes, street view factors have been widely incorporated in modelling to address these concerns. However, accuracy assessment of tree

canopy estimation, which is crucial for quantifying the uncertainty of models, is still lacking due to a lack of measurements.

2.2. GSV-based tree view factor estimates

Gong et al. [21] proposed an approach for accurately deriving view factors for the sky, trees, and buildings of street canyons in the high-density urban environment of Hong Kong using publicly available GSV images and a deep-learning feature extraction algorithm. In this study, we use publicly accessible GSV images to estimate the TVF of street canyons in high-density urban areas of Hong Kong and Singapore. Street panorama images sampled at 30-meter intervals are first collected using the GSV API [22], [23] based on the latitudes and longitudes of the sampling points. Extraction of features, including sky, trees, and buildings, is implemented using the scene parsing method in a deep-learning framework [24], [25]. We then project the panorama images from cylindrical to azimuthal projection to generate the fisheye images. From the fisheye images, TVF is calculated by applying the classical photographic method [26]. The workflow procedure for view factors calculations

using this GSV-based method, and the detailed descriptions are shown in Gong et

al. [21]

3. Results

3.1. Mapping tree canopy of street canyons using GSV images

This research quantifies spatial distributions of GSV-based TVF estimate in high-density urban areas in Kowloon and Hong Kong Island in **Fig. 2** to compare their spatial variation and frequency distributions, as shown in **Fig. 3**. In general, we find the spatial patterns of TVF estimate are similar and consistent with the corresponding building height and density. Areas with higher density have lower TVF, and vice versa. The high-density residential areas, located in southern and western Kowloon and northern Hong Kong Island, which cover about 58% of the study area, are dominated by low TVF (0.0-0.2), because of the high-density construction and narrow streets that block sky visibility and limit space for greenery. The coastline regions and low-rise areas, which cover about 20% of the study area, show much median TVF (0.2-0.3), because of fewer buildings and more sky openness. In low-rise regions near country parks in the southern part of the study area in Hong Kong Island, where building density is low, however, the much lower sky openness, is mainly due to high tree cover (> 0.3) in this area, which blocks much of the sky visibility.

The mean TVF values of the whole areas and built-up areas of Hong Kong is 0.40 and

0.14, respectively, and there are small differences between Kowloon area (0.12) and Hong Kong Island (0.19). **Fig. 3** shows the frequency distribution of the TVF and SVF in Hong Kong to investigate the frequency density of VFs. The TVF in the high building density area is dominated by values less than 0.1 and the mean value is 0.143. The low TVF is mainly limited by the high building density and narrow streets. This mean TVF is smaller compared with Singapore (0.26), a sub-tropical Asian city with high building and population densities (see **Fig. 4**).

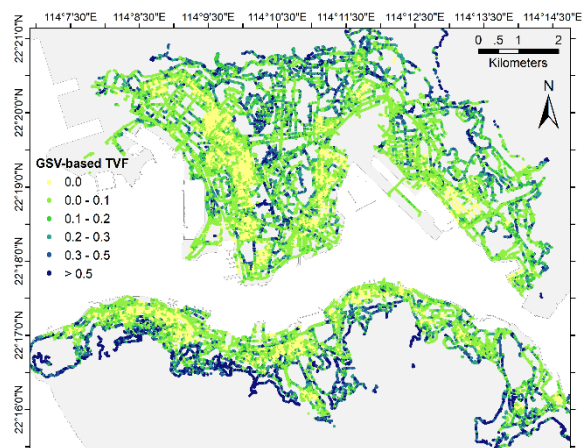


Fig. 2. Mapping of GSV-based estimate of tree view factor of street canyons in high-density urban areas of Hong Kong derived from 29,264 GSV images along streets at 30-meter intervals.

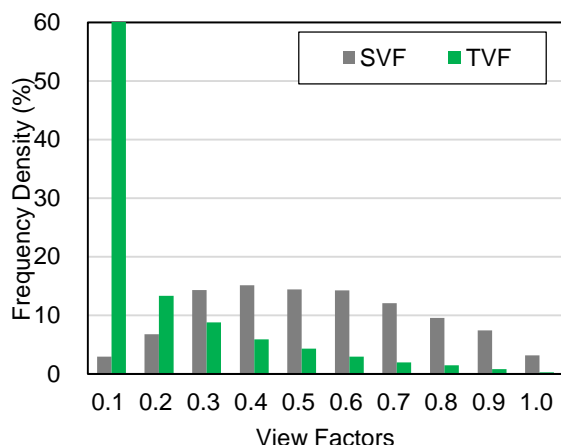


Fig. 3. Frequency density of TVF (green bar) and SVF (grey bar).

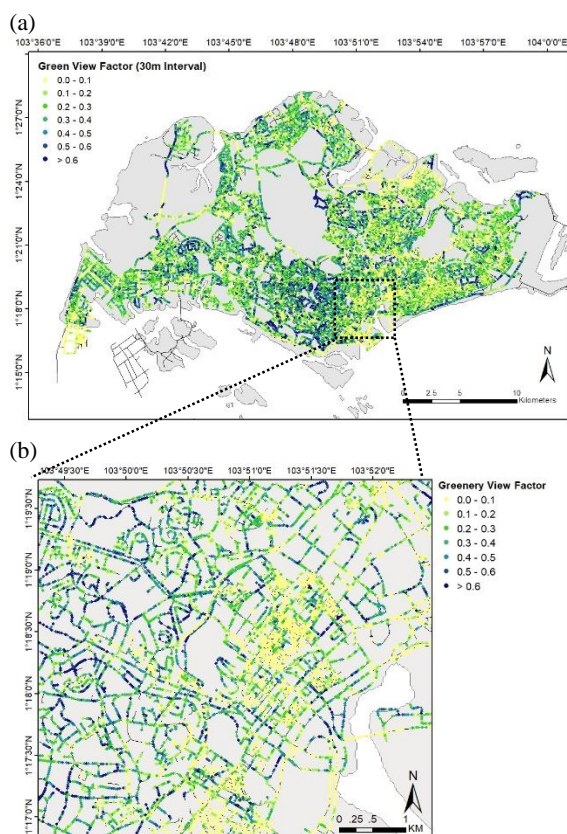


Fig. 4. (a) Mapping of GSV-based estimate of tree view factor of street canyons of Singapore derived from 63,488 GSV images along streets at 30-meter intervals; (b) Tree view factor of street canyons of high-density areas of Singapore.

3.2. Validation of GSV-based tree view factor estimate

To assess the accuracy of the scene parsing deep-learning technique in extracting street scenes, we randomly select 100 sampled street points, and collect their corresponding GSV images. Manual delineation on the images by eye inspection is implemented to extract the tree feature to generate a reference dataset (as truth). As a result, **Fig. 5** shows the comparison of calculated tree canopy from GSV images using feature extraction based on the scene parsing deep-learning technique and based on the collected reference data. We can see the two datasets exactly agree with each other, with R^2 of 0.986 and RMSE of 0.025 for TVF. This agreement suggests that the scene parsing deep-learning technique is able to accurately extract the street-level features in high-density urban areas of Hong Kong.

The comparison of tree view factor estimates and direct measurements using hemispherical photography is a convincing way to verify the effectiveness and assess the uncertainties associated with GSV-based method for estimating tree view factor of street canyons. Here we use fisheye lens hemispheric photography to verify the applicability of GSV-based method in high-density urban areas of Hong Kong. Forty photographs were taken at 40 selected sample points (20 in the high-rise area of Mong Kok and 20 in the low-rise area of Kowloon Tong) in Kowloon. The photographs were taken at 1.5 m above ground level, using a digital camera, Nikon FM601, with an 8-mm circular lens. The results shown in **Fig. 6** suggest that a GSV-based streetscape study is effective and accurate in high-density urban areas of Hong Kong, characterized by compact high-rise areas with complicated street environments

and by low-rise areas with dense tree canopy. We compared survey-based reference TVF data and GSV-based TVF estimate. The GSV-based method we propose to use in high-density urban areas of Hong Kong performs much better in estimating TVF (see **Fig. 6**) with higher R^2 (0.987 versus 0.027).

building area (in triangles), and 20 samples in Kowloon Tong within low-rise area (in circles);

4. Discussion

4.1. High-accuracy tree view factor estimate for better modeling of urban thermal environment

The climate of Hong Kong during hot and humid summers causes thermal discomfort and decreases the quality of living, and both effects are intensified by the UHI effect because of limited tree distribution in heavily built-up areas. There is a pressing need for high-accuracy estimate of tree canopy, which is effective indicator of the geometry and structures of street canyons for climatic study. This study proposes the use of publicly available GSV panorama images and a deep-learning technique to estimate the TVF at street level in high-density urban areas of Hong Kong. From the verification results against reference data (as truth), the GSV-based TVF show a satisfying agreement (with R^2 values larger than 0.95) with the reference data. This result indicates the high accuracy of estimating TVF using GSV images and the deep-learning technique. These high-accuracy estimates will improve the calculation of urban thermal radiation in modeling the street canyon thermal environment in Hong Kong. Moreover, the GSV-based method developed is capable of providing more detailed TVF estimates at various scales from a small site to an entire city. Since GSV images are available in many cities all over the world, this method provides a low-cost and effective approach to support global studies of urban thermal environments.

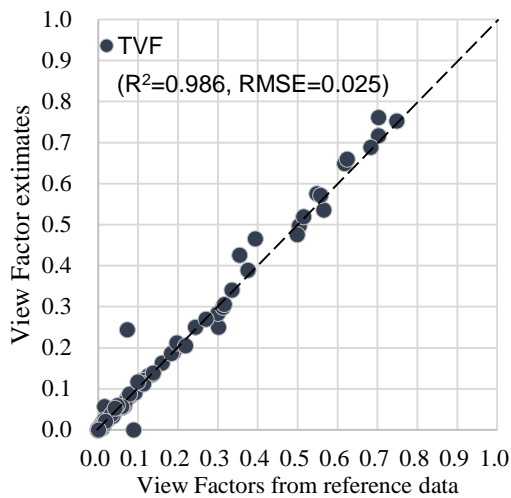


Fig. 5. Accuracy assessment of feature extraction using the pyramid scene parsing networks (PSPNet) in a deep-learning framework to calculate tree view factor from GSV images in high-density urban areas of Hong Kong. The R^2 and RMSE between the two datasets of view factors are also indicated.

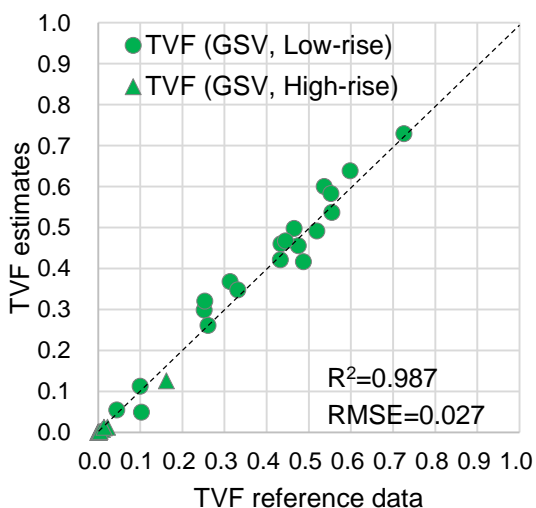


Fig. 6. Scatter plot of TVF reference data from field survey and the corresponding GSV-based TVF estimates. The sampling TVF data include 20 samples in Mong Kok within high-rise

4.2. Temporal variation of street-level tree view factor

Hong Kong and Singapore are located in a subtropical monsoon region with little effect of seasonality on the variation of the street tree canopy. A specific assumption on the seasonality is that the leaf cover of street trees does not change during different seasons even though the acquisition time of GSV images differs. This is a reasonable assumption since Hong Kong is located in the subtropical monsoon region where the street trees can be maintained throughout the year [27]. Moreover, Hong Kong and Singapore are highly developed high-density city where the built-up areas are limited and therefore very little change has taken place during recent years [15], [28] that will significantly affect the street skylines.

However, for temperate climate regions, the seasonality of TVF will be a big issue, given that the street trees will be in an annual cycle of greening during growing seasons, and turning yellow and falling during the autumn and winter seasons. The change in color of tree leaves poses a challenge for tree view factor studies using conventional tree detection method based on the traditional spectral (RGB) information. The developed deep-learning method in this study, on the other hand, extracts street features based on local and global context information independent of spectral information. Therefore, it has an advantage over the traditional pixel-based spectral method. The developed method in this study can be used to address the problem of VF seasonality by first training the deep-learning module with tree image samples from different seasons and then applying it to GSV images grouped into different seasons.

5. Conclusions

This study focuses on (1) developing an approach for accurately deriving tree view factor of street canyons in the high-density urban environments using publicly available GSV images and a deep-learning feature extraction algorithm; (2) verifying the accuracy of the developed GSV-based method using reference data of hemispheric photography from field surveys; and (3) comparing the GSV-based tree view factor estimate of Hong Kong and Singapore, two subtropical high-density cities. The following conclusions can be drawn:

- Street tree canopy maps in high-density urban areas of Hong Kong and Singapore are generated. The mean TVF values in the whole Hong Kong and high-density areas of Hong Kong is 0.40, and 0.14, respectively. The mean TVF is smaller compared with Singapore (0.26).
- The spatial patterns of TVF estimate are similar and consistent with the corresponding building height and density. The TVF is dominated by values less than 0.1, which is limited by the high building density and narrow street environment.
- Verification using reference data by hemispheric photography from field surveys shows that the GSV-based TVF estimate have a satisfying agreement (with R^2 value larger than 0.95) with the reference data. It suggests the effectiveness and high accuracy of the GSV-based method.

The developed method for analyzing tree canopy in a 3D street environment will play an important role in relating science-based evidence for urban climatic studies and

decision-making in landscape planning and design processes.

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The application of urban flooding potential analysis and area inundated land-use suitability for detention park -- The case for Taipei Da Gou Creek Park

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Abstract

The urban flood potential analysis associated with land use measure, a non-engineering approach, can manage urban storm and runoff water and draw creek's upstream and downstream areas intelligently, and more important, spatially distribute flooding potential or predict areas inundated for land use suitability through the lowest spot of major or sub-drainage outlet. This study looks at upstream rural and downstream urbanized urban flood potential areas, and collaborates with local geographical information system (GIS) with consideration of resident sustainability in compliance with flooding potential constraints and opportunities. This study applies Taipei Da Gou Creek Park inundated site as a case and ex post facto examines the data tracing back 1961 through 2009, documented by Taiwan Metrological Service Bureau data, and the data published on 1977, Highway Bureau Service drainage research, with local Taipei City Water Resources Service's data up to 2008. Land use suitability diagrams for Taipei urban flood disaster adaption of most likeness or of improbability precipitation volume are indicated. An normal admired urban storm and runoff water intensity is set to have design storm by an equivalent of 2-year recurrence year with a 2-hour precipitation duration time; An extraordinary one, flooding design precipitation applies an rainfall intensity by recurrence of greater than 25 year or by an equivalent to 50 to 100-year recurrence, 2 hour design rainfall duration intensity is examined. Analyzing anticipated peak rates of upstream and downstream inundated areas, the study clarifies study site terrain with soil and slope conditions and set up schematically site storm management and area inundated land use suitability for detention park accordingly. This study is to suggest construction proposal of park and its adjacent areas avoid inundated areas or eventually only create recreation or retention land use and stay away from occupancy of flood-prone residence land use.

Keywords Flooding Potential Analysis; Inundation; Area Inundated; Human Occupancy Land Use; Inflow or Outflow hydrograph; Storm and Runoff Water Storage Diagram; Ecosystems Services Land Use Suitability; Taipei Da Gau Creek Park;

1. Introduction: Purpose and Significance

The Disaster Prevention and Protection Act (DPPA) for Taiwan Area, Section 7, Article Number 22, defines flooding as a real disaster.^[1] Indeed, people shall review flooding potential and its corresponding hazardous outcomes, foresee inundated area, and propose adopting and mitigating for better quality of life accordingly.

This study chooses Taipei Da Gou Creek Park as a case of application for redeeming such the said ecosystem service for human well-being through the prediction of urban storm and runoff water volume and possible storage for urban stream catchment.

The Park, after opening to the public on 2009, the Da Gou Park is getting more and more advertised, as a theme of governmental achievement for multi-use of flooding detention, prevention, and recreation. The Park becomes not a due compensation for the flooding loss but a true implemental tool for flood management example. The authority asserts that the current detention for prevention flood is good enough. Any improbability of extra precipitation is not necessarily going to happen in any predictable time soon. The public media, news and internets are also showing a lot of success stories related to this Park.

Does such optimistic judgment stay unyielding? Could the Da-Gou Park work as a suitable, “spongy or resilient” detention park-land use for public good? Does the Park a hydrological icon where partly detention in the upstream area and partly retention in the downstream area catch flooding problem? ^{[2][3]} This study is then to clarify and reconsider the land use suitability or inundation at the downstream area at Da Gou Creek man-made outlet. A quick pilot calculation draw as an inflow, outflow, and possible storm and runoff volume storage

diagrams though their perception hygrograms. The results are to verify the applicable areas inundated for land use policy.

2. The Site for Flooding Potential Analysis

The study site, a 340-hectare area with most of woodland covered, averagely 17.5 percentage slope, has an about 3,500 meter long stream and has a hierarchical network of channels. It takes shape of the catchment and drains storm and runoff water from small rills through gullies to creek and to the destination retention Da Hu (Great Pond). It eventually has suffered receiving powerful typhoons which cause severe downpours ^{[1][4]} that causing a great deal of discharge fluctuation for the stream.

Where the study site at downstream area was a field of swamp, it now becomes a impervious blanket for highway and luxury condominium high-raises urban area. No particular flooding happened before when the site was swamp; Now it did flood after the high-raises and buildings constructed.

The community then has solicited to request deterrence or prevention of detention constructed facilities no matter whether the area inundated was chosen inappropriate or developments created the flooding.

The amount of sediment has built up gradually in the flat bottom of developed urbanized area. The drainage area, or catchment, is adjacent to the major, much bigger Da Hu (Great Lake) catchment. The Figure 1 and Figure 2 show the site and its surrounding's topographic grades and hydrological storm and runoff water routing.



Figure 1 Study site (Research Scope) and catchment or drainage area (Catchment Area).

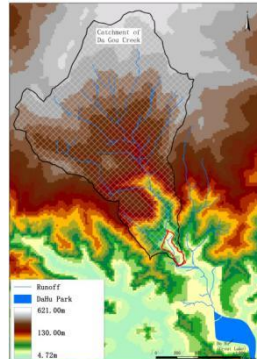


Figure 2 The basic topographic grades and hydrologic runoff routing for Da Gou Creek Park and its surroundings, places, and regions.

This study reviews current climate change indicating possible storm and runoff water volumes back to the probability of values greater or less than design storm management design rainfall intensity. It applies recurrence analysis through hydrological, not hydraulic, approach via current and historical recorded precipitation data documented by Taipei Meteorological Bureau.

The study predicts the Park's inflow and outflow storm and runoff water to be retained by the detention facilities at the existing channels, weirs and orifices beyond the creek's lowest spot at outlet.^{[12][13]}

There is an estimate of rainfall volume and duration time held in the pipes and channels into the adjacent streets between the park and its surroundings with or without overflowing credentials. The study calculates storm and runoff water volume by determining the rates and volumes of storm runoff, using rational and modified rational methods for upstream and downstream two areas. It investigates existing high points, low points, ridges, valleys, swales, points of

concentrations. The study checks whether storm drainage systems exceeds the rate of flow or not, and reviews the existing and original drainage volume with and without Da Gou Park. It is comparing possible storage volume prior to and after the development in the end.

The coefficient value, C ,^[4] is decided separately by existing land use types, slopes and topographical characteristics. The urbanized downstream area is high impervious. See the Figure 3.

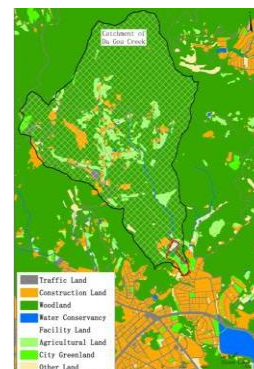


Figure 3 The land use patterns.

Whole site is a portion of hill slope down to the flat gentle valley slope and ended up with connection of intersection at main streets to the Da Hu (Great Lake) detention pond, the average c value is as high as to 0.5 to 0.7. The cumulative percent frequency or probability of annual precipitation at Taipei, 1961-2009, shows a straight line indicating the annual precipitation values are normal distributed.^[12]

The storm frequency, defined as the number of years during which the design storm, or a storm exceeding it, is based on the Taipei Central Meteorological Services' survey of probabilities for 49 years. That is, the annual perception data from 1961 through 2013, as shown in the Figure 4. This study discovers, from the governmental web site information, that the Da Gou Creek has

a 20- year design storm with responding frequency and duration respectively for storm water management system according the above-mentioned DPPA Act and other regulations as well.

3. Method and Analysis

Learning from the cumulative percent frequency or probability of annual precipitation at Taipei, this study find out that normal 2.0, or 2.2 year recurrence of the design storm frequency^{[8][9]} is around 2,249 mm per year. The representative mean value of average one is around 2,250 mm. However, this 2,249 annual rainfall in mm per hour (mm/hr) shall be considered as only a possible range. The flooding potential shall be examined the range at least up to or within one standard deviation above the mean stays additional 34 percent of all occurrences represented by the frequency distribution.^{[10][11][12]} The Figure 4 indicates the cumulative percent frequency as followed. The details, see the Figure 4

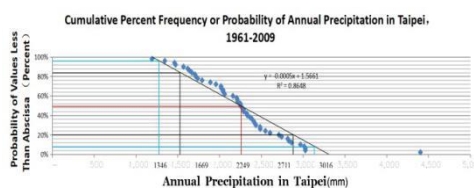


Figure 4 Cumulative Percent Frequency or Probability of Annual Precipitation in Taipei

In addition, according to Taipei Non-urban Land Use Development Guideline of 2013, the study complies with the said requirement of peak runoff rate at every drainage area for the developed or undeveloped urban area, such as the reconstruction or construction of drainage connections, outlets, catch basins, and piping at minimum, not maximum rate. They only need to meet peak runoff rate of cubic meters per second (m³/s) for less than

a 10-year recurrence storm frequency systematically; or a 25-year recurrence design storm for major connection and piping; and a 2.5- to 5-year recurrence design storm for the rest of design storm and runoff water intensity.^[11]

4. Storm and Runoff Water In-Flow, Out-Flow, and Storage

The calculation of Da Gou Creek Park drainage area is based on the mean average value around precipitation of 2, 250 mm per year and transmits into 80.93 mm per hour as calculated by Log-Pearson III's method (1976), or 84.55 mm/hr by Chow's method (1976) with a 2- hour short rainfall duration time. The Table 1 compares and shows Taipei design rainfall intensity with a particular precipitation frequency by possible recurrence for peak runoff rate calculation.

Table 1 Comparison of rainfall intensity at Taipei via different method and design storm recurrence year precipitation frequency for Da Gou Creek Park, Taipei.^[10]

Estimate Method	Recurrence (by Year) - Precipitation (by mm)				
	200	100	50	20	10
1. Log-Pearson III	100.17 mm	95.05 mm	93.33 mm	87.07 mm	80.93 mm
2. Chow	133.70 mm	122.48 mm	111.21 mm	96.17 mm	84.55 mm
3. Hazen		108.26 mm	-	90.56 mm	

Source: from Taiwan Province Highway Bureau (1976).^[10]

The modified rational method, with an antecedent precipitation factor in rational formula, has determined the Da Gou Creek Park's lowest spot's inflow and invert outflow volumes. The method (MRM) allows runoff for storm duration shorter or longer than the time of concentration, and that is applying in this study case. Applying hydrograph diagram as indication that is a plot of flow rate (q) versus time (T), more particular, the tabular is representative of plots showing the estimate of hydrograph

distribution. The Table 2 shows the results as followed.

Table 2 The total maximum estimate of flood detention volume at a series recurrence years.

Recurrence Years	Duration Time (t)	Rainfall Intensity (i)	Antecedent Rainfall Factors (C _a)	Max. Inflow (Q ₁) m ³ /s	Max. Outflow (Q ₂) m ³ /s	Inflow Volume (V ₁) +10,000 m ³	Outflow Volume (V ₂) +10,000 m ³	Estimate Outflow storage (V) +10,000 m ³	Actual Flood Level Height (H) m	Actual Flow Detention Volume (V _d) +10,000 m ³
2	30	79.60	1.00	56.38	44.40	10.15	7.99	2.16	21	2.10
5	45	80.13	1.00	61.01	44.40	16.47	11.99	4.48	23	4.95
10	60	89.80	1.00	63.04	44.40	22.70	15.98	6.72	24	7.81
25	90	80.81	1.10	69.20	44.40	37.37	23.90	13.39	26	12.71
50	120	87.32	1.20	74.23	44.40	53.44	31.97	21.47	26	12.71
100	150	86.58	1.25	76.66	44.40	69.00	39.96	29.04	26	12.71

By measuring duration of rainfall events, this study has produced a set of hydrographs, by the duration time of storm and runoff water. Specifying the flow rates (q) of upstream area at any time during the storm and runoff water volume process by hydrographs, the total estimate of storm and runoff water volume from up-stream area can be identified. It is about 133,900 cubic meters at a 25- year recurrence. ArcGIS's spatial analysis with volumes of cut-and-fill modelling is to clarify that. Probability of precipitation values rate of Taipei is for double reference.

The following Da Gou Creek Park's inflow and outflow hydrograph by particular 2-, 5-, 10-, 25-, 50-, and 100 year recurrence is listed. Each Figure shows the storm and runoff water inflow, outflow, and storage volumes respectively.

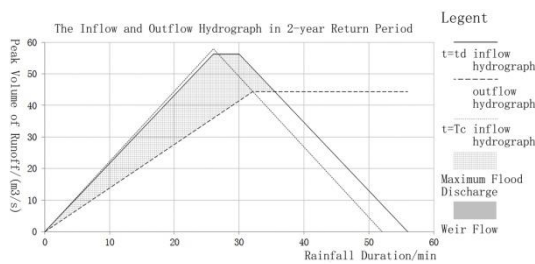


Figure 5-a The diagram of inflow and outflow volume by hydrograph with maximum flood discharge volume by a 2- year recurrence; that is, a normal daily or average rainfall intensity .

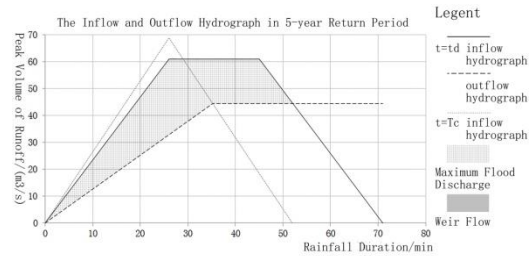


Figure 5-b The diagrams of inflow and outflow volume by hydrograph with maximum flood discharge volume by a 5- year recurrence.

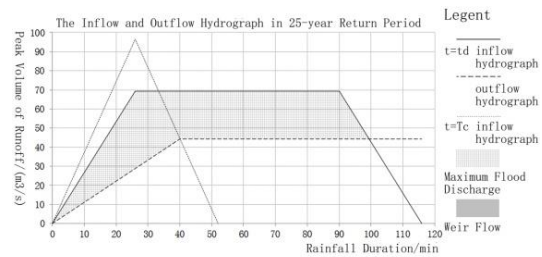
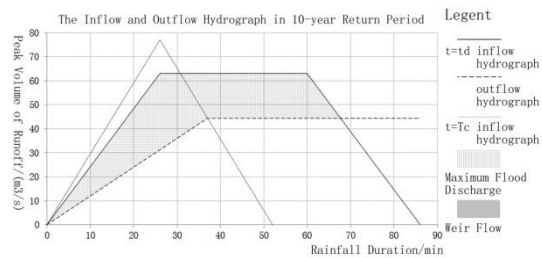


Figure 5-d The diagrams of inflow and outflow volume by hydrograph with maximum flood discharge volume by a 25- year recurrence; that is, an existing or normal weir storage volume in site.

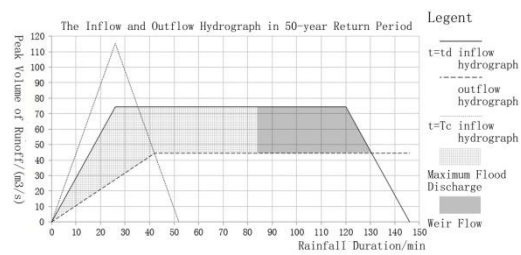


Figure 5-e The diagrams of inflow and outflow volume by hydrograph with maximum flood discharge volume by a 50- year recurrence; that is, an exceeded volume , about 8.76 * 10,000 m³, than existing-normal weir storage volume in site.

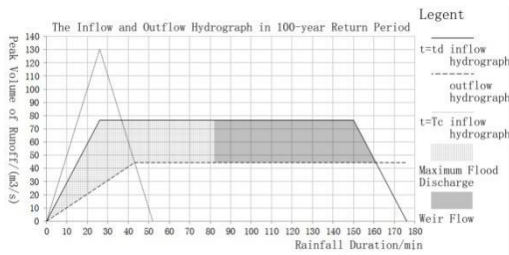


Figure 5-f The diagrams of inflow and outflow volume by hydrograph with maximum flood discharge volume by a 100- year recurrence; that is, exceeded a lot of volume, about 16.30 *10,000 m3, than existing-normal weir storage volume in site.

5. Result: Area Inundated and Determining Suitability for Detention Park Land Use

Figure 5-c The diagrams of inflow and outflow volume by hydrograph with maximum flood discharge volume by a 10- year recurrence.

Table 3 The methods for determining the weight of ecological services and functions of suitability evaluation.

Factor Overlapping Method	Factor Weight Grade Method	Ecological Factor Combination Method	Factor Limiting Method
Set up planning goal(s) or single factor;	Give weight to different factors according to their importance;	Group combination of the suitability of land value based on single or hierarchical combining factors;	Evaluate dominate factor(s) and its influence and decisive role;
Carry out gradation graph;	Multiply each ecological factor by weight, and get the suitability- value.	Calculate ecological factors and independent variables for calculation as a factor.	Specify the dominate operation process;
Create comprehensive analysis chart to generate single-factor according to the land value- suitability.			Identify critical indicators based to minimum requirements of land use types.

Source:Li, P 2011^[5]; Millennium Ecosystem Assessment Ecosystems and Human Well-Being: Synthesis, 2005 ^[6]

Whether people are aware of the risk of residence in a flood-prone land subject to flooding, developments of high-rise luxury apartments and dwellings are still to be located on the Da Hu (Great Lake) Section where Da Gou Creek stream running through. This study has analyzes the area inundated, which is the best or highest “suitable” or land use “suitability” of detention park land use; yet it is the worst or least “suitable” for land use “suitability” for other, non-detention park land use such as residence, factory, or commercial use.

In this case study, land use situation or “suitability” may further be compromised or complicate if the topographical grade, slope, soil, vegetation and land use associated with increasing flood hazard potential to downstream areas outside the study site, when climate change may happen dramatically and significantly. The Table 3 shows an initiative pilot evaluation method for the evaluation.

Started studying and got immediate result shows that an analytic hierarchy processing with expert opinion analysis for ecosystems and human well-being regulating flood, the assessment designate the most possible flooding potential area, or the most area inundated land use type, at upstream and downstream areas. The calculation results indicate land parcel of study site and place an average high, or much lower or higher index value of function level of of detention preventing park. It is a kind of suitability mapping yet only on and along Da Gou Creek Park, the stream and its surrounding district with another larger watershed included.

In detail, the index system includes three levels: first, level of the index complied with the fundamental requirement of M1, regulating flood; second and third, M2 and M3, the index for ecosystem

services. Second, the level of index is the provisioning: N1, flood potential; and N2, Slid hazard potential; N3, de-vegetation; N4, runoff routing; N5, soil deformation; and N6, landscaping accessibility. After being weight of the said level's index, the study reaches an overall integrity of flood potential or area inundated as listed in the Table 4, and in the the map of the Figure 8 as will be discussed in the end.

Started studying ecosystem assessment framework with Arcgis' modelling and mapping and got final results show, this study specifies Da Gou Creek Park potential flooding areas by design storms and runoff water recurrence, and compares volumes of inflow and outflow by different hydrographs, for the valley bottomlands and

Source: 1 Taipei City, Standard, 2003. [10] 2 Zhao Q. 1993. [13], 3 Chen J., Zhang J., Zhang S. 2017[7]

The study specifies inundated areas by mapping of the flood potential based on the above discussed results organized on Table 4, and based on the analyzed by design storm of 25 recurrence year, presented at three levels of inundate storm water height: first, 0.0 through 0.5 meter; second, 0.5 through 1.0 meter; and third, 1.0 through 3.0 meter. Figure 5 and Figure 6 indicates the map under three different inundated height levels.

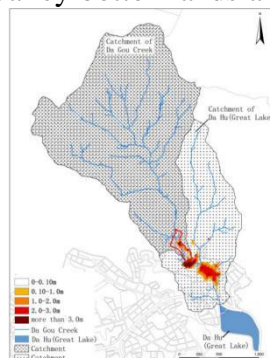
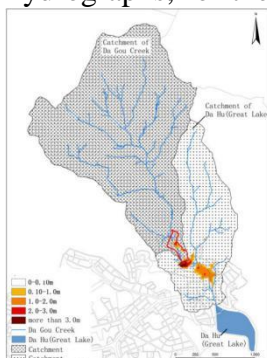


Figure 3-c The flooding potential distribution before the Da Gou Creek Park constructed by a 10-year recurrence.

Figure 3-d The flooding potential distribution before the Da Gou Creek Park constructed by a 25-year recurrence.

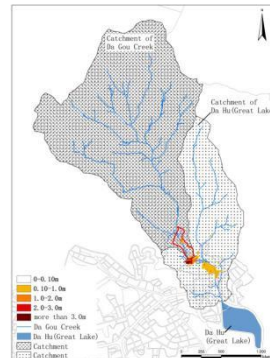


Figure 3-a The flooding potential distribution before the Da Gou Creek Park constructed by a 2-year recurrence.

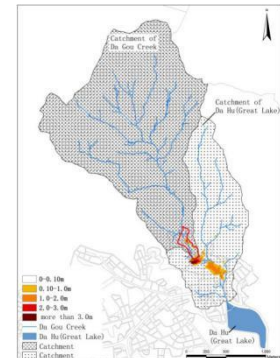


Figure 3-b The flooding potential distribution before the Da Gou Creek Park constructed by a 5-year recurrence.

the channel of Da Gou Creek above the reservoir retention facility at Da Hu (Great Lake) District.

Table 4 Ecosystem Services Regulating Flood and Area Inundated Suitability of Detention Park Land Use.

Objective Layer	Criterion Layer	Index Layer	Ordinal Scales (by meter, or slope by %)	Assessment Index	
Ecological Suitability Assessment Index System of Flood Detention Park	Disaster Prevention M1 (W1=0.4)	The Inundation Potential Distribution	0-0.5m	1	
			0.5-1m	3	
			1-3m	5	
		Slope	N1 (W1=0.6) ⁽¹⁾	30-50%	1
			N2 (W1=0.4) ⁽¹⁾	15-30%	3
	Ecological M2 (W2=0.35)	Vegetation Form	Forest	1	
			Lawn	3	
			Farmland	5	
		Potential Runoff	N3 (W2=0.35) ⁽²⁾	115-250m	1
			N4 (W2=0.35) ⁽²⁾	50-115m	3
		Soil	N5 (W2=0.3) ⁽²⁾	0-50m	5
			N6 (W2=1) ⁽³⁾	Sand(y) Soil	1
Service M3 (W3=0.25)	Landscape Accessibility	Clay	3		
		Silt(y) Soil	5		
		800-1500m	1		
		500-800m	3		
		<500m	5		

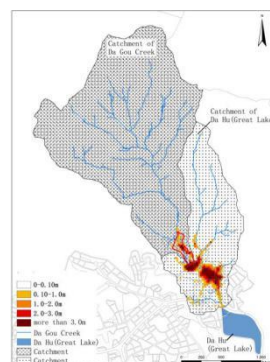


Figure 3-e The flooding potential distribution before the Da Gou Creek Park constructed by a 10-year recurrence.

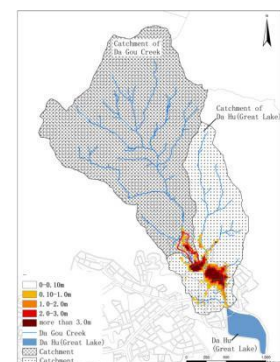


Figure 3-f The flooding potential distribution before the Da Gou Creek Park constructed by a 25-year recurrence.

Park constructed by a 50-year recurrence.

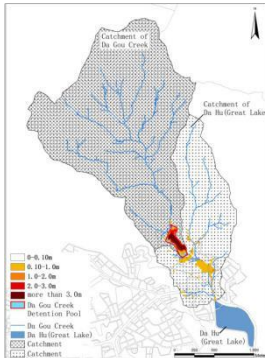


Figure 4-e The flooding potential distribution after the Da Gou Creek Park constructed by a 50-year recurrence.

Park constructed by a 100-year recurrence.

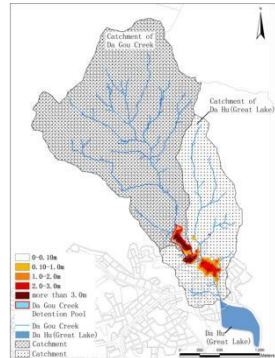


Figure 4-f The flooding potential distribution after the Da Gou Creek Park constructed by a 100-year recurrence.

including silt loam and clay soil; and six, by landscape accessibility or distance to access.

All mappings designate the land-use suitability for Da Gou Creek park and its surroundings upstream and downstream inundated areas for detention park land use, where are certain that the most likeness of the site and place can be used for detention or retention facilities as well.

In detail, the flooding potential levels are identified as first, the a flood-prone scale at 1.71 through 2.64, the less detention; second, the scale at 2.64 through 3.58, the medium suitable for detention; and third, the scale at 3.58 through 4.5, the most suitable for detention. That is, the last or

Through the above-mentioned analytic hierarchy process (AHP) method, or single integrated factor analysis, [7] with expert opinion analysis, the Figure 5- a, 5-b, 5-c, 5-d, 5-e, and 5-g have shown a series single-purpose suitability land use map for proposed detention-park, according to first, by inundated land distribution; second, by topographical slope, third, by region's vegetation forms; fourth, by potential runoff

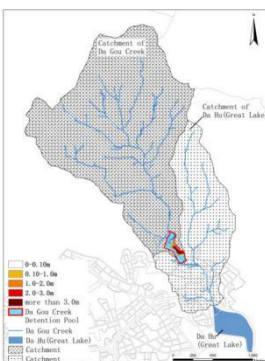


Figure 4-a The flooding potential distribution after the Da Gou Creek Park constructed by a 2-year recurrence.

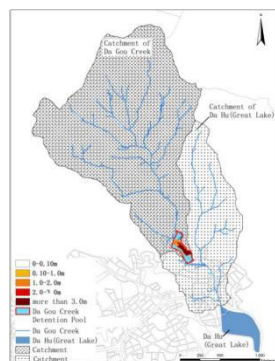


Figure 4-b The flooding potential distribution after the Da Gou Creek Park constructed by a 5-year recurrence.

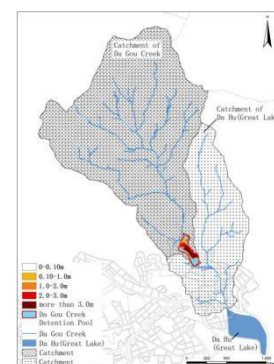


Figure 4-c The flooding potential distribution after the Da Gou Creek Park constructed by a 10-year recurrence.

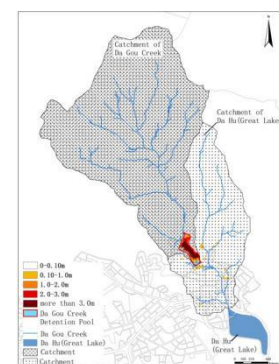


Figure 4-d The flooding potential distribution after the Da Gou Creek Park constructed by a 25-year recurrence.

third scale vale, the most significantly represents the most likeness of area inundated, and the first scale value represents the least possible area inundated; the second scale vale represents the medium area inundated between the last and the first scale area values.

Multi- or six- single integrated factor analysis mapping [3][4][5][7] indicates the the most likeness of the site and place can be

routing distance; fifth, by soil types

used for detention or retention facilities as shown in the Figure 6.

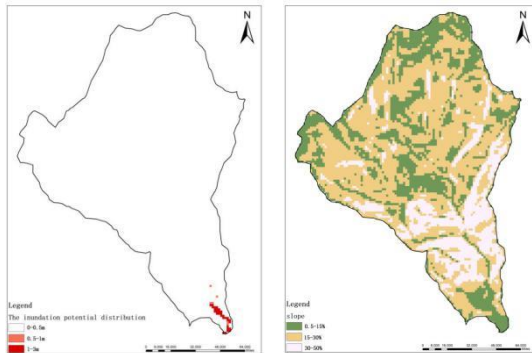


Figure 5-a Single factor analytic hierarchy process method, or an integrated analysis of eco- systems service flood regulation suitability assessment for flood detention park land use for Da Gou Creek Park and its surrounding area by area inundated land, or inundation potential distribution.

Figure 5-b Single factor analytic hierarchy process method, or an integrated analysis of eco- systems service flood regulation suitability assessment for flood detention park land use for Da Gou Creek Park and its surrounding area by topographical slope.

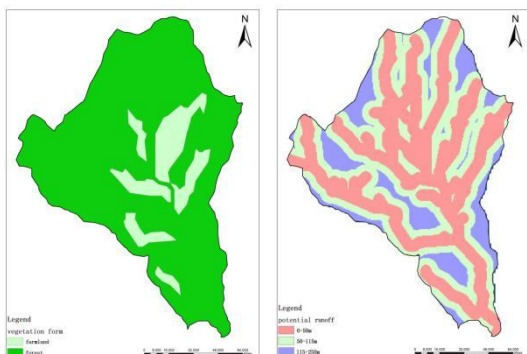


Figure 5-c Single factor analytic hierarchy process method, or integrated analysis of eco- systems service flood regulation suitability assessment for flood detention park land use for Da Gou Creek Park and its surrounding area by region's vegetation forms.

Figure 5-d Single factor analytic hierarchy process method, or integrated analysis of eco- systems service flood regulation suitability assessment for flood detention park land use for Da Gou Creek Park and its surrounding area by potential runoff routing distance.

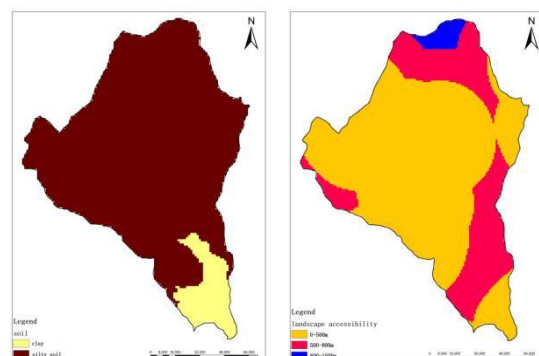


Figure 5-e Single factor analytic hierarchy process method, or integrated analysis of eco- systems service flood regulation suitability assessment for flood detention park land use for Da Gou Creek Park and its surrounding area by soil types.

Figure 5-f Single factor analytic hierarchy process method, or integrated analysis of eco- systems service flood regulation suitability assessment for flood detention park land use for Da Gou Creek Park and its surrounding area by landscape accessibility or distance to access.

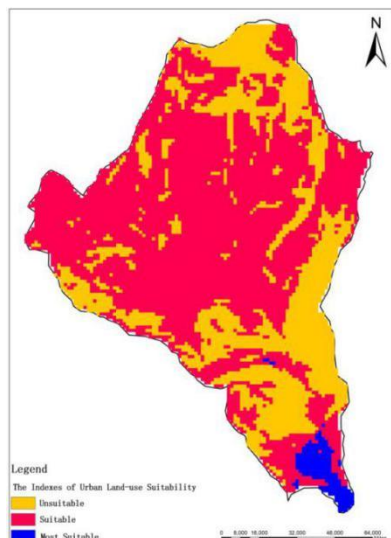


Figure 6 Multi- factor analytic or integrated analysis of eco- systems service flood regulation suitability assessment for flood detention park land use for Da Gou Creek Park and its surrounding area by the index of urbanized or rural inundated area.

6. Discussion and Suggestion: Human Occupancy of Flood-Prone Lands and Suitability.

The urban flood potential analysis associated with land use measure is a sound non-engineering approach: it adapts two or three- dimensional mapping for zoning. It reviews urban development with man-made detention and retention facilities for both urban and rural areas. Yet, this study see the fact that when the flood lapses, and the evidence of flooding damage immaculate, the hazard threat fades. The perception of flood urgency swifts from attention until next one, a 50-, 100- or 200-recurrence year storm, is to come.

With respect to information of environmental planning and design, land use suitability or area inundated mapping data should be opened, yet it is somehow obscured by dishonest, if not corrupted,

politicians, land developers, or the others with interests in socio-economic growth and local pride. Thus, has thoroughly been lined up with ecosystem services among human services and GPS modeling, this study clarifies flood potential of Da Gou Creek at Park and human safe fit for security concerns. It provides a typical eco-indexing of systems of human well-being services such as the calculation of closed drainage system and flooding potential.

The results imply that further examination and mapping is highly recommended, particularly, for the areas where highly possibly inundated at the starting outlet, through lower open outlet surrounded by developed urbanized areas and ended up at Da Hu (Great Lake) retention facility pond.

What is validity of drainage is to examine the research site that needs free from logical flaw or free from data validities; That is, the study suggests empirical checks of rational or modified rational method which the drainage area is normally less than 80 hectares^{[12][13]}.

In this study, the drainage area is as big as 340 hectares and still likely appeared to be applicable because of the allowable calculation measure which listed the drainage area for calculation to the maximum of 1,000 hectares, according to the Disaster Prevention and Protection Act (DPPA) of Taiwan rural area.

The study recommends, first, inspection of precipitation shall be within one standard deviation above and below the mean which lies in 68 percent of all occurrences such as represented by the frequency distribution and further compare at at least a 30- or more year recorded data in calculation and

combine data with uncertainty flooding possibilities:

Second, focus on examining flood probabilities responding to micro-topographical contours with larger scale. Any emergency evacuation such as avoiding typhoons and extreme, torrential rain occurrence shall be further weighted and considered into the calculation and mapping.

Third, examine typical current drainage structures which appear to be short in the site and off-site in terms of drainage regularities. The storm and runoff surface drainage collection shall modify its maximum amount of average plus the flooding potential, up to the range at least within one standard deviation above the mean stays additional 34 percent of all occurrences represented by frequency distribution.

In addition, the peak runoff rates for the Da Gou Creek Park's hydraulic structures, culverts and reinforced concrete channel waterways must fit into the storm frequency more than by 25 year recurrence and up to at least a 50- year recurrence with at least 12 hour duration time. So does the connection piping with pumping on the top of bank.

Existing off-site disposal to the Da Hu (Great Lake) shall also seriously review its maximum volume in compliance with this climate change requirement. The designed reconstructed storage pond and detention reservoir with stepping stone for recreation need to reconstruct to fit additional rainfall intensity which exceeds a 50-recurrence design storm rainfall intensity.

In the end, three things, for collecting, conducting, and disposing storm and runoff water systematically all together into one shall be considered as a major framework critically to fulfill; It shall be never be overestimated whatsoever.

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Research on Spatiotemporal Distribution and Environmental Demand of Physical Activities for the Elderly in Community Park at Cold Region Based on Healthy Perspective: A Case Study of Beixiu Park in Harbin, China

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Abstract

With the continuous improvement of the ageing in our country, how to deal with the healthy problems of the elderly has become one of the hot issues in the whole society. Urban community parks are one of the main spaces of physical activities for the elderly. The construction of community parks which is suitable for the elderly's outdoor activities has positive significance. Based on theory of environmental activities, the research takes the physical activities of the elderly as an object and selects a representative community park in Harbin as a research site. Scanning observations and semi-structured interviews were used to collect data. The data was digitally visualized through GIS software. From the perspective of time and space, the amount of the elderly, types of activities, spatiotemporal distribution, and environmental characteristics were studied, to provide reference which build the urban park. The Research found that: (1) The physical activities of the elderly in community parks mainly include 8 types of Physical Fitness Activity, 3 types of Social Interaction Activity, 5 types of Leisure Recreational Activity, and 4 types of Static Rest Activity. (2) The park activity shows a trend of two lows and three highs over time, forming a peak period of three healthy activities. It has obvious time effect. (3) The outdoor activities of the elderly are balanced in spatial distribution and have obvious boundary effects. Different types of activities have obvious domains.

Keywords: The Elderly; Community Parks; Physical Activity; Spatiotemporal Characteristics

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1. Introduction

With the continuous improvement of the ageing in our country, how to deal with the healthy problems of the elderly has become one of the hot issues in the whole society. Research in the public health field shows that regular participation in physical activity can bring many health benefits^{[1][2]}. Urban community parks are one of the main spaces for physical activities for the elderly. The construction of urban community parks which is suitable for the elderly's outdoor activities has positive significance.

After years of development, there have been some achievements in the field of elderly. At the policy level, the World Assembly on Ageing report in 2002 states that "the dwelling and its surroundings are particularly important for the elderly. Consideration should be given to provide important mental and psychological security for the elderly."^[3]The 12th Five-Year Plan for the development of China's aging undertakings in 2011 emphasizes: "Accelerate the construction of old-age activity venues and facilities, and focus on improving the living condition of the elderly. Make use of public spaces, such as parks, green spaces, squares, to open up sports and fitness facilities for the elderly."^[4] Wang Z (2010) found that different environmental and other individual specific factors were found to be significantly related to meeting recommendation within either walking for transport or walking for leisure^[5]. J. Eronen (2014) investigated the factors affecting the physical activity of the elderly through random interviews and questionnaire surveys, and found outdoor recreation facilities is an important factor to promote outdoor physi-

cal activity^[6]. Kalevi Kor-pela (2017) and others found that happiness is positively correlated with the frequency of physical activity in nature, which fully demonstrates the importance of physical activity outdoors^[7]. Kirsi E. Keskinen (2018) investigated the relationship between the environment and the physical activity of the elderly through questionnaires and interviews and found that the spatial diversity is positively correlated with the frequency of physical activity of the elderly^[8]. Zhao Xiumin (2016) extracted environmental elements in various types of space to analyze the relationship and extent of the impact of environmental elements on outdoor activities^[9].

Studies on the outdoor activities of the elderly have achieved certain results, but most of them are based on theoretical discussions of the needs of the elderly for outdoor activities. However, few studies based on empirical investigations of the elderly's outdoor activities to ascertain their actual needs. Therefore, based on the behavior observation, this study analyzes the differences in the temporal and spatial characteristics of outdoor activities of the elderly from the time and space of the activities, and aims to provide reference to design the sustainable outdoor activity space for the elderly.

2. Research Methods

2.1. The research site

In this study, Beixiu Park in Nangang District of Harbin City was selected as the research site. The park has a long history

and is an important part of the city's texture. As one of the few community parks in Nangang District, the park had a survey. The users are mainly elderly people, and their use rate and activity are high. The garden area is about 150 meters long, 80 meters wide, and covers an area of 1.2 hectares. It consists of green space and central activity space. The park is surrounded by urban roads and is surrounded by residential areas. With convenient transportation, the elderly can easily walk from the residential area to the park.

2.2. Research Methods and Data Collection

In this study, taking the behavior of the elderly as the object. Through behavior observation, the physical activity of outdoor elderly people in the park was comprehensively recorded by mapping. The physical activity of the elderly is digitally visualized through the GIS and analyzed by SPSS. From time and space, the study was conducted on the amount of elderly people visiting, activity types, spatiotemporal distribution and environmental behavior characteristics. The data was collected from March 28th to April 1st, 2018(except March 31th). The observation time was controlled every 10 minutes, covered every area of the park. All observed behaviors of the elderly would be recorded on the plan of the park through the GIS (Figure 1).

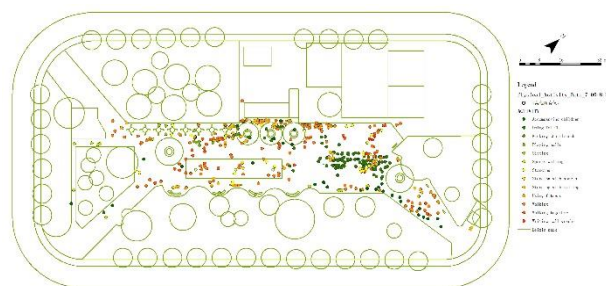


Fig.1. map of data into GIS (7:00-8:00)

3. Data description

The total number of physical activity was 17868 in the park, the data of male was 10037, the data of female was 7831. There are 23 kinds of physical activities for the elderly in the park.

Based on healthy perspective, we classified the physical activities into four types, they were Social Interaction Activity, Leisure Recreational Activity, Static Rest Activity, Physical Fitness Activity (Table 1).

There are 23 kinds of physical activities for the elderly in the park, of which more than 1500 were standing with talking, sing fitness equipment, playing poker, square dancing, sport walking, watching. The activity data 500-1500 were standing, sitting, sitting with talking, accompanying children, walking though, doing tai chi, playing chess, playing shuttlecock, ballroom dancing, walking with talking. Less than 500 activities included standing with sports, walking the dog, writing calligraphy, lying, running, playing balls, singing. in the activities of the elderly, males main activities were watching、 playing pokers、 using fitness、 standing with talking and females mainly did square dancing and sports walking (Figure 2).

Through analyzing the various types of activities data, it was found that among the four types of activities, the number of Physical Fitness Activities were the most, accounting for 41% of the total data, followed by Leisure Recreational Activity, Social Interaction Activity, Static Rest Activity. The proportions were 22%, 21%, and 16% (Note: The four types of activities don't include walking through, the same as below). It was found that the gender had an

influence on the choice of outdoor activities for the elderly on Independent-Samples T Test by using SPSS ($P=0.003$, $P<0.05$). Males more likely to do Leisure and Entertainment Activities such as playing pokers, while females mainly choose Physical Fitness Activities such as square dancing. (Table 2).

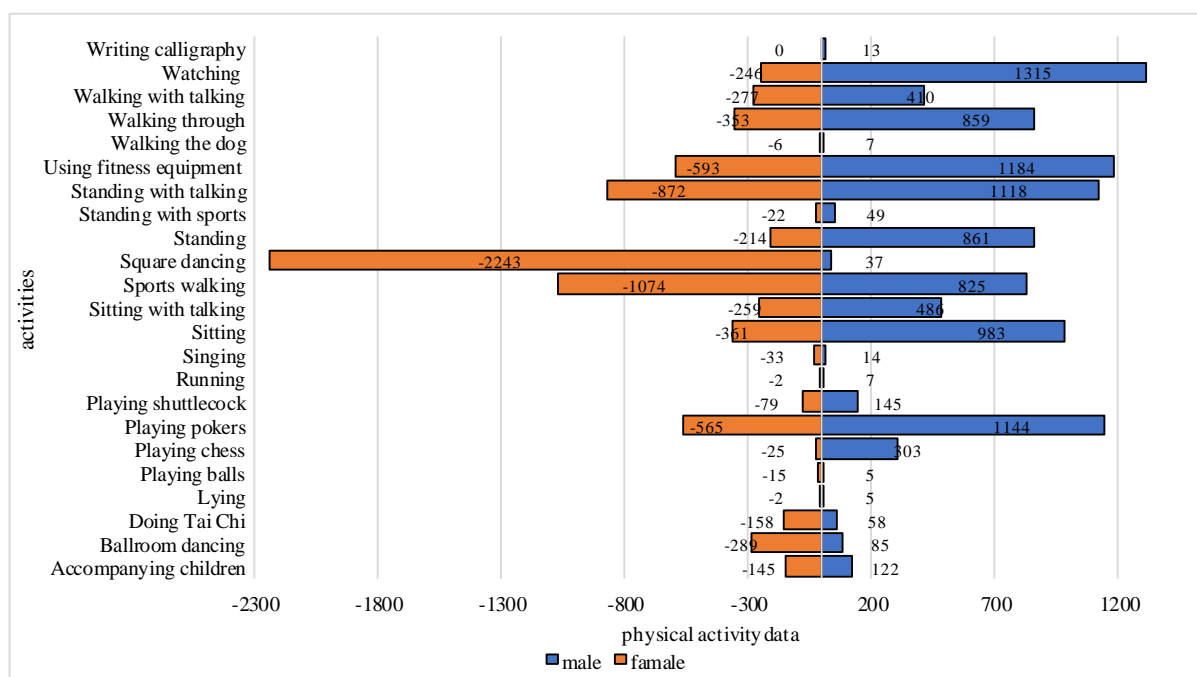


Fig.2. Total Physical Activity Data for the Elderly

Table.1. The classification of outdoor physical activities for the elderly

Type of activity	Effect	Activities	Functional level
Physical Fitness Activity	They can improve the health, increase interactions, regulate blood sugar, reduce blood fat, etc. They can prevent diseases	Square dancing, Sport walking, Running, Standing with Sports, Doing Tai Chi, Using fitness equipment, Playing shuttlecock, Playing balls, Ballroom dancing	Physical level, social interaction level
Leisure Recreational Activity	They can activate the brain, slow down the decline of intelligence, cultivate the elderly 'sentiments, enrich their lives, and rebuild their self-confidence.	Playing pokers,Playing chess, Writing calligraphy, Singing, Watching, Walking the dog	psychological level, social interaction level
Static Rest Activity	They can cultivate their mind, recover the body, relieve fatigue.	Sitting, Standing, Lying, Accompanying children	psychological level
Social Interaction Activity	They help the elderly to eliminate loneliness, loss, fear and other negative emotions, promote communications.	Standing with talking, Sitting with talking, Walking with talking	social interaction level

Table.2. Four types of Physical Activities Data for the Elderly

		Social Interaction	Static Rest	Leisure Recreational	Physical Fitness	P
		Activity	Activity	Activity	Activity	
male	frequency	2017	1971	2796	2397	0.003
	%	22%	21%	31%	26%	
female	frequency	1411	722	875	4473	
	%	19%	9%	12%	60%	
total frequency		3428	2693	3671	6870	
%		21%	16%	22%	41%	

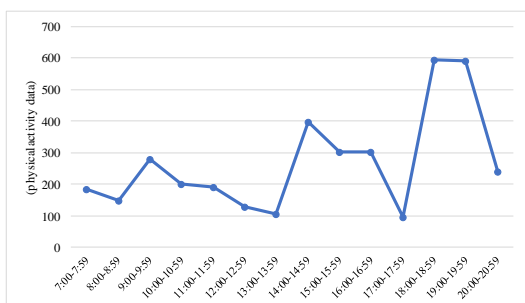


Fig.3-1. The temporal characteristics in 28/3/2018

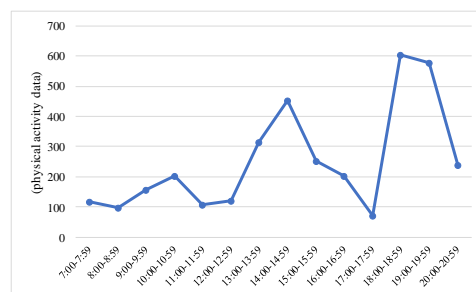


Fig.3-2. The temporal characteristics in 29/3/2018

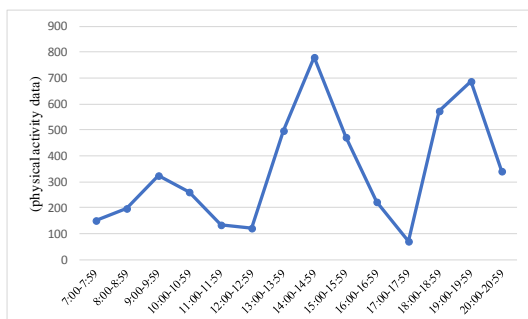


Fig.3-3. The temporal characteristics in 30/3/2018

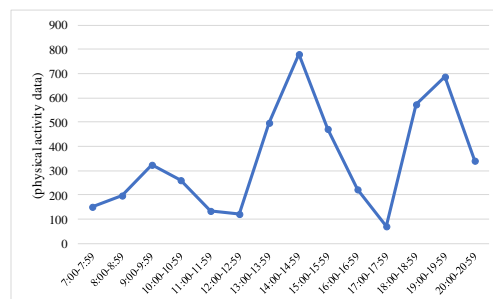


Fig.3-4. The temporal characteristics in 1/4/2018

Fig.3. The temporal characteristics in the different days

4. Temporal characteristics of physical activities

4.1. Temporal Features at Different Time granularity

Though analyzed the elderly's physical activities data in a whole day, it was found that the physical activities data of the elderly has changed significantly over time. The peak period of healthy behavior formed at 9:00-10:59, 14:00-14:59, 18:00-19:59 (Figure 3). We do the variance analysis by using SPSS in whole day, found that the

variance of the data was relatively large, indicating that the number of physical activities of the elderly was obviously limited by time.

4.2. Temporal Features of different types of physical activities

With the change of time, the elderly in the park show different tendencies on the types of activities. The period 7:00-7:59 and 18:00-19:59, were mainly doing Physical Fitness Activity, both accounting for 64%. The data of Social Interaction Activity and Leisure Recreational Activity increases at 8:00-11:59, the proportion is about 60% totally. At 13:00-16:59, there were mainly Leisure Recreational Activity and Physical Fitness Activity, accounting for 61% totally (Figure 4).

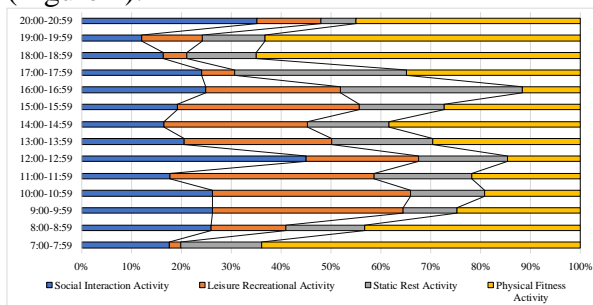


Fig.4. The temporal characteristics of different types of activity data for the elderly

Among the static rest activity, sitting was the most popular activity. The participation rate was 52%. The following were standing and accompanying children, accounting for 38% and 10%. The data of lying was rare.

Static Rest Activity data began to increase at 8:00, the peak periods were 10:00-10:59,14:00-14:59,18:00-19:59.

Analyzing the reasons, it was found that the temperature of cold cities is low in the

morning and the sunlight was more abundant after 10 o'clock. In the afternoon, the sunshine is the most abundant and the temperature kept rising. The number of people who had a rest in parks reached the maximum (Figure 5).

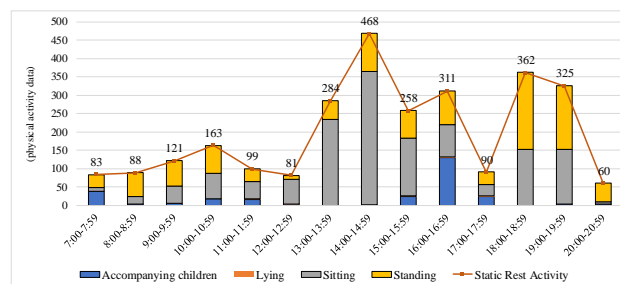


Fig.5. The temporal characteristics of the Static Rest Activity

In Social Interaction Activity, the main behavior was standing with talking, the participation rate was as high as 58%. Social interaction activity has changed markedly over time, The three peak periods were 9:00-10:59,14:00-14:59,20:00-20:59.Standing with talking mostly occurred at 13:00-15:59 and 18:00-20:59. Standing with talking often took place at 9:00-10:59 and 14:00-14:59, Walking with talking mostly occurred in the 9:00-10:59 and 20:00-20:59 (Figure 6).

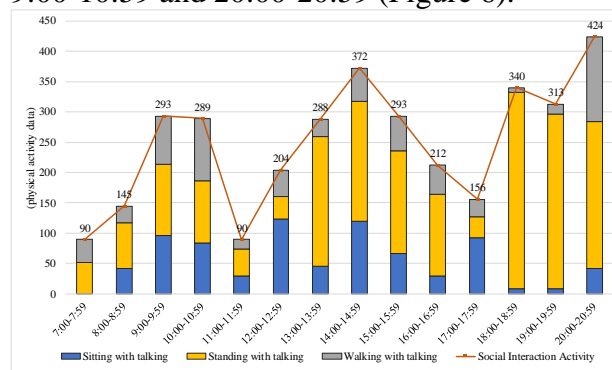


Fig.6. The temporal characteristics of the Social Interaction Activity

In Leisure Recreational Activity, the main activities were playing pokers and

watching. The participations were 46% and 42%. the activity data were 1,709 and 1,561 times. The total data of writing calligraphy, singing and walking the dog was less, only 1.8%. The three peak periods were 9:00-10:59, 13:00-15:59, 19:00-19:59. 13:00 - 15:59 is the highest peak period in a day. Writing calligraphy and singing had a timely use of the site, mainly occurring in the morning and occasionally occurring in other periods. Playing pokers and playing chess have been happening since 8:00, mainly focus on 9:00-10:59 and 14:00-14:59, only few people played pokers in the evening. (Figure 7).

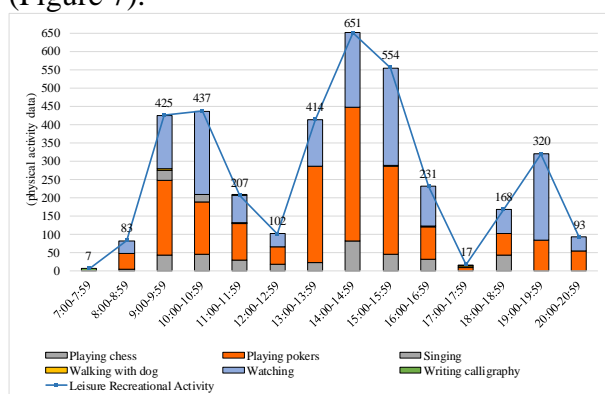


Fig.7. The temporal characteristics of the Leisure Recreational Activity

In Physical Fitness Activity, the main activities were Square dancing, sports walking and using fitness. The participations were successively 33.31%, 27.75%, and 25.96%. The total data of playing balls, running, standing with sports, accounting for 1.08%, only 74 times. In Physical Fitness Activity, the three peak periods were 7:00-7:59, 14:00-14:59, 19:00-19:59, 19:00-19:59 is the highest peak period in a day. Ballroom dancing and square dancing had a timely use of the site. mainly occurring in 13:00-15:59 and 18:00-19:59. Doing Tai Chi, playing balls, and running also mainly occurred

during the early morning, it rarely occurred in other periods. Sports walking and using fitness been occurred all the day. Sports walking mainly occurred in 9:00-10:59 and 18:00-19:59, using fitness equipment were mainly occurred in 14:00-14:59 and 18:00-18:59, 18:00-18:59 was the highest peak period in the day.

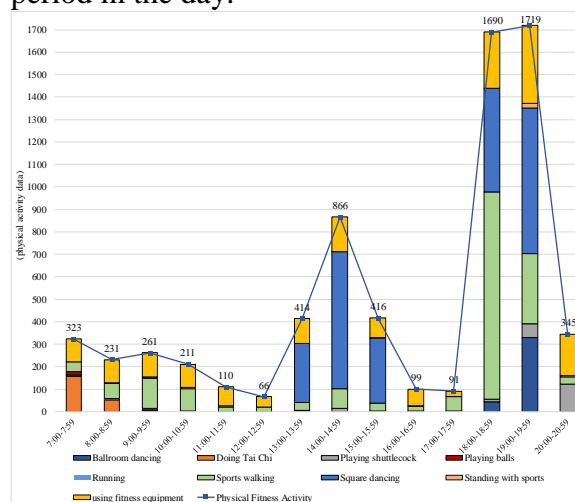


Fig.8. The temporal characteristics of the Physical Fitness Activity

4.3. Period characteristics under different genders

During the activity period within a day, elder people of different genders have changed significantly over time. The number of men who participated in the activity in the morning was higher than that of women, and they rose continuously after 8:00 and reached the maximum at 10:00-10:59. In the afternoon, female data increased, reaching the first small peak between 14:00-14:59, but the overall data was more than men. At night, both male and female data reached the highest peak of the day between 18:00-19:59. The overall data was slightly higher than that of men. Analysis of the reasons

revealed that there were plenty of sunshine in the morning and there were more male seniors who came to the park to play poker. The increase in female data in the afternoon and evening was due to the increase in female seniors who came to the park to dance square dances (Figure 9)

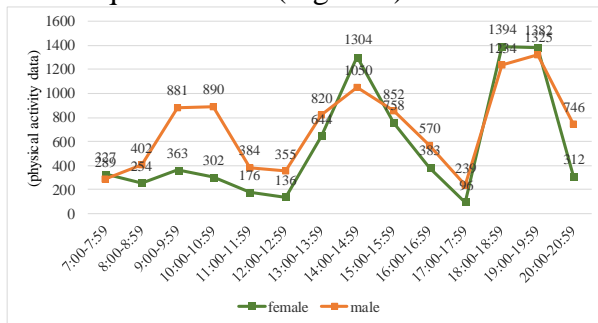


Fig.9. The temporal characteristics of the different genders

5. Spatial characteristics of outdoor physical activity

5.1. Spatial agglomeration characteristics

In the spatial distribution, the elderly had the obvious tendency of using the space in the park. The tendency was that the activities were in the north of park more than the south, the east were more than the west. The use of square space had obvious boundary effect. The obvious imbalance in the spatial distribution of the elderly reflected the different ability that support physical activity in different areas in the park. (Figure 10).

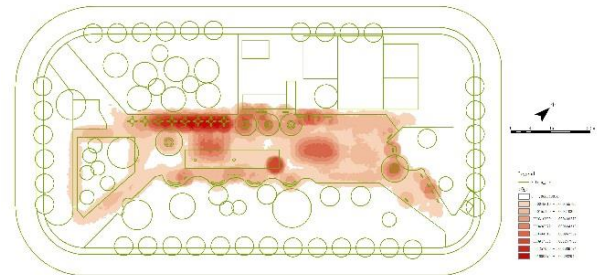


Fig.10. The spatial density analysis of total activity data

5.2. Spatial characteristics of different types of activities

Using the GIS to do the Point Density (Figure 11), it was found that the Social Interaction Activity almost covered the whole park, but the main areas were the stone table on the north side of the park, the landscape tree pools and the landscape bench surrounded by plants on the south side.

Static Rest Activity was mainly distributed on the north, south and east sides of the park, while the west side was less. Sitting and lying mainly relied on facilities, while accompanying children and standing were mainly carried out in the outer areas of activities.

Physical Fitness Activity formed a number of core gathering areas in the park, main areas were the middle of the park, the open space in the east park, and the fitness facilities, while the space utilization rate in the west of the park increased. According to the observation, it was found that the fitness activities were highly dependent on the sites and facilities, they required fitness equipment. The site had a low limit on playing shuttlecock, the elderly can carry out it at any small open space. It is necessary to pay attention to the non-slip surface of the

floor. Green shade and seats are required on the outside of the activity. Square dancing, Doing Tai Chi and ballroom dancing are generally multi-person group activities or dozens of people's collective activities, which are mainly conducted in open squares. The sport walking had a low dependence on the site and obvious boundary effects, the elderly mainly walked around the boundary of the park.

5.3. Spatial Features at Different time periods

The physical activities of the elderly in the park formed the peak of healthy behavior at 9:00-10:59, 14:00-14:59 and 18:00-19:59. In the spatial distribution of total data, at morning rush hour 9:00-10:59, it was a significant north-south boundary effect, the distribution density of activities data gradually decreasing from north to

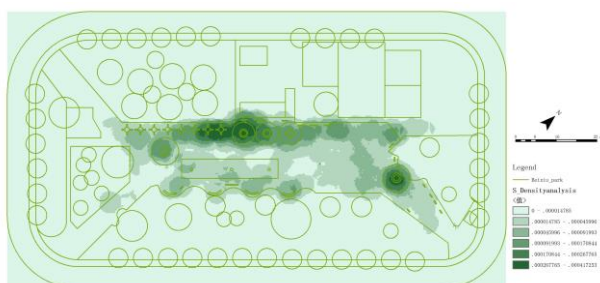


Fig.11-1. The spatial distribution characteristics of the Social Interaction Activity

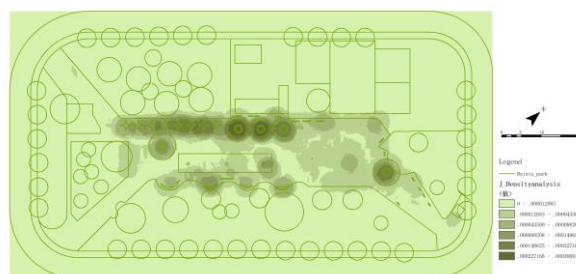


Fig.11-2. The spatial distribution characteristics of the Static Rest Activity

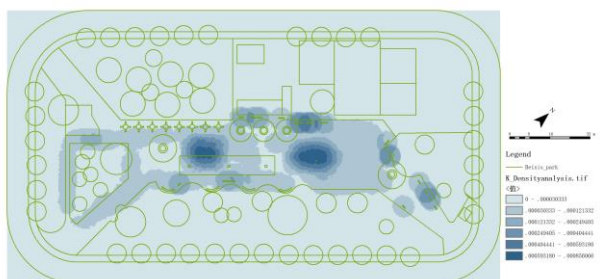


Fig.11-3. The spatial distribution characteristics of the Physical Fitness Activity

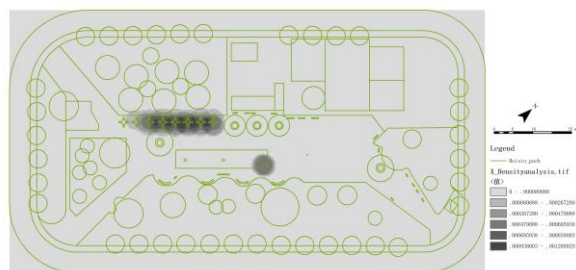


Fig.11-4. The spatial distribution characteristics of the Leisure Recreational Activity

Fig.11. The spatial distribution characteristics of different types of activities

Leisure Recreational Activity mainly relied on rest facilities. Watching caused by playing chess and pokers was an important type of activity for the elderly. Therefore, there should be sufficient seats in the surrounding areas. Playing chess and pokers relied on the park landscape seats, stone tables and chairs, landscape installations etc.

south of the park, mainly distributed at the stone table on the north side and the seat on the south side. At afternoon rush hour 14:00-14:59, the boundary effect on the north side was obvious, the data on the south side was reduced. At evening rush hour 18:00-19:59, the distribution of activity data was

relatively balanced, the data on the west side increased, the boundary effect was intensified, the central activity gathering area moved westward, located under the device with lights

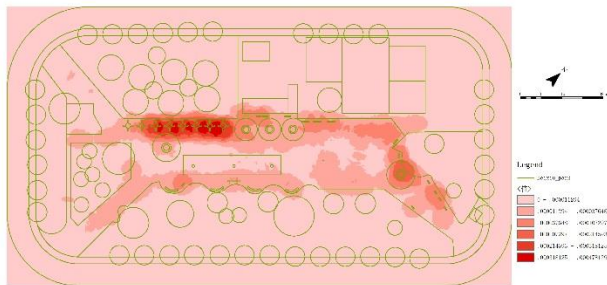


Fig.12-1. The spatial distribution in morning rush hours

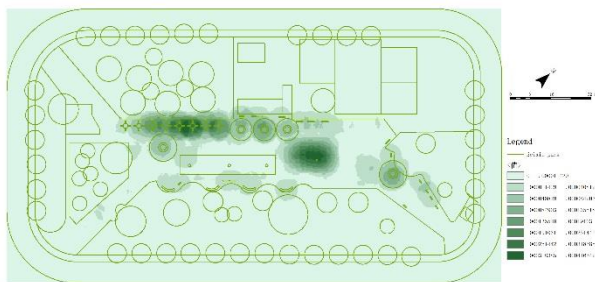


Fig.12-2. The spatial distribution in afternoon rush hours

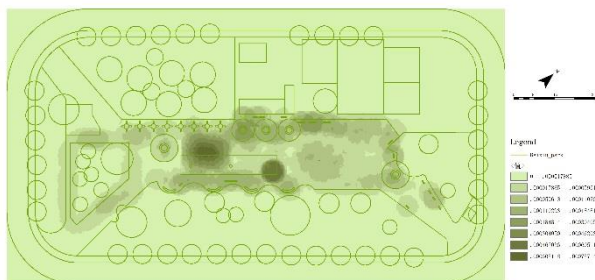


Fig.12-3. The spatial distribution in evening rush hours

6. Discuss

Ann Forsyth said that small urban parks should provide opportunities for the elderly to socialize and be close to nature [10]. The aging population is the main user of the

urban community parks in China. With the continuous improvement of the ageing, the demand for outdoor activities will be strengthened [11]. More and more attention has been paid to the research of the relationship between the park's environment and the elderly's [12]. The design of park environment has also paid more and more attention to the healthy demand of the elderly.

(1) There were a various of physical activities of the elderly in the park, based on healthy perspective, we classified the physical activities into four types, they were Social Interaction Activity, Leisure Recreational Activity, Static Rest Activity, Physical Fitness Activity. The demands for the environment of these activities are different, the organization and distribution of the activities are obviously different. According to the survey, it was found that there was mutual interference in various activities in the park. There was a spatial overlap between walking along the border and the activities located at the rest-seat area on the border of the site. Based on the guiding role of active facilities, the design of the site and facilities should be based on the type of activities for the elderly. For example, according to the boundary effect and the diversification of activities, the edge space should be planned in a hierarchical manner and he layout of the facilities should be distributed, to divide the activities of elderly people and reduce interference between activities, improve the quality of the activities.

(2) The park activities had obvious temporal effect, the peak periods of healthy activities were 9:00-10:59, 14:00-14:59 and 18:00-19:59. The multi-periods of activities reflects that the climate in the cold region

and the schedule of the elderly have influence on using the site. The morning rush hour shows that after the temperature of the park has risen and the commuting period, the elderly began to carry out intensive outdoor physical activities. In the afternoon, the temperature at 14:00-14:59 was the highest in the whole day, the elderly began to carry out intensive outdoor physical activity after the nap. The environmental factors such as sunshine and wind speed had an obvious influence on the outdoor physical activity of the elderly in winter area. Except the safety factors such as antiskid surface, In the winter, The elderly has special requirements for the landscape environment on the light transmittance of plants and the containment of space.

(3) The boundary effect of activities in the park was obvious, and the utilization rate of open space at the center was low. The activities would be carried out only at specific periods. At other times, the activity was mostly walking through and few elderly people would stay to have activities. The square dancing which appeared in the specific periods is the special fitness way for Chinese elderly people. It is a typical manifestation of the collective life style of Chinese young people to the old age period. At the same time, the playing chess, playing pokers and watching are also a special culture of the Chinese elderly people. These characteristics announce that the culture has influence on outdoor physical activities. Therefore, at the planning of outdoor healthy environment for the elderly, outdoor facilities and space planning should be conducted on respecting the cultural connotation of the elderly and studying the cultural structure of the elderly.

7. Research limitations

The data from observing activities of the elderly, it is impossible to effectively identify the age group of the elderly, so it is impossible to analyze the characteristics of the elderly at different ages. This study recorded the activities as point data, it may be difficult to capture for fast moving activities.

8. Conclusion

The elderly in the park were the subjects in the study, Through behavior observation, a comprehensive record of the outdoor physical activity (PA) of the elderly in the park was conducted by using map annotation. And spatial behavior characteristics of the elderly were explored from different time granularity and spatial scales.

The Research found that:(1) The outdoor physical activities of the elderly in community parks mainly include square dances, walks, jogging, standing exercises, tai chi, equipment fitness, dancing balls, playing dice, and social interactions. , sitting, chatting, accompanied, walking, entertainment, playing poker, playing chess, calligraphy, watching, walking a dog, resting leisurely activities, standing watching, lying and taking children, physical fitness activity is mostly the main type of activity. (2) The park activity data has changed significantly with time passing. The overall trend of the park is two lows and three highs. The peak period of healthy behaviors was formed mainly at 9:00-10:59 in the morning, 14:00-14:59 in the afternoon and at 18:00-19:59 in the evening which has

an obviously time effect. (3) The outdoor activities of the elderly are unbalanced distributed and have obvious boundary effects. Different types of activities have obvious domains. Physical Fitness Activity has a high degree of dependence on the site, not only on the site's scale and paving, some activities need to be set up with fixed facilities before it can be carried out; other Social Interactions Activity, Leisure Recreational Activity requires the least in site facilities, It can be carried out around the activity site and rest facilities.

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Study on Urban Bicycle Greenway Planning Based on Big Data Analysis of Shared Bicycle

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Abstract

Chinese greenway construction will enter a new period of development. Related research and practice are mostly focusing on the construction of regional greenways. However, considering the urban traffic congestion and the worsening air pollution problem, urban bicycle greenway should be high-ranked in the future greenway construction in China. Because it is mainly located in the urban built-up area, the selection of line is influenced by complicated factors, such as the existing urban land use layout, the network structure and the usage demand. At present, China greenway line selection is mainly based on the analysis of the suitability of the value as well as potential of urban land use, but has rarely emphasized the daily use demand of citizens. With the increasing popularity of sharing bicycles, the big data reflects the daily usage demand of urban bicycle residents.

The research considers both two aspects, big data of shared bicycle social behavior and potential of green space utilization. By sharing the cycling OD data, we can get the intensity degree of the shared bicycle destination, establish the evaluation index system by using the entropy method to get the landscape utilization potential of the green space node, and sum up the suitability distribution of the greenway node, finally choose 47 greenway connections node. Also, by sharing the bicycle track data to get the most used roads of the shared bicycle, the linear green space distribution is extracted by remote sensing visual interpretation to obtain the potential of the greenway corridor based on the greenway connection, and the two are overlaid to obtain the greenway connection suitability distribution map, which become Greenway routing cost grid based on the cost path model. Finally, the lowest cost path is obtained by connecting nodes and cost grid, the initial route selection of greenway is determined, and the route selection model is optimized according to the status quo of land as well as other economic, social and cultural factors. This article suggests to organize the greenway systematically and divide it into two greenway systems: the integrated greenway system and the commuting greenway system.

Keywords: urban greenway, bicycle greenway, big data of shared bicycle, least- cost path, route selection, entropy method;

1. Urban Bicycle Greenway

With the rapid development and expansion of cities, urban population continues to increase, and urban problems such as traffic congestion, air pollution and fragmentation of green spaces are gradually intensified. The demand for improving the urban space quality is getting increasingly prominent. The construction of the greenway, which connects the broken green spaces in the city, provides a comfortable slow-moving experience for the urban residents and improves the living quality of the residents, providing a new development mode for urban stock renewal and sustainable land use.

Since the 90s of the last century, China has entered a rapid development stage of greenway research and practice. Today, with the continuous progress of urbanization in China, there's a conspicuous shift of regional development from high-speed expansion to refined innovation. Greenway construction practice will also bring about new changes.

According to the spatial distribution feature, greenways can be mainly divided into three types: area-type, city-type and community-type. Regional greenways are mainly for the connection of key ecological land at the regional scale. Urban and community-based greenways are mainly for the connection of the main places of activities for residents, such as urban parks, street green spaces, schools and businesses within the built-up areas.

Compared with the regional greenway, the urban greenway construction is restricted by the land use for the built-up area, more emphasis is placed on the excavation of the potential of the urban space and the daily needs of residents. Compared with the

community-type greenway, urban-type greenway can solve the problems of urban landscape and traffic more systematically in the urban space system [11-13], which is of great value to today's urban construction in China. At present, the research and practice of greenways in China mainly focus on regional greenways instead of urban greenways [14], and the method of line selection mainly focuses on the evaluation of suitability analysis based on multivariate land value [15-16]. This paper discussed the urban greenway planning in China, focusing on the methods of line selection and layout within the city connected to the various functional groups.

Greenway mainly carries three kinds of slow traffic manner, walking, running and cycling [17]. Demand for bicycles, as one of the important functions carried by urban greenways, is an important factor in route selection [18]. The construction of urban bicycle greenway will provide a more comfortable and convenient experience for work commuting and daily life service, which is of great significance for encouraging green travel and alleviating urban traffic congestion. Especially in China's mega-cities such as Beijing and Shanghai, bicycles are becoming an important choice for intra-city travel, and form a complete urban public transport system by connecting with public transport and subway.

Urban bike greenway line selection mainly considers two key elements: First, the potential of the built-up area. According to existing research, the construction of urban greenway relies mainly on urban road corridors and various types of linear green space [19]. Second, bicycle usage needs and space model.

ow social life and day-to-day commuter links to reflect the social preferences of cycling. Therefore, this study attempts to combine spatial potential with big data analysis of social behavior to explore a new approach to greenway line selection.

2. Big data of shared bicycle

Big data has the following four characteristics: volume, variety, velocity, and value [20]. With the rapid development of information technology, the data show an explosive growth, and the use of big data has caught more interests of the public. In recent years, big data has been widely used in urban planning research, especially for the studies of social behavior. By interpreting big data properly, the daily rules of public social behavior shall be effectively reflected, which provides the basis for our decision-making concerning urban planning. Moreover, with the continuous accumulation of data, the persistent improvement of extraction, analysis and visual interpretation technologies will further enhance the accuracy of the analysis [21-23].

The explosive development of shared bicycles makes their big data have extensive research and application prospects. «The 2017 China Share Cycling Market Research Report» shows that the number of shared bicycle users is expected to reach 209 million in 2017. As of mid-March 2017, the total number of bicycle-sharing vehicles in the country has exceeded 4 million [24-25]. Relying on the shared bicycle positioning system, the data analysis of origins, destinations and riding routes can accurately and intuitively identify the resident's riding

behavior and high-frequency use space, which brings a revolutionary breakthrough in the public participation in urban planning [26]. With the increasing amount of data, the accuracy of research results can be accordingly improved. Meanwhile, this is also the main service function of an urban greenway, since sharing bicycles primarily addresses the last kilometer of residents' public trips. Sharing Bicycles Big Data shows the high frequency areas, providing an prominent basis for planning a greenway network that is convenient for citizens to bike and optimize the layout of the urban land.

3. Bicycle Greenway Planning Technology Based on Sharing Bicycle Big Data

This paper utilizes big data of shared bike and potential value analysis tool to explore the needs of urban bicycle greenway and the route selection of urban bicycle greenway. This route selection method can bring urban space of high-frequency use into the greenway connecting patches to meet the daily needs of residents and maximize convenient service for residents' living, work-traveling.

Based on the least-cost path model, this paper selects the connection nodes and cost grid of urban bicycle greenway from the two aspects of sharing bicycle big data and the potential of green space utilization

The first step is the selection of the connecting nodes. Firstly, from the aspect of shared bicycle big data, through analyzing and interpreting the OD data of bicycle sharing, we can get the region of high bicycle usage frequency as the important

connection node of the greenway. Secondly, from the perspective of the potential of green space utilization, ArcGIS software was used to analyze the spatial distribution of existing urban green space. The entropy method is used to establish the evaluation index system, and the importance and carrying capacity of the green space are analyzed. The potential of landscape utilization of the green space node based on urban greenway is obtained. The two are overlaid to obtain suitability distribution of the greenway connecting nodes, and the greening connecting nodes are selected according to the regions' rating of suitability.

In the second step, the social demand and the existing green space corridor are taken as the cost measure factors to generate the greenway alignment cost grid based on the cost path model. First, through the fitting of the riding track data and the current road space, the road and the linear space with high travel frequency of the bicycle in the research area are analyzed. Secondly, extract the linear green space distribution by visual interpretation of remote sensing to obtain the potential of the greenway connection. The two are overlaid to derive the greenway connectivity suitability map and generate a greenway alignment cost grid based on the cost path model.

Finally, the least-cost path is obtained by combining the connection node and cost grid, and the initial green line selection is delineated. From the perspective of commute demand, leisure experience and other aspects of the alignment to optimize the greenway selection, dividing it into two types of bicycle greenway system, comprehensive type and commuting type, thus complete the urban greenway selection for bicycles

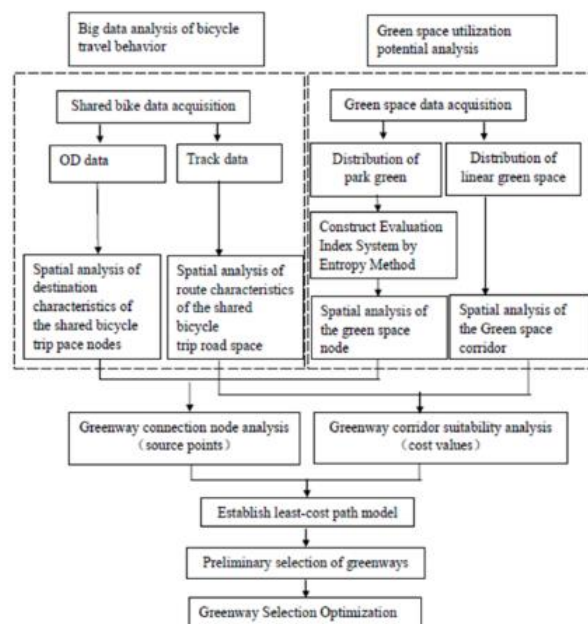


Fig. 1. framework for bicycle greenway planning

4. Urban Bicycle Green Route Selection Planning of Beijing Haidian District

4.1. Data Sources

This research data includes:

(1) The "secondary data" of Mobike shared bicycle usage records in Beijing, including the OD data and the fitted road data based on the trajectory data. The raw data come from Maui Technology Co., Ltd. from September 1, 2016 to September 30, 2016 One-month raw data of bicycle use, including cycling ID, starting time of bicycle use, starting point of riding and end of riding. This paper studies the use of motorcycle cycling big data, with the largest user base and stable and reliable positioning data. These data are based on users 'completely spontaneous cycling behavior, which can objectively reflect citizens' riding behavior characteristics and space requirements.

(2) Based on the remote sensing images of high score II in Haidian District, Beijing, the spatial distribution of green space in Haidian District was collected by visual interpretation, including the park green space, the protective green space and the urban road space.

4.2. Analysis and Selection of gateway connection node

The gateway connection node is an important part of the gateway route selection. It is a high-frequency destination

for citizens to daily-travel or has valuable green space. From two aspects of the citizen bike travel high-frequency destination and green landscape service potential, we conduct a comprehensive analysis, select the connection node. Through the gateway these high frequency node space to connect, so as to meet the daily needs of commuters and commuting needs, which is in line with the service function of the urban bike gateway.

4.2.1 hotspots of shared bicycle use

Origin-Destination data, referred to OD data for short, includes location information that shares the starting and ending location of a cycling ride. Through the analysis of OD data, the distribution characteristics of the shared bicycle trip space are obtained, reflecting the spatial movement of residents using the shared bicycle trip and the main demand area of the urban shared bicycle [27]. The big data information includes the running records of all the shared bicycles in Beijing for one month. Each record contains the vehicle ID, On point, Off point, and so on. Through the analysis of visual data, we generate the distribution map of hotspots of shared bicycle use on weekdays and holidays (Figure 2), and obtain the high frequency

spatial distribution of shared bicycle use.

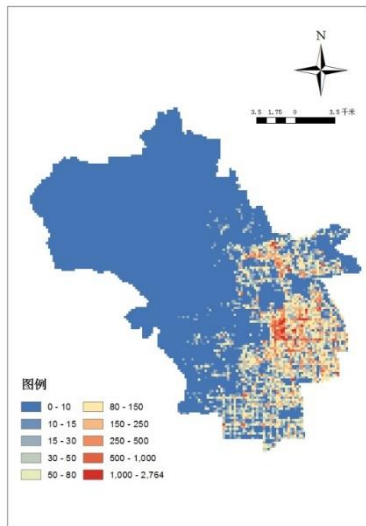


Fig. 2. Distribution of Shared bikes origin–destination

In ArcGIS software, OD data of working day and OD data of weekend are overlaid, and the activity space and intensity characteristic of shared cycling are analyzed to determine the node space with high usage frequency. As shown, the color from blue to red, the more reddish area sharing bicycle the greater the use of density. The activity space and intensity characteristics of the shared bicycle OD data can more accurately reflect the spatial distribution characteristics of citizens' travel, covering important office, residential and commercial functional areas and important transport hubs such as the subway stations and the bus stations.

The shared space for high frequency use of cycling in the study area mainly includes two major regions: one is Zhongguancun, Peking University and most of the east of it. As the center of Haidian District, it has important industrial R & D, office and commercial service functions, with the most densely populated and distributed colleges and universities. The second one is the surrounding areas of Shangdi, Xierqi and

Zhongguancun Software Parks. Mainly for large residential and office space. Important nodes in the first area include Peking University and Zhongguancun area surrounded by Line 4 and Wanquanhe Road; a section of Chengfu Road near the exit of Peking University's East Gate Subway Station; a section of line 13 from Haidian Bridge to West Tucheng,; a section of the North Third Ring Road. Important nodes in the second area include: Shangdi Subway Station, Xierqiqi Subway Station, and Sina Headquarters Building.

4.2.2. Green space node potential analysis

Select the existing park green as an important landscape service node for the greenway connection. The research uses the entropy method to make a comprehensive evaluation of the existing park green space, establishes the evaluation index system, and generates the evaluation level spatial distribution map. Evaluation index is divided into ecological value, landscape value and cultural value. Based on the principle of integrity and principle of authenticity, we used Expert Scoring and Public Participation to calculate score of parks, and we chose the entropy method to calculate the weight value of the value index [29-30] (Table 1).

Table 1. The cost values and weights assigned for the analysis of entropy method.

	ecological value	Landscape value	Cultural value
ej	0.98	0.98	0.99
dj	0.02	0.02	0.01
wj	0.30	0.44	0.26

Based on the weight of each index obtained, the greenway-based park green space evaluation score is calculated by weighted calculation (Appendix A).

Based on the above evaluation results, we link the score of each green space with the vector map of the spatial distribution of green space through the attribute table link in Arcgis, and re-classify the score of each green space to obtain ten levels. The green space-based park green space service value hierarchy map (Figure 3) is obtained.

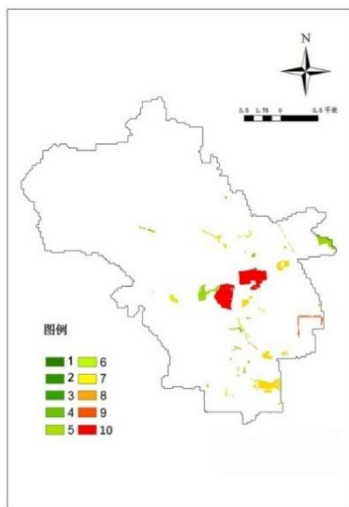


Fig. 3. Distribution of the green space node value in study area

4.2.3 Selection of greenway connection node

By overlaying the citizen's share of the spatial distribution of intensity levels of cycling destination and the potential spatial level distribution of green landscape nodes, the suitability distribution map of greenway

connecting nodes is obtained (Figure 4).

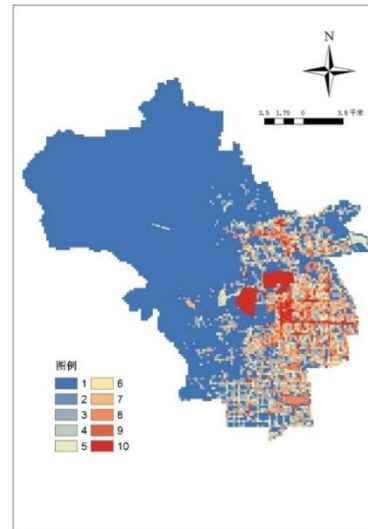


Fig. 4. The spatial distribution of greenway connection node suitability

As is shown in the figure, the adaptability of greenway route connecting nodes shows a positive correlation with the overlay scores, while the areas with reddish to blue color and the more reddish areas indicate that the suitability of greenway connecting nodes is higher. By filtering out the highest level area, set 47 connection nodes (Figure 5).

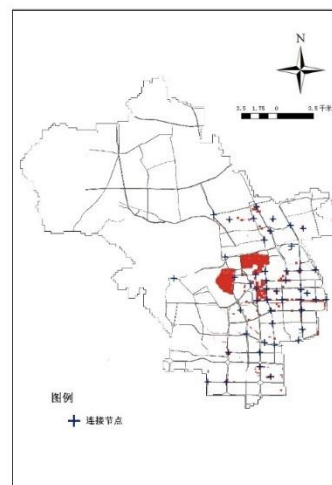


Fig. 5. Map of greenway connection node selection

4.3. Analysis of greenways corridors suitability

4.3.1 Road Usage Analysis of Shared Bicycle Based on Trajectory Data

The trajectory data is the data information obtained by sampling the movement of the moving object. The shared cycling trajectory data can be matched to the real road network through the key preprocessing steps in the location service [30]. By fitting the cycling track of the shared bicycle to the existing road, the preference of the road selected by the bicycle travel can be obtained as the route selection guide of the urban bicycle. Through data visualization, a road map of the shared bicycle use is generated (Figure 6) to reflect the distribution of high-frequency road used by the shared bicycle.

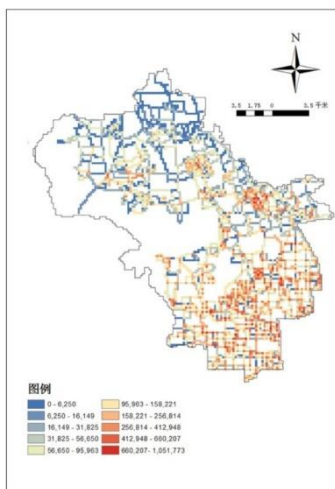


Fig. 6. density distributions of shared bicycle using road

The frequency of shared bicycles' using varies on different roads, and even varies on different areas on one road. The using ratio of road space near major residential, commercial and office areas is noticeably higher. The frequency of use around the metro stations also increased significantly, showing a tendency to radiate outward from

the metro stations. To a certain extent, it tells that shared bicycles is better suited to solve the "last kilometer" problem of residents traveling, which is in line with the main service functions of the urban bicycle greenway.

4.3.2. Green space corridor utilization potential analysis

The linear green space is an important bearing space for the connection of greenways, and is also an important green corridor in the city. The spatial distribution of the linear green space in the study area is identified through visual interpretation through remote sensing, and a spatial distribution map of the space potential of the green space corridor is generated. (Figure 7).

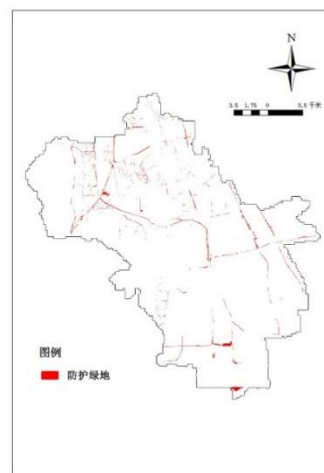


Fig. 7. Distribution of the current linear green space in study area

4.3.3. Greenway corridor suitability analysis

The overlay analysis of the distribution characteristics of road intensity connected to citizens' bicycle trips and the green space utilization potential of the greenway was used to obtain the suitability map of green line selection (Figure 8). Based on the social demand and the existing green space corridors as the cost metrics, the green line selection costing grid based on the cost path

model is generated to establish the least- cost path model for path selection.

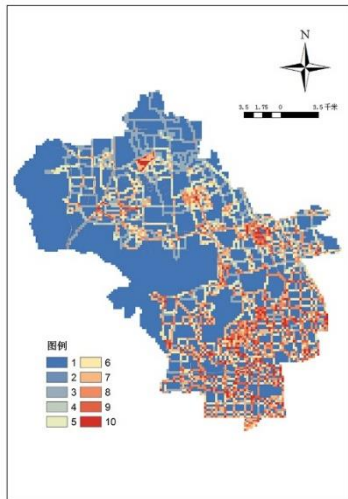


Fig. 8. The density maps reflect potential utilisation of greenway corridors

4.4. Urban Bicycle Greenway line selection

4.4.1 Create least-cost path

The “cost path” tool in GIS is used to identify the 47 important connecting nodes of greenway as the starting and ending points. Through cost-weighted distance functions that are generated by use frequency of road intensity connected to citizens' bicycle trips and the green space utilization potential of the green space corridors, the minimum cost path between the corresponding connecting nodes is obtained (Figure 9).

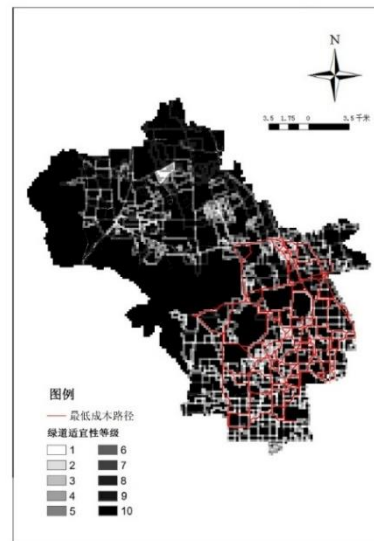


Fig. 9. Create least-cost path

4.4.2 Initial line selection of the greenway system

Based on the analysis of the minimum cost path of greenways obtained through the analysis of big data combined with ArcGIS, a coherent, multi-functional and vibrant green network is formed to maximize the satisfaction of citizens' commuting needs and guide healthy travel modes. An initial selection line of the urban bicycle greenway in Haidian District is finally formed (Figure 10)

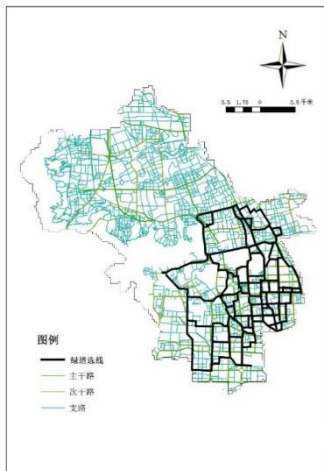


Fig. 10. Map of initial line selection of the greenway system

4.4.3 Greenway Selection Optimization

Considering the current status of land use conditions, leisure needs of residents, and different levels of existing roads, the initial greenway system was optimized and divided into two different levels of greenway systems, ie, integrated greenway systems and commuter greenways. The system will eventually form the overall greenway route selection plan for Haidian District (Figure 11). While ensuring the continuity of the greenways, the two systems give different features to the greenways from the perspective of the existing natural environment, road system, landscape style, commuting needs, and walking experience.



Fig. 11. Map of greenway system consisting of an integrated greenway system and a commuter greenway system

(1) The integrated greenway system

To build a integrated greenway based on the selection of green lanes that have large flow of bicycles, can connect existing high-quality park green spaces. The integrated greenway meets the needs of daily cycling and jogging. It also integrates existing fragmented green space, connects various important park green areas, and provides ecological service functions. It also provides recreational facilities in the greenway system to meet residents' daily fitness, entertainment, social and other needs. The overall integrated greenway system has formed a multifunctional system that integrates ecological landscape features, historical culture, social economy, and citizen commuting functions.

(2) The commuter greenway system

We sort out the other lines that have a large flow of existing bicycles, mainly responsible for work and life commuting services, and plan commuter-type greenway systems. The system makes full use of high-frequency use of urban secondary roads and

branch roads to meet the current commuting needs, thereby improving residents' bicycle travel experience and promoting daily low-carbon travel of urban residents, which alleviating the growing pressure of urban private motor vehicles.

5. Conclusions

This article analyzes the spatial distribution of cycling in Haidian District through shared bicycle big data, mapping the spatial characteristics of citizens' cycling. At the same time, based on the characteristic that green space corridors are the main space carriers for the construction of urban greenways, the appropriate spatial distribution characteristics of routes plan for urban bicycles greenway are explored. The research uses big data to analyze social behaviors, and implement a scientific and precise greenway route selection plan from the bottom up, which provides all new approach for greenway route selection planning. In the context of urban renewal and smart development, this new method can be enlightening both theoretically and practically.

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Materialising Microclimates: designing with data for thermal effect

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Abstract

The thermal condition of a landscape is a powerful determinant of social and ecological engagement with a site. Despite this, designing for thermal performance remains largely unexplored in landscape architecture. The last ten years have seen extensive scientific research in measuring and quantifying external thermal comfort, mapping urban heat islands and predicting new climatic conditions. Frequently this research concludes with recommendations for better links with urban and landscape design and planning. This paper will explore potential methods of data-driven design for outdoor thermal performance. Taking thermal sensation as an example of complex and irregular variables, the research draws on technological advancements as well as new theoretical influences, including big data and performative design, to inform landscape specific design methods. Illustrated with design work from masters' studios run at the University of Melbourne, Australia, these investigations demonstrate emerging opportunities for designers to embed data in their practice. The project discussed uses designer led data capture and simulation of wind and temperature as creative methods for working with change through design. By addressing thermal sensation in design, this research demonstrates the value of maintaining habitable external space for people in cities. This is a necessary focus for landscape architecture as the challenges of climate change, including warming cities, become ever more apparent.

Keywords: Design method; environmental data; thermal comfort; thermal sensation; microclimate

1. Introduction

The experience of heat in a landscape greatly influences how a space can be used. Extremes of hot or cold weather significantly deter users from external space. As climate change continues to disrupt normal seasonal cycles, there is convincing evidence that temperature change, notably heat is a major challenge for urban environments [1]. Cities are especially vulnerable to warming where greater energy use and hard surface materials further contribute towards the

urban heat island effect. Increasing urban temperatures diminish people's engagement with external space and in extreme conditions can be dangerous to human health, causing heat stroke, sickness and death in vulnerable populations [2].

Strategic responses to the problem of urban warming range from energy reduction to broad scale tactics for reducing overall city temperatures [3]. However, plans for very large-scale temperature mitigation require an

extensive scale of intervention. For instance, a 2015 study of vegetation for cooling the city of Melbourne found that typical summer temperatures could be reduced up to 2°C ‘by replacing the Melbourne CBD with more vegetated suburbs and planted parklands’ [4]. Whilst this scale of response has the potential to significantly cool the city, it lacks viability as an implementable solution.

The scale of external urban site interventions is an important component in understanding how to manage outdoor thermal performance. Smaller scale interventions may have less impact on overall temperatures, but when positioned as an effect on human thermal sensation, smaller site design can offer strategic opportunities for supporting people in urban spaces. As Norton argues, ‘people’s experiences of the climate and high temperatures occur mostly at the micro-scale, in the layer of air between the ground and the top of roofs or trees’ [5].

Recent scientific research of microclimate conditions using real-time data provide important opportunities for better

addressing thermal behaviors in urban sites. However, these often-detailed measurements must be understood alongside the more subjective qualities of thermal sensation. Designers hoping to use this information must address complex dynamic environmental phenomena alongside equally complex human experience.

2. Experiencing temperature

Addressing temperature at a human scale is a different ambition to reducing the temperature of an entire city. Human thermal sensation is influenced by the constantly changing interactions between air temperature, wind flow, radiated heat, solar exposure and humidity. Whilst these factors overlap with the conditions that produce ambient air temperature, such as material mass and wind, thermal sensation additionally deals with human physiology and subjective experience. Table one shows the relative environmental, physiological and psychological factors that produce human thermal sensation.

TABLE ONE: THERMAL SENSATION VARIABLES

Parameter	Symbol	Related Factors
ENVIRONMENTAL		
Ambient air temperature	(T_a)	Vapour Pressure
Humidity	(%rH)	
Dew Point		
Wind Velocity	(V)	Solar Exposure Diffuse radiation Beam radiation
Radiant Heat	$t_r - t_a$ (°C)	
PHYSIOLOGICAL		
Metabolic rate	(M)	Activity
Clothing	(Clo)	
PSYCHOLOGICAL		
Personal Preference		
Acclimatisation		

An individual's experience of temperature depends on personal metabolism, activity, clothing values and subjective preference. For example, the thermal experience of someone jogging is different to someone who is stationary. Equally, someone who is more accustomed to the heat will have a lower tolerance for relatively cooler conditions. In *Architecture of the Well-Tempered Environment* Reyner Banham [6] gives the example of British troops in Aden, Yemen in the 1960's who were accused of subtly torturing their Arab detainees by running the air conditioners at 'full cool'. Banham points out that this torture could have simply been the British preference for coolness in the hot dry desert climate. Some of the earliest research on thermal sensation and heat stress was developed for the military as North American and European troops were sent into unfamiliar and often hot environments.

There are now over 100 different indices for measuring combinations of thermal sensation, thermal comfort and heat stress. Many of these simply express the interaction of air temperature with a secondary parameter such as wind, though the complexity of indices has increased in recent years [7, 8].

The majority of thermal sensation indices are designed for internal environments, where environmental factors can be tightly controlled to produce specific and ideal temperature ranges. Influencing the thermal experience of outdoor environments remains challenging due to the lack of absolute control over significant variables. Whilst internal environments are often maintained in consistent 'steady state' conditions, it is impossible to reproduce this consistency in outdoor spaces [9].

Many existing data driven thermal sensation metrics rely on assumptions of quantified control. However, in external sites, precise calculation does not necessarily lend itself to suitable design responses.

In external sites, design strategies can address relative temperature changes rather than reproducing internal static ideals. It is possible for design interventions to reduce thermal fluctuation or sudden change by moderating thermal transitions. Alternatively, design can aim to heighten experience, to enhance moments of difference, using contrast as a generator of experience. In each of these propositions, understanding the behaviour of site temperatures is essential. Site specific temperature data can provide real-time information about temperature fluctuation; including daily and seasonal change as well as critical environmental and material influences on thermal change.

3. Designing with Data

Landscape architecture has a long heritage of using data to inform design. From the development of Geographic Information Systems (GIS) at Harvard in the 1960's, the collection and analysis of site data has been central to landscape design. However, use of data often relies on reductive methods. For instance, existing site conditions are drawn from single site surveys prior to the process of design where data is treated as static, representing one condition in one moment of time. The recent rise in accessible technologies, such as real-time environmental sensors offer new scope to these traditional methods.

As new data sources have become available, including satellite, GPS and local sensors, the quality of site data has changed to include unprecedented

accuracy and detail. Emerging technologies have contributed to the information-based paradigm shift of high quality, rapidly producing data streams, known as big data.

The mass, detail and real-time speed of big data proposes alternative interrogations of temporality and dynamics [10]. Michalatos further suggests that big data changes traditional statistical analysis from means and averages to include both the ordinary and the exceptional [11]. Consequently, big data is producing methods for understanding the world that are not reliant on reductive processes but can incorporate updateable and changing information. For design, this suggests an expanded conceptualisation of data from analytics into a tool for research-based speculation.

Sensing environmental data further clarifies the value of big data for landscape architecture. Environmental big data includes meteorological, hydrological and atmospheric information. Sensors can record external phenomena including temperature, humidity, pressure, air speed, lux, barometric pressure, air particles, radiation and decibels. Beyond the collection of explicit data sets, this information can be made relative to one another. Accordingly, environmental systems can be interrogated for relative performative attributes, exposing complex dynamic processes and how they are subject to influential and relational change. Thermal sensation is an important example of an interactive physical system, where comparative and relational data can expose both behaviours and influences.

The last ten years has seen extensive scientific research in measuring and quantifying external thermal sensation, mapping urban heat islands and predicting new climatic conditions in different geographic regions. Whilst these studies

have highlighted the importance of context specific information, design specific methods for climate responsive generative outcomes are rare [12]. Often this research concludes with recommendations for better links with urban and landscape design and planning or guidelines of singular tactics such as more trees and fewer hard surface materials. For instance the 2017 Australian Cooperative Research Centres (CRC) *Guide to Urban Cooling Strategies* offers a selection of interventions including shade, permeable paving and additional evaporative cooling mechanisms to be applied in different Australian cities [13].

These approaches offer evidence-based technologies for cooling urban environments; however, the generic application fails to address relationships between environmental variables. Further, there are no recommendations for working with specific qualities for human inhabitation or use of space. The nomination of guidelines leaves designers with little space to explore the possibilities of dynamic thermal spatial design.

The following project demonstrates a series of data driven methods used in developing a speculative design for a new 'student precinct' at the University of Melbourne, Australia. In this project, the use of data addresses creative methods for understanding site specific thermal behaviours and generating novel user based spatial outcomes for improved thermal sensation.

4. Student Precinct 2.0

The new student precinct at the University of Melbourne, Australia is the redevelopment of an existing campus plaza as shown in figure 1. The new external open space is conceived as the student heart of the campus [14]. Students will use the outdoor space for study, meetings and

gatherings throughout the year. The significance of the outdoor area for occupancy means that the climatic performance of the external space is fundamental to the success of the project.



Fig. 1. The Student Precinct site on the corner of the University of Melbourne Parkville campus [15]

The speculative design proposal ‘Student Precinct 2.0’ uses thermal sensation within the climatic context of Melbourne as a core design provocation. Melbourne is known for unpredictable and rapidly changing weather [16]. Whilst considered a temperate climate, an average Melbourne day can change from cool to uncomfortably hot over very short periods of time. The urban microclimate is influenced by differences in hot northerly wind and cooler southerly wind in addition to intense solar exposure. These highly changeable climatic qualities challenge single tactic design methods, subsequently, this project engages with the distinctive

attributes of Melbourne’s unpredictable weather to generate a series of potential thermal experiences throughout cycles of days and seasons.

4.1 Designer led data capture

Initial design research used temperature data collected by the designers themselves to map existing on site thermal gradients. Designer led data capture provides quantified information of ambient air temperature variations as well as first-hand experience of relative thermal sensation. These comparative measures allow the designers to interrogate the site through temperature change and transitions, with an emphasis on opportunities for amplifying or modifying thermal experience for users.

Using iButton temperature sensors, the designers walked through the site following specific transects. The walks produced a thermal mapping of temperature change, moving into and out of buildings and across different landscape surfaces and conditions. The resulting axonometric map of the site shown in figure 2, provides the designers with a basis for observing user behaviour in conjunction with environmental phenomena such as sun, shade, wind and noise. As a site survey device, the focus on transitions highlights points of relative change in time and disparity between conditions rather than absolute measurements.

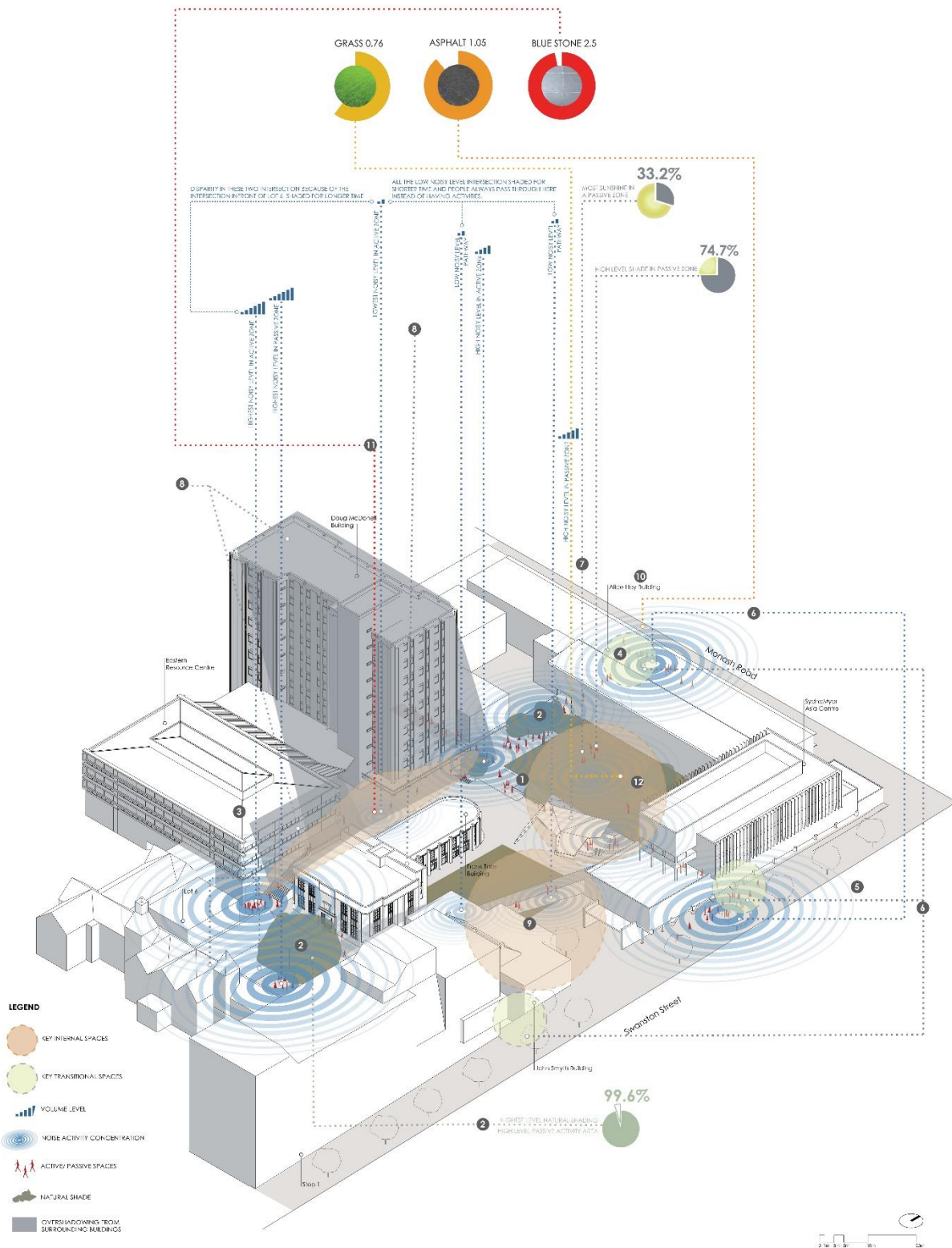


Fig. 2. Data driven atmospheric axonometric mapping of environmental site phenomena and user behavior on site.

As an empirical method, the combination of real-time data with on-site observation allows the designers to test their assumptions about thermal performance. For instance, the influence of shadow was assumed to reduce heat build-up over a day. After the mapping, the designers note for one heavily shaded area; ‘It is hotter even under the tree shadows by 5pm, consequently, natural shade in this instance does not equate to a cool environment. It does however, minimize the residual heat maintained by the ground material’[17]. Thus, the spatial differences between the sensor and the human body offer insights into the behaviors of heat across small areas, further allowing the designers to re-test their own hypothesis. Accordingly, data capture becomes an integrated part of the early design process as the designers work with existing conditions to understand drivers for new thermal relationships.

This example of designer led data capture does not offer a generative design response, however, the process of data capture and atmospheric mapping suggests rules for a design intervention. The relative combinations of wind, sun, shade and landscape materiality provide an onsite benchmark of relational effects for producing temperature difference. These physical rules are well established in thermal comfort science, however the diversity of conditions in external space give a contextual example of how people engage with different combinations of thermal difference, providing designers with a broader palette of opportunities. Using the knowledge gained from existing site processes, the designers engaged predictive methods of simulation to test potential design interventions.

4.2 Simulation as proof of concept.

Using the rules of thermal transitions generated by the on-site data capture, the designers simulated potential future atmospheric conditions. The digital simulations tested combinations of wind, solar exposure with new spatial form and materiality with the intention of highlighting preferable thermal performance at different points in the day. Here, the shift to generative design utilises data to show many possible atmospheric conditions. Rather than attempting to produce a single or ideal thermal state, the simulations operate as a proof of concept, revealing the greatest potential for creating a variety of desired effects over days and seasons [18].

To predict longer term climatic conditions including seasonal changes, the designers accessed open source data sets from the Australian Bureau of Meteorology. These larger data sets address some of the limitations of working with small site-specific data and providing a secondary source of validation. Using multiple data streams offers greater rigour as results become further verified through each data driven test and design exploration. Consequently, the accrual of data builds confidence in the results of simulations and models [19]. Furthermore, localised data becomes more ‘big data like’ as it produces inter-related outcomes which are responsive to the design investigation [20].

Simulating possible wind, solar exposure and seasonal temperatures generates potentially endless combinations of microclimate conditions. To control variability, the designers worked at critical moments during summer and winter. The simulations were overlain with expectations of user engagement with the site as an important refinement to atmospheric outcomes. Illustrated in figure

3 are simulations of foot traffic, dominant wind flows and heat at 9am and 4pm during summer and winter. These time points are important moments for student movement on site as people arrive and

leave campus but also offer the greatest differences for understanding site microclimate variability.

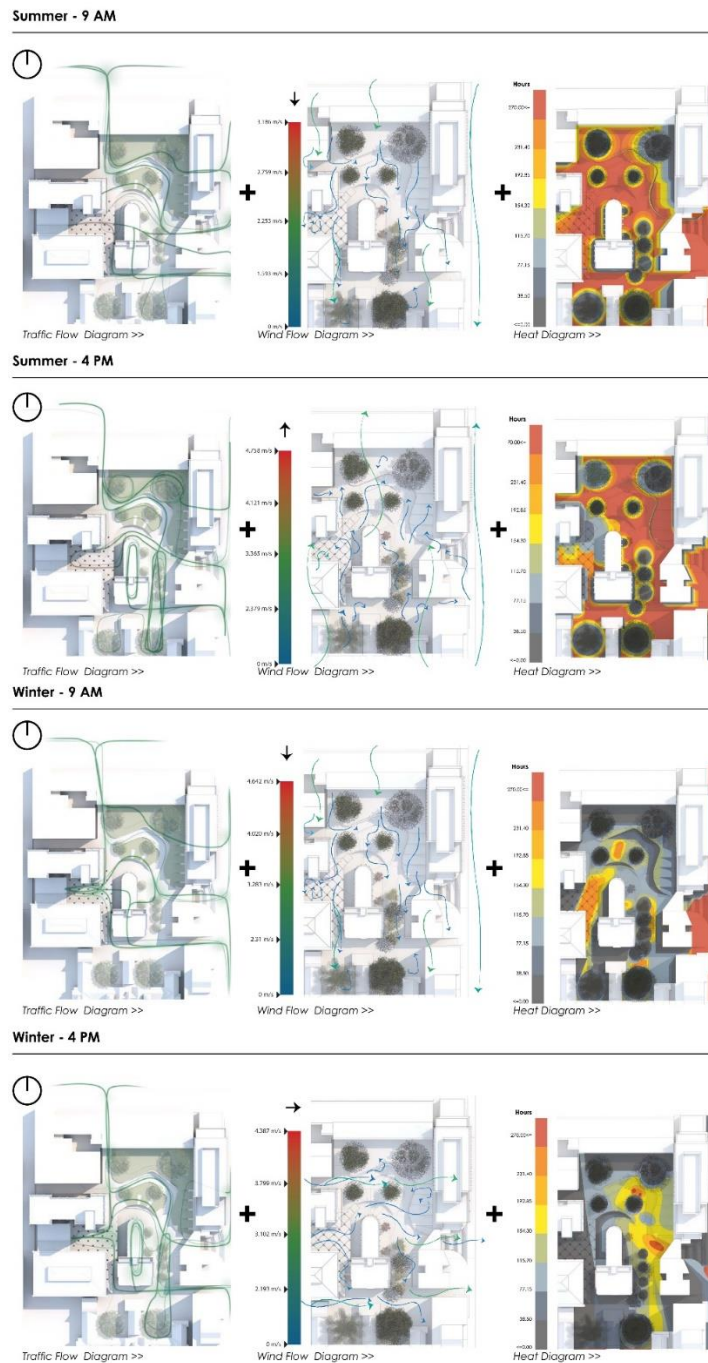


Fig. 3. Winter and summer comparisons of temperature differences across site combined with dominant wind behaviours and likely pedestrian traffic flows.

The diagrams shown in figure 3 are a distillation of multiple digital simulations generated from computational fluid dynamic (CFD) modelling and grasshopper plug-ins. The combination of multiple simulation tools provides a comparative metric for the designers to reflect on potential new conditions and modify the design response. This non-linear design process utilising simulation as a predictive method has become more common as digital design practices facilitate the incorporation of environmental data with generative design [21]. Developments in accessible technology including sensors and digital simulations make the integration of performance criteria, such as thermal sensation into the early stages of design, more accessible.

Furthermore, designers can interrogate performance criteria of a site at a range of scales. For instance, a whole site can be conceived as a series of thermal transitions which simultaneously can be examined as distinct moments of user experience, understood through the immediate interactions of the body in space, within a moment of time.

The final design speculation for ‘Student Precinct 2.0’ illustrated in figure 4 is a fluid landscape highlighted with discrete microclimates designed to perform across a variety of seasonal conditions. The ‘arcade / undercroft’ is a sheltered area of

thermal mass for winter but also a deeply shaded refuge during the heat of summer. The space engages with the adjoining building to maximise the internal – external thermal boundaries by limiting the ‘hard edge’ of temperature change between inside and outside. Importantly, the range of microclimates across the site offers users diversity of experience and choice in the many possible conditions of Melbourne’s seasons. By engaging with thermal sensation as a relative condition within the variable Melbourne climate, the designers generated a nuanced site design featuring thermal performance as an attribute of inhabitation.

The methods for utilising data described here demonstrate creative applications of quantitative measurements. New sensor and simulation technologies offer designers unprecedented insight into site dynamics and behaviours; however, these findings also require a theoretical foundation that enables design as a creative discipline.



Fig. 4. The final landscape design incorporates internal and external spaces as a series of transitions between thermal potentials in the changeable climate of Melbourne.

5. Conclusion

This research highlights critical questions for designers working with climate data. The reframing of thermal performance from an optimum static condition to moderating relative changes offers a design specific perspective on climate control. By addressing thermal sensation through design methods, this research aims to demonstrate the value of external space

for people by offering more than generic guidelines to cooler cities. As the new challenges of climate change emerge, including rising temperatures, the role of landscape architecture and design is important in providing innovative and quality open spaces.

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Big Data Analysis for Cultural Ecosystem Services in Landscape Research

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Abstract

Ecosystem services are the benefits of nature provided to human society. Among the ecosystem service categories defined by the Millennium Ecosystem Assessment, cultural ecosystem services (CES) relate most to the intangible nature of ecosystems. With the emergence of the 4th industrial revolution in recent years, the role of big data in capturing and providing insight into people's perceptions of the environment is increasing. Landscape architecture improves quality of life by creating, planning and designing a natural environment. Therefore, it is necessary to grasp the CES to people in parks through various data provided in real time through the use of big data in the field of landscape architecture. The aims of this study are to analyse the reviews of users of urban parks using big data analysis and to present the values of CES reflected in these reviews.

First, we used an open source program, R 3.4.4, to extract keywords related to CES. We read through reviews related to parks on the TripAdvisor website to extract keywords. We studied the period from May 2014 to December 2017 for Olympic Park, Seoul Forest, Han River Park and Namsan Park in Korea. Then we analysed the value of CES as determined in previous studies through a literature review and a comparison using CES keywords extracted during the previous step.

The result of this study: First, regarding park reviews, 350 reviews of Olympic Park, 191 of Seoul Forest, 771 of Han River Park, and 813 of Namsan Park were extracted from TripAdvisor. To reviewers of Olympic Park and Seoul Forest, recreation was the most important factor. Users of Han River Park and Namsan Park tend to have a greater interest in aesthetic services than recreation factors. However, CES should include a variety of inspirational and heritage services as well as recreation and aesthetics. These parks also need to make efforts to increase user awareness of a wider variety of CES. Second, this study also analysed urban park user reviews and compared it with the value of existing CES and the value of urban park CES. In CES research carried out between 2010 and 2015, rather than

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assessing CES by measuring people's perceptions, studies focused on measuring areas, components, and facilities of the natural environment. However, the value of CES as determined in this study utilizes the concept of post occupancy evaluation, which is continuously accumulated and updated, and the data constructed by the intention of those who used the spaces examined. In the planning, design, and management of urban parks as well as other landscape spaces, results of this study will be present as an efficient way to update visitors' awareness immediately and continuously.

Keywords: Big data ; Ecosystem services ; Social media

1. Introduction

Resource depletion and biodiversity reduction due to climate change and human environment activities have led to a need to evaluate environmental resources and their value [1], and consequently the concept of ecosystem services has emerged. Ecosystem services mean the benefits of nature to provide services to human life [2]. Ecosystem services grew out of the concept of “natural capital” in the 1970s. Ecosystem services concerns itself with human interaction with ecosystems. It expanded to include ideas related to the value of the natural environment and sustainable services in the marketplace in the fields of the environment and economy in the 1980s and ecology and economics in the 1990s [3]. Since then, the concept and research surrounding it have continued to evolve, from the Millennium Ecosystem Assessment (MEA) published by UNEP in 2005 to The Economics of Ecosystem and Biodiversity (TEEB) published in 2010 by the European Commission [4].

The most commonly defined concept of ecosystem services is the process of viewing ecosystem services providing benefits or deriving benefits from natural environment [5]. However, over time, ecosystem services have come to be recognized as not simply providing benefits but recognizing a collection of functions, services, and benefits [6]. There are four categories of ecosystem services.

This study focuses on cultural ecosystem services (CES) for human wellbeing under the concept of ecosystem service mentioned above. The MEA defines the concept of CES as “the nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experience” [5]. CES are spoken of as part of cultural services [2], life-fulfilling functions [2], information functions [1], amenities and fulfillment [7], cultural and amenity services [8], socio-cultural fulfillment [9]. In a rapidly urbanizing world, securing long-term quality of life becomes a major challenge. In an industrialized society, CES are more important than other ecosystem services, such as provisioning, regulating, and supporting [10]. As a result, the demand for CES is expected to increase at a time when the 4th industrial revolution has arrived [11].

In 2005, the MEA clearly linked the field of biophysics with human well-being in a study of the consequences of ecosystem change. Of the major ecosystem service categories defined by MEA, CES are the most closely related to the intangible properties of ecosystems [5]. The provisioning service aspect can be measured in the form of food, water, etc. In the case of regulating service, it can be measured by the amount of carbon sequestration and the quality of the water. In the case of supporting service, it can be measured in the form of biodiversity and landscapes. However, CES has features that are

determined by intangible values [12], and research has been carried out to evaluate them before [13]. According to the European Landscape Convention, the landscape has an important public interest role in the cultural, ecological, environmental, and social fields, which are key elements of individual and social well-being [14].

Human decisions and preferences play an important role in the formation of urban spaces [15]. Landscape architecture improves the quality of human life by planning, designing, by creating buildings and natural environment (www.asla.org). Ecosystem services are provided in the process, and landscape spaces such as urban parks are important in terms of providing CES to people. In the existing landscape architecture field an effort was made to determine values by short-term interview [16] or the questionnaire method [17] and to use the results for the design of the landscape space. With the advent of the 4th industrial revolution in recent years, a discussion has arisen about the utilization of big data, which aims to instantly grasp and reflect people's perceptions of the environment [18]. Big data analysis is used in various fields as a method of collecting and utilizing atypical and various data in real time, and this has not been done before. Therefore, it is necessary to grasp people's perceptions of landscape spaces or CES by using a lot of data, provided in real time, from existing evaluation methods in the landscape architecture field. Big data analysis, which utilizes a lot of data provided by various people online, may be somewhat less feasible than existing research process and methods. Nevertheless,

as diverse social data provided in real time accumulates, the feasibility of using it will be higher. Therefore, in the landscape area, it is necessary to recognize the data provided by various people along with the necessity of CES and utilize it as big data.

Therefore, the purpose of this study is to analyze the reviews of users of urban parks using big data analysis and to present the values of CES reflected in these reviews. First, in this study, opinions of users on four representative urban parks in South Korea were analyzed using text mining, a big data analysis technique. Second, the value of users according to the categories of CES and the improvement plan of landscape space through comparison with existing studies were suggested. The result of this study is expected to be a starting point for the design of future landscape spaces considering CES by continuously reflecting the needs of users.

2. Methods

First, for data extraction, this study used an online review website called TripAdvisor. This website is the largest travel community in the world, with approximately 439 million reviews by approximately 390 million individual visitors per month. The reviews cover 6.8 million tourist attractions, accommodations, and restaurants in a total of 49 countries [19]. These features make it ideal as a source from which to extract valid data regarding the evaluation of landscape spaces. In order to crawling CES data, this paper used the open source program named R 3.4.4. R is a good open source language for scientific calculations and has been

recognized as a reliable software tool for statistical modeling, but now it is also being used as a powerful tool for data mining and analytics. Of these, R Studio is most commonly used and can display editor, console, command, and package management on one screen and link it with the source code management system. In addition, it can support multiple platforms such as Linux, Mac, and Windows, and it has a built-in feature called R Markdown [20], which can easily combine code and documents and enable replicability analysis. This study used R Studio. The study data search covered the period from May 2014 to December 2017, when TripAdvisor entered the South Korean market. TripAdvisor selected four city parks (Olympic Park, Seoul Forest, Han River Park, and Namsan Park) in Seoul which showed at the top of page. Second, for cleaning extracted data and presenting term frequency, R Studio was used to extract the data from sentences identified at the first step according to the frequency of words used and to exclude irrelevant words.

3. Results and Discussion

3.1. Analysis of reviews by urban park users

At this stage, TripAdvisor crawls reviews from people from four city parks (Olympic Park, Seoul Forest, Han River Park, Namsan Park) in South Korea, refines the data, and analyzes the term frequency. In all, 350 reviews of Olympic Park, 191 reviews of Seoul Forest, 771 reviews of Han River Park, and 813 reviews of Namsan Park were extracted.

From Olympic Park, the following words were derived: walk, bicycle, tree, family, show, mat, exercise, date, picnic, famous, rest, children, grass, rabbit, autumn, stadium etc (Fig 1). In reviews of Olympic Park, from the list of words, the word walk was the most frequently used (43 times), indicating that for user of this park, walking was the main interest. In addition, exercise, show, date, and other terms appeared in the reviews of Olympic Park, indicating that users were interested in the recreation of the CES. In addition, it was found that people think about the aspect of aesthetics in relation to Olympic Park, since they used words such as amenity, happiness, relaxation, quiet, and interest, though these words did not appear with the frequency of the word walk. In addition to recreation and aesthetic terms, which are most often seen in CES, the use of terms such as exhibition and history suggest that Olympic Park can provide diverse CES. Although it is currently recognized by people to be lower than other services, it is considered necessary to provide various CES.

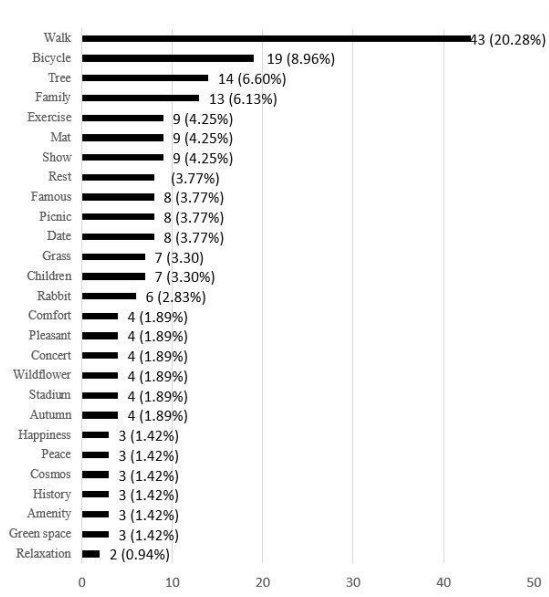


Fig. 1. Term frequency of Olympic Park

From Seoul Forest, the words walk, cherry blossom, date, deer, night view, bicycle, etc. were derived (Fig 2). As in the case of the Olympic Park, the most frequently used word used in reviews of Seoul Forest was walk (116 times), and the proportion of the words date and bicycle is high, indicating that users are most concerned about recreation. The most remarkable point is that the proportion of the mention of cherry blossoms in Seoul Forest. This means that not only aesthetics but also inspiration of cherry blossom viewing by people in the spring season can provide various CES. In addition, the famous deer, the Han River, ponds, and various plants, animals and natural and environmental factors were mentioned in reviews of Seoul Forest, meaning that people find an impressive sense of beauty in the park.

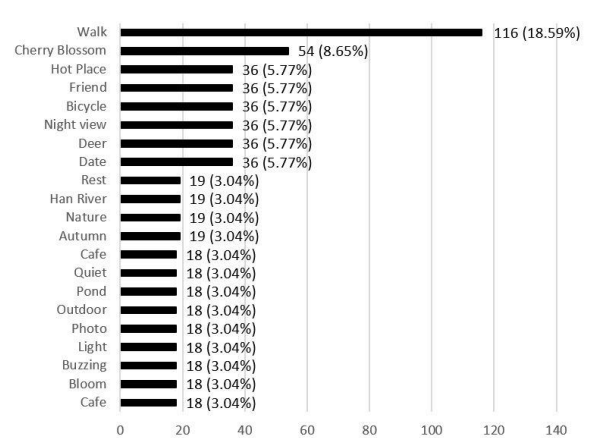


Fig. 2. Term frequency of Seoul Forest

From Han River Park, the words bicycle, walk, exercise, night view, etc. were derived (Fig 3). Unlike Olympic Park or Seoul Forest, the word bicycle is the most important word in reviews of Han River Park (16 times). Indicating that people are more aware of recreation there than other aspects. In addition, terms such as night view, rest, relaxation, and moonlight were found to be more important in the Han River Park than other CES. The terms such as night view and rainbow, which are often mentioned in reviews of Han River Park, show that a variety of CES are generated by providing inspiration to various people as well as aesthetic service. The park is directly adjacent to the Han River, and it can be seen that the terms swimming pool and canoe are used widely by reviewers.

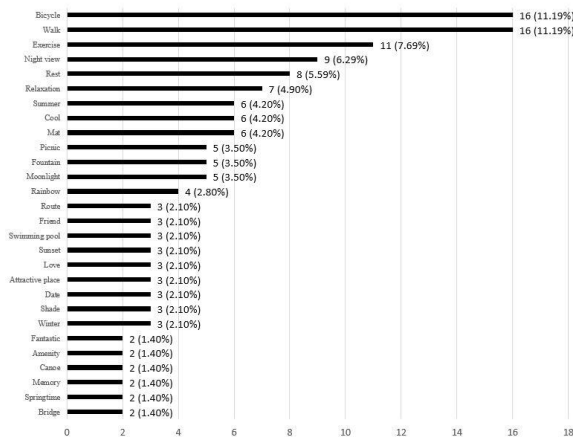
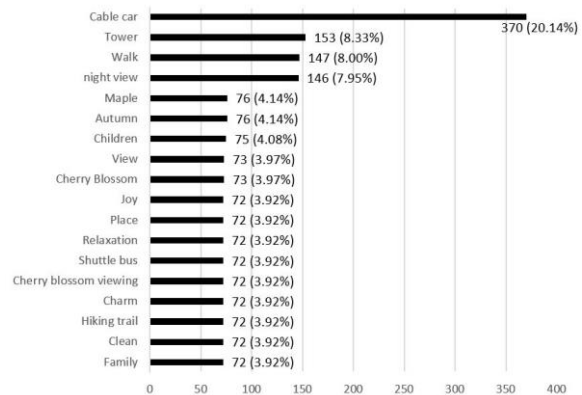


Fig. 3. Term frequency of Han River Park

Lastly, from reviews of Namsan Park, variables such as cable car, tower, walk, night view, autumn, and maple are derived (Fig 4). The cable car (mentioned 370 times), which occupies the largest portion of word usage in Namsan Park reviews, is considered to be the result of recognizing the interest of people who frequent the park, which is built in Namsan, in the center of Seoul. In addition to the cable car, the Namsan tower is recognized as being significant to users both in recreation and aesthetic aspects. In addition, in terms of aesthetic, maple and cherry blossom were mentioned frequently by users, and it was found that Namsan Park was the main place in terms of both active and aesthetic aspects.

Fig. 4. Term frequency of Namsan Park

Unlike other parks, Namsan Park has shown that the maple is more frequently mentioned than the cherry blossom. Maple is a keyword that does not appear in other parks, and this is because of the park's unique maple landscape, which suggests that Namsan Park provides various aesthetic values.



In conclusion, to reviewers of Olympic Park and Seoul Forest recreation was the main factor. Among them, the high proportion of the term walk is due to the large size of the Seoul Forest and Olympic Park and the well-developed places for walking. However, the Olympic Park commemorates the opening of the Olympic Games in South Korea, and in the case of the Seoul Forest, it is a historic place that was a racecourse in the past. It can be concluded that CES need to be provided with a variety of inspiration and heritage services as well as recreation and aesthetics, and people's perceptions needs to be improved. In addition, Han River Park and Namsan Park have a higher proportion of aesthetic service interests than recreation factors. This can be seen as related to the fact that these city parks are adjacent to mountains and rivers. These parks also need to make efforts to make users aware of a wider variety of CES.

3.2. The value of CES and comparison with previous studies

This chapter analyzed the urban park user reviews and compared it with the value of existing CES and the value of urban park CES. CES have been slightly differentiated

in detail since the MEA in 2005, but they have been largely divided into learning and inspiration, physical and psychological experience, and spiritual.

Studies that have measured existing CES have been in place since 2010 and continue to be in place (Table 1 for CES categories and indicators) [21~32]. Studies of CES measurements from 2010 to 2015 dealt with the classifications of recreation, aesthetics, and inspiration. However, the method of measuring indicators of the CES that were provided differed from one researcher to another, and in most studies, CES were measured by focusing on recreation. Most of evaluation that is continuously accumulated and updated. The value of ecosystem services recognized in this study is not measured by refined data. However, it is the data constructed by the intention of those who used the spaces examined in this study (Table 2 for CES value of urban parks in

the studies that measured recreation focused on activities (walking, jogging, etc.) and the number of users [33]. Aesthetic service was intended to be measured by asking people about abstract ideas through a questionnaire or by directly evaluating the natural environment [34]. In CES research carried out between 2010 and 2015, rather than assessing CES by measuring people's perceptions, studies focused on measuring areas, components, and facilities for the natural environment. However, the value of CES identified in this study is not a measure by evaluation of facilities or objects, but rather a concept of post occupancy (Seoul). Also, it can be said that such data can be update according to the perceptions and values of the people who use the city parks continuously, which makes it more valuable for our purposes that temporary utilization data.

Table 1. CES categories and indicators

Year	Researcher	Categories of CES	Indicators
2010	Raudsepp-Hearn et al.	Deer hunting, Tourist attractions / Nature appreciation / Summer cottages / Forest recreation	1. Deer kills 2. Tourist attractions 3. Rare species 4. Tax value of cottages 5. Forested land
2012	Maes et al.	Opportunities for recreation and tourism	1. Recreation potential
	Moore & Hunt	Recreation / Education / Aesthetic	1. Walking/jogging, wildlife viewing 2. Physical, chemical, and biological processes and structure of stormwater control measures
	Norton et al.	History / Place Inspiration / Calm / Leisure-Activities / Spiritual / Learning / Landscape	1. Water, rivers streams; bogs and marshes; coast; mountains and hills; moorland; grassland; woodland and trees; field system; hedges, walls, lances, villages

	Sander et al.	Outdoor recreation Scenic quality	1. Distance to park/trail/lake/stream, 2. tree cover, grass/water/forest view
2013	Bieling	Identity / Heritage / Spiritual services / Aesthetic services / Recreation	1. Subsistence gardens; Hunting facilities; pond; Christmas tree plantation 2. Memorials, commemorations, historical sites 3. Christmas tree plantation 4. Bench 5. Hiking trails and signs; Recreational facilities; Hunting facilities
	Casalegno et al.	Aesthetic value	1. Density of uploading photographs
2014	Brandt et al.	Aesthetic values proxy for the provision of space for recreation and cultural experiences	1. Landscape aesthetics [lakes, rivers and forests, roads, railroads and settlements] 2. Park visitation
	Buchel et al.	Recreation Social setting Mental and physical health Aesthetic appreciation Inspiration Spiritual experience Sense of place	1. Exercise, running, cycling, skating, walking dog, lunch, reading 2. With children to play, pick nick, barbeque, date 3. Recharge my batteries, feel healthy, clear my head, have energy 4. Enjoy nature, watch animals, enjoy plants, trees and flowers, enjoy smells of grass and plants 5. Get new ideas, creative inspiration, painting, writing, music, learn nature 6. Pray/ meditate, respect nature 7. Feel connected
	Fletcher et al.	Aesthetic Recreation and leisure Cultural heritage and identity Inspiration for art and culture	1. infinity, peace, passion and freedom, color, clarity of water, smell 2. activities (particularly swimming), and relaxation/ holidays, nature, aesthetics and cleanliness 3. fishery 4. poetry, sea
	Nahuelhual et al.	Heritage value associated to Chiloé native potato as a culturally significant	1. Agriculture Heritage (AH) as s spatial proxy of different dimensions that are spatialized with kernel density estimation 2. Vegetation and open water to provide

		species; Systems of knowledge; Relations (or social networks) established in the agri-cultural society of Chiloé Island	soothing benefits, to promote health and well-being, and to provide a sense of beauty to observers.
2015	Mononen et al.	Recreation Nature tourism Science education Nature-related heritage Landscape Arts and popular culture	1. Natural area, 2. summer cottage, national park 3. sacred place, unusual rock/tree, lake, springs 4. landscape 5. arts, painting, compositions, poetry, song

Table 2. CES value of urban parks in Seoul

Categories of CES	Indicators
Recreation	Walk, bicycle, exercise, picnic, concert, canoe, cable car
Aesthetic	Scenery, happiness, cosmos, maple, cherry blossom, rainbow, moonlight
Inspiration	Exhibition, art, photo
Heritage	History

4. Conclusion

The purpose of this study is to analyze the post occupancy reviews of urban park users and to compare them with previous researches so as to find ways to improve CES in the landscape space continuously. First, based on the information of the TripAdvisor community, we selected four city parks in Seoul, South Korea (Olympic Park, Seoul Forest, Han River Park, Namsan Park) and analyzed reviews of park visitors. Second, we analyzed the value of CES by comparing the reviews with existing CES

research. The results of this study will be presented as an efficient way to update awareness of visitors immediately and continuously in the planning, design, and management of urban parks as well as other landscape spaces. Future research will suggest various ways to design and manage a sustainable landscape space by systematizing the method of measuring the value of CES to urban parks as well as various landscape spaces based on the big data analysis used in this study.

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Smart Investigation: Evaluation of Beijing Olympic Forest Park based on Online Big Data

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Abstract

With the rapid development of the Internet and the application of big data technology, a series of concepts like urban informatics, social media and cloud sourcing have become more and more popular. As for a totally new investigating method, analysis with online big data is smarter than before to get visitors' evaluation after visiting city parks. By collecting, screening and making detailed analysis of these digitalised data, the study quantifies park effects and puts forward related suggestions to promote it, so as to provide new ideas for the sustainable development of city parks.

This paper takes Beijing Olympic Forest Park completed in 2008 when Beijing Olympic Games held as a case to make an investigation based on online comments data. Beijing Olympic Forest Park is one of the most popular parks in Beijing for recent years. Visitors leave a huge amount of comments data on the websites after their visiting, which provides basic support for analysis based on big data. In addition, there have been changes in many aspects in the past 10 years since 2008. It is also facing enormous challenges brought about by rapid urbanization and social development. Therefore, the case study on Beijing Olympic Forest Park is typical and representative even to other city parks.

The evaluation system is divided into two parts: comprehensive evaluation (including keyword analysis and sentiment analysis) and single-factor evaluation. In single-factor evaluation, the study tries to build an evaluation system from 4 indicators (landscape, facility, accessibility and management) based on 631 online comments from an authoritative website. By screening and scoring these data with information-grasping software, the study gets the results of evaluation.

The results show that Beijing Olympic Forest Park is overall good especially in landscape factor. But there are also much discontentment exposed by visitors, especially in green-space, landscape infrastructure, internal transportation and management level. According to the results of the investigation, the paper proposed corresponding improvement suggestions for Beijing Olympic Forest Park. Firstly it should integrate the surrounding resources and attach importance to construction of greenway and green network. Secondly, strengthen the maintenance of landscape infrastructures and transportation facilities. What's more, it should tighten up the management and create comprehensive benefits through a variety of marketing methods.

This investigation is a totally new attempt to make online comments data applied to the evaluation of urban park planning and landscape design, it will assist improving parks better according to the analysis of extracting relevant information selectively.

Keywords: urban informatics; big data; landscape architecture; Beijing Olympic Forest Park; evaluation

1. Introduction

Online comment is a mode of third-party assessments with mobile clients using the mobile Internet, combined with the geographical position and personalized consumer demand, providing information of catering, shopping, leisure and life service areas anytime and anywhere, such as business information, consumer preferences and evaluation of consumption released by interactive platforms^[1]. As the user's experience feedback, online comments data has been widely used in commercial industry, service industry, tourism and other industries after-use of the evaluation system. For example, Wu Hangdong (2015) used online comments data to evaluate the theatre usage, it obtained audience's attention and satisfaction with the theatre^[2]. Zhong Mingming (2016) made an evaluation of the usage of the Heaven Scenic village, from 5 aspects of tourism experience, tourism facilities, tourism services, tourism safety, and tourism environment, the problems existing in the development of scenic spots were analyzed^[3]. Ding Yusi (2014) scheduled for analyzing evaluation of five-star hotel service. Comparing the evaluation content with the hotel service quality assessment index, the quality of five-star hotel service was analyzed^[4]. But at present there are a lack of cases which apply online comments into the field of landscape evaluation after-use.

Compared with the traditional questionnaire survey, online comments data not only has the advantage of easy-getting, but also can reflect the visitors' preferences and satisfaction of the park better due to

online comments are filled out by visitors spontaneously. However, there are many disadvantages in this method. For example, visitors' comments are more subjective and have personal feelings to parks. So there may be some errors in data semantic analysis. Learning from past experience of evaluation methods which are presented, on the basis of using the software analysis and combining with artificial interpretation screening, this study tries to build a set of reasonable evaluation system to enhance the accuracy and objectivity of evaluation results.



Fig. 1. Aerial view of Olympic Forest Park



Fig. 2. Layout of Olympic Forest Park

The paper takes Beijing Olympic Forest Park as a case, which is regarded as the “green lung” of Beijing. It originates from the design concept of “Axis to Nature”[5]. The park covers an area of 680 hectares and is divided into the South Park, North Park and some other facility zones, providing leisure and recreation services for millions of surrounding residents. There has been a lot of researches on the Olympic Forest Park since it was built. Most of the researches are conducted from the planning and design of the park, plant collocation, water system planning, etc. Of course, there are also cases of after-use evaluation. For example, Zhao Jingyun (2014) evaluated the southern wetland of the Olympic Forest Park using post-evaluation methods (POE) through questionnaires and interviews^[6]. Hao Xinhua (2016) analyzed the southern area of Olympic Forest Park with the help of multi-source data (microblogging sign-in POI data, Baidu map LBS data), getting the distribution of the park crowd and the degree of preference^[7]. These researches have significant implications for this paper.

impressions and feelings about the park through semantic analysis software. At the same time, according to the analysis results and Baidu thermal diagram, generating visitors favorite map; Single-factor evaluation is mainly based on four indicators (landscapes, facilities, accessibility and management) for more detailed single analysis, the evaluation system is divided into three parts of data filtering, score assignment and calculation. First of all, in the data filtering step, because the visitors' comments on the park are often too subjective, the description of the problem is often mixed with personal emotions, so the invalid information needs to be eliminated first. Secondly, selecting comments on specific assessment factors of a keyword index by using information software. Then according to all valid comments on detailed semantic analysis, corresponding scores are given according to the degree of satisfaction of the reflection (1 point: not satisfied, 3 points: general, 5 points:satisfied). Finally, it will get a score of certain evaluation factor according to the calculation of the average.

2. Methods

2.1. Evaluation system

The data of this study comes from the authoritative public comment website in China (<http://www.dianping.com/>). Until to March 2, 2018, a total of 631 visitors comments were collected. The evaluation system is divided into two parts: comprehensive evaluation and single-factor evaluation. The comprehensive evaluation includes keyword analysis and sentiment analysis. It tries to obtain visitors' general

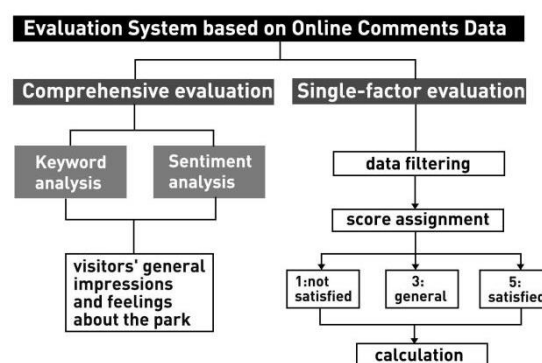


Fig. 3. Evaluation system based on online comments data

2.2 Single-factor evaluation

In the single-factor evaluation system, the specific evaluation indicators need to be determined first. The online comments data obtained on the Internet is published online by visitors in the form of words or pictures, which reflects the perception and evaluation of the visitors after the visiting. Through the preliminary screening and making analysis of these data, combining with suggestions of professional landscape architecture experts, the study divides the evaluation factor into 4 categories (B1 - B4), and 11 detailed evaluation indicators (C1 - C11).

4 categories are landscape, facility, accessibility and management, which can describe the visitors' satisfaction of the Olympic Forest Park at different aspects. The landscape factor is used to evaluate the effect and maintenance level of the park landscape, including green space, plant, water and landscape ecology; Facility factor is used to evaluate the maintenance and operation of the infrastructure in the park, including public service facility (toilets, shops, etc.) and infrastructure maintenance (lamps, seats, pavement, etc.); Accessibility factor includes external transportation, internal transportation (bicycle, electric car); Management factor includes park activities, service attitude and operation.

The frequency of different indicators in the comments can represent the importance of an evaluation indicator to visitors. By this way, the study gets the weight of every factor in the figure, the data indicates that plant, water, public service facility, infrastructure maintenance and internal transportation which have a high weight are the most concerned indicators to visitors.

The study can preliminary calculate the comprehensive score of the Olympic Forest Park by making a weighted summation of all factors.

target	category	indicator	weight
Evaluation of Beijing Olympic Forest Park based on Online Big Data	B1 landscape	C1 green space	0.12
		C2 plant	0.18
		C3 water	0.05
		C4 ecology	0.09
	B2 facility	C5 public service facility	0.13
		C6 infrastructure maintenance	0.1
	B3 accessibility	C7 external transportation	0.04
		C8 internal transportation	0.16
	B4 management	C9 activity	0.07
		C10 service attitude	0.02
			C11 operation

Tab. 1. Single-factor evaluation indicator & weight

3. Results

3.1. Comprehensive evaluation results

The figure 4 shows the word frequency distribution status of the Olympic Forest Park generated by the word frequency analysis software. It can be seen that most of the words show the satisfaction and praise of visitors such as “good”, “suitable”, and “great”. Among the words related to landscape and green space, “forest”, “sunflower”, “wetland”, “cosmos” and “ginkgo” appear most frequently, indicating that the forest landscape can represent the general landscape style of the park, while the plants with ornamental characteristics such as flowers and autumn leaves are deeply loved by visitors; Among the words related to activities, “running”, “exercise”, “photograph”, “fitness” and “tent” show that

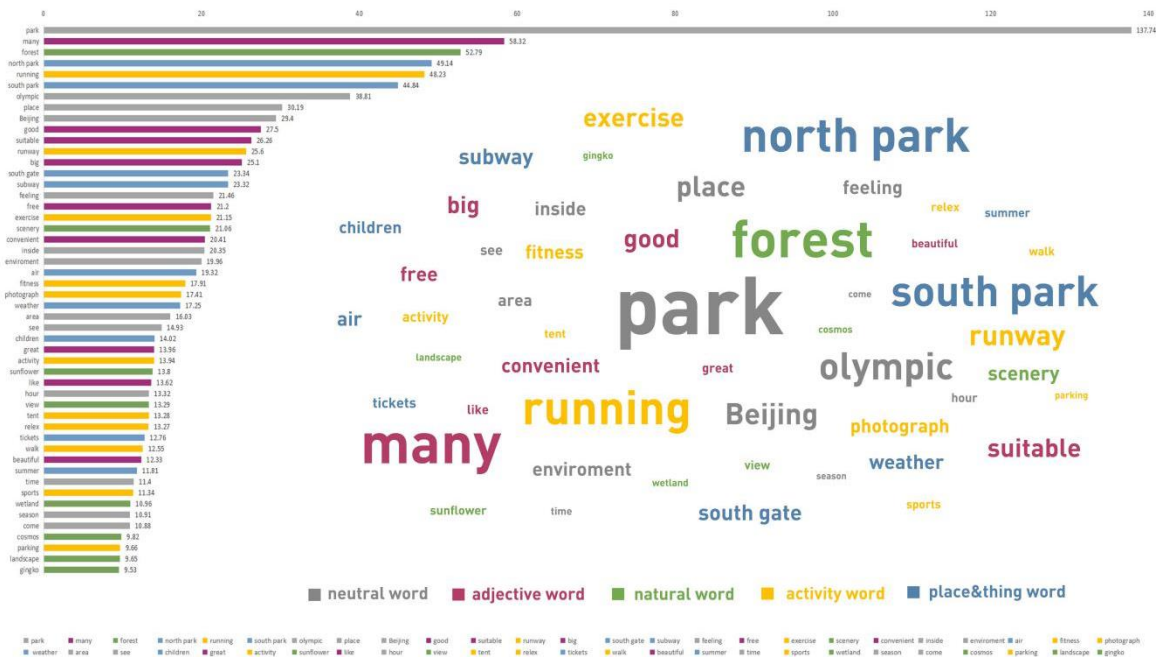


Fig. 4. Keyword analysis of Olympic Forest Park

the activities in the park mainly consist of physical exercise, especially running. It benefits from the wide and comfortable ring runway set in the Olympic Forest Park; In terms of words about places and things, “south gate” and “subway” indicate that the south gate of the park is the most concentrated area for visitors, and the convenient subway is one of the most commonly used transportation facilities. “Weather” and “air” indicate that the air quality in the park is significantly better than the surrounding area, benefiting from the various types of vegetation planted in the park.

In addition, combined with the Baidu thermal diagram, the paper draws a map showing degree of visitors' affection to the Olympic Forest Park. The figure 5 shows that visitors in the southern part of the park

are significantly more than those in the northern area; the entrances and exits of the park are crowded, particularly in the south gate area; the ring runway around the park is significantly more crowded than the inner area; the lawn area, the lake and wetland area, and the flower field area are more attractive than the mountain forest area. Obviously, the densely populated areas are also the visitors' favorite activity areas.



Fig. 5. Affection thermal diagram

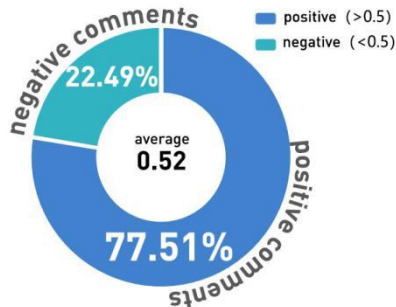


Fig. 6. Sentiment analysis

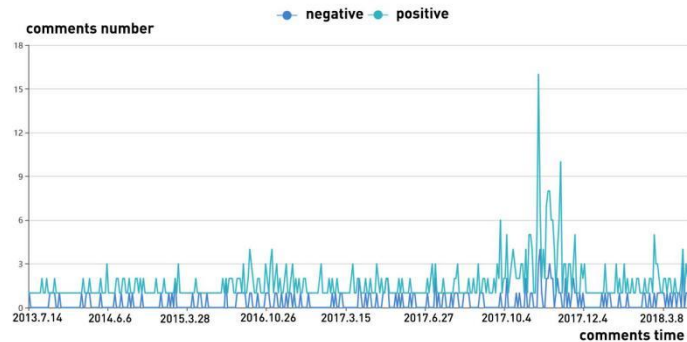


Fig. 7. Comments number distribution with time

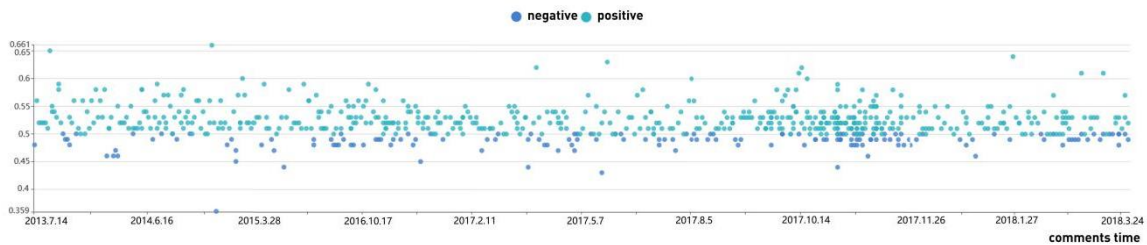


Fig. 8. Comments scores distribution with time

The figures 6-8 reflect how positive or negative the visitors' evaluation is through the sentiment analysis software. The score is divided into half by 0.5 points, positive comments are above 0.5 points, and negative comments are below 0.5 points. The result shows that 77.51% of the comments are positive, 22.49% are negative, and the average score of comments is 0.52 points, which means that the overall comments are positive.

In perspective of the time dimension, from 2013 to 2018, both of the evaluation score and quantity assumes a gradual growth trend, especially during the period from October to December 2017. At that time, the park was hosting the Cosmos Flower Show. And during the autumn, the Ginkgo biloba

was turned yellow, so the beautiful plant landscape attracted a large number of visitors to take photos and visit, which resulted in blowouts of the comments number.

3.2. Single-factor evaluation results

In the single-factor evaluation, visitors' attitude to each factor can be revealed more clearly through quantitative analysis. The results in the table 2 shows that most indicators get 4+ such as C2 plant, C3 water, C4 ecology, C7 external transportation, C9 activity. There are also some aspects not well like C5 public service facility, C6 infrastructure maintenance, C8 internal transportation etc. Overall, the

comprehensive score of the Olympic Forest Park is 4.01 points (5 points are the total points), which reveals that the park achieved success in general. The following will analyze the results from these four aspects specifically.

In terms of landscape factor, all four indicators are above 4 points, showing that the beautiful natural scenery of the Olympic Forest Park is attracted with visitors. Comparing with some small parks of the inner urban area, the Olympic Forest Park has different kinds of landscape types, including mountain, grassland, wetland, lake, etc. The wetlands in the northwest with pastoral scenery are deeply loved by people especially. Moreover, many birds and other wild animals are attracted by the natural environment here. After decades of development, a stable ecological chain has been formed, and the natural ecology has reached a balance. Every autumn, the golden leaves fallen everywhere in the park lawns become the symbolic landscape of the park.

During the past ten years since its completion, the Olympic Forest Park has become a green core in the north of Beijing, providing residents with a good place to relax and play. But there is also much discontentment exposed by visitors: In C1 green space indicator, more than 20% of visitors reflect that the green space is less connected to the surrounding area and some space is not well utilized. For example, due to the inconvenience of surrounding transportation and the backwardness of the surrounding area, the visitor number of the north park is obviously less than the south park, which makes the south park crowded during the holiday while the north park silent. Many of the sports venues around the park are abandoned after the games and are rarely used.

In terms of facility factor, visitors are not satisfied with the two indicators of C5 public service facility and C6 infrastructure maintenance. There are 35% of visitors complaining about lacking of landscape

target	category	indicator	weight	1	3	5	comments number	score
Evaluation of Beijing Olympic Forest Park based on Online Big Data	B1 landscape	C1 green space	0.12	26	58	143	227	4.03
		C2 plant	0.18	9	56	259	324	4.54
		C3 water	0.05	8	33	74	115	4.15
		C4 ecology	0.09	13	60	144	217	4.21
	B2 facility	C5 public service facility	0.13	27	92	114	233	3.75
		C6 infrastructure maintenance	0.1	21	98	59	178	3.43
	B3 accessibility	C7 external transportation	0.04	5	9	82	96	4.60
		C8 internal transportation	0.16	55	63	157	275	3.74
		C9 activity	0.07	4	28	76	108	4.33
	B4 management	C10 service attitude	0.02	10	14	23	47	3.55
		C11 operation	0.04	9	32	21	62	3.39
toall			1			631	4.01	

Tab. 2. Single-factor evaluation results

infrastructure such as toilets and service rooms, due to the number of toilets are insufficient and the distance is too far since the beginning construction of the park. Many enquiry service facilities are not open at ordinary times. In addition, the large size of the park has caused the desolation of facilities in many remote locations. However, there are quite a few visitors who have expressed their positive attitude towards the park facilities and believe that it is much better than most of other parks in Beijing.

In terms of accessibility factor, visitors have the opposite attitude towards C7 external transportation and C8 internal transportation. It is very convenient to get the Olympic Forest Park because it has direct subway and public transportation after its completion. However, inside the park, external vehicles including bicycles are forbidden, causing inconvenience to many visitors. 42% of visitors reflect that the park forbids cycling which is inconvenient to riders. Since the park is too big to walk, bicycle riding is very necessary. But there is only charged bicycles and electric cars inside, ordinary bikes are not allowed in.

In terms of management factor, C9 activity gets a very high score, this is due to the rich variety of events organized by park managers such as the marathon, rainbow run, flower show, etc. Especially, running has become the special feature of the park, the

surrounding residents like running in the park on the weekend or after work, the park sets up a comfortable red plastic runway which is very comfortable to runners. Besides, 28% of visitors complain about the low-level management in the park. The park lacks sufficient management, the landscape is often not maintained timely.

4. Suggestions

According to the conclusion of the investigation, the paper proposed corresponding improvement suggestions for Beijing Olympic Forest Park. First of all, the park should continue to maintain the existing good landscape, and promote the balance of the development between the north park and the south park, especially enhance the popularity of the north park. For instance, the north park countryside features can be enhanced through activities such as hosting land art exhibitions and cross-country experiential events. At the same time, the park should open some sports venues freely to meet the public sports needs. Secondly, the park should strengthen the maintenance of the infrastructure, increase the service inquiry facilities, it can add recreational facilities and children playgrounds appropriately. Thirdly, the park should set up dedicated bike lanes and



Fig. 9. Beautiful scenery, comfortable runway, colorful activities

multiple entrances to surrounding visitors. With the popularity of “sharing bike”, parks should be accessible to bicycles. Last but not the least, park managers need to change their ideas, improve the level of management and service, integrating into the market-oriented operation system continually^[8].

In addition, parks should establish a set of evaluation system based on the evaluation of visitors through the regular survey or Internet survey like online comments data in the future, which would be benefit to find their own problems in time, and then deal with these problems pointedly. Forming a good interaction between visitors and parks will be a new direction for future park evaluation research.

5. Conclusions

It is a new attempt and exploration to evaluate the park based on online comments data. As a kind of big data, online comments data applied to the evaluation of urban planning and landscape design after use will help to realize the application value of big data to guide practice according to the analysis to extract relevant information selectively^[9]. Of course, there are many deficiencies in this study. For example, the evaluation data from visitors is subjective sometimes and lacks of professionalism and objectivity. The selection process of the online comments data should be more scientific and rigorous, and the subjective interpretation may make the final calculation result in a certain error. But as a new way of park evaluation, its analysis process and the results have a certain innovation

significance and reference value, can provide a new train of thought for subsequent park development.

Through the study of the online comments data evaluation of the Olympic Forest Park, it can be seen that visitors' recognition of the park is still relatively high after many years. It is hoped that the park will establish a good interactive relationship with visitors, and the suggestions and evaluation of visitors will be applied to the improvement of the park.

Acknowledgments

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[FEATURED SESSION SPEAKERS]

DAY 2 TIME: 10:30 – 10:50

Denser, Greener, Smarter

Professor Thomas Schroefper

Professor and Founding Associate Head of Pillar, Architecture and Sustainable Design
Singapore University of Technology and Design
Singapore

Synopsis:

Contemporary architecture and urban design practice in Singapore and beyond is increasingly exploring the integration of green spaces in buildings, producing innovative building types for high-density urban environments that include public spaces, extensive sky terraces, sky bridges, vertical parks, roof gardens, and other 'green' components. Combinations of all these, often applied to mixes of residential, civic and commercial programmes, conjoin at times to produce 'vertical cities' in which the built sections become part of larger urban ecosystems such as parks, gardens and river networks. Density and sustainability here are not seen as contradictory, but rather as mutually dependent and synergistic.

The presentation discusses Dense and Green Building Typologies, a five-year research project at the Singapore-ETH Centre Future Cities Laboratory (SEC-FCL), in collaboration with the Singapore University of Technology and Design (SUTD). The research explores innovative dense and green buildings through a systematic study of their urban, architectural, environmental, social, urban and economic benefits in high-density cities. The presentation further introduces FCL's larger High Density Mixed-Use Cities research 'scenario' that the project is part of. The scenario develops new integrated planning approaches, research methodologies and implementation processes to support higher population densities, higher standards of environmental sustainability and enhanced liveability.

The presentation provides an overview of the project by discussing aspects of five of its areas of research:

Urban Design and Architecture Benefits explores design strategies that mitigate the negative effects of high density.

Environmental Benefits studies the performance of dense and green building types in terms of thermal comfort, heat gain, urban heat island effects, air quality and noise pollution.

Social Benefits investigates dense and green building types in terms of use and appropriation as well as psychological comfort.

Economic Benefits examines the role of dense and green building types in land value appreciation.

Design Strategies integrates all work packages to develop innovative approaches to future high-density urban design and architecture.

Dense and Green Building Typologies is conducted by a multidisciplinary team of researchers. These work synergistically with other research teams at FCL and bring together expertise in urban planning and design, architecture, landscape architecture, building technology, social science, ecology and economics. Beyond FCL, the research team has established a number of important collaborations with Singapore Government agencies, including the Urban Redevelopment Authority, the Housing and Development Board, the Building and Construction Authority, the National Parks Board and the National Environment Agency, as well as clients and practitioners. International collaborations include the Swiss Federal Institute of Technology Zurich (ETHZ), the Politecnico di Milan and the University of New South Wales.

The research findings of Dense and Green Building Typologies have been presented at international conferences and symposia and published in journals and books including by Springer Nature. The project is currently exhibited at the Venice Biennale 2018. A book titled Dense and Green Cities: Architecture as Urban Ecosystem is slated for publication by Birkhäuser in 2019.

DAY 2 TIME: 10:50 – 11:10

Using Data Analytics and Geospatial Modelling to strengthen parks planning

Huang Zhongwen

Director
Digital planning and Department
Singapore

Synopsis:

To develop a City in the Garden, Singapore has adopted over the decades a continuous series of innovations in how we plan for green and blue spaces, as well as policies to encourage urban greenery. In recent years, URA with agencies have also been exploring the use of data analytics and GIS to further strengthen the way we plan for parks and greenery. The sharing will highlight ways in which it has been applied to enable a more data-informed way to plan for parks and green spaces to create an even more livable environment and achieve better planning outcomes for people, while also optimizing the use of land and other resources.

DAY 2 TIME: 11:10 – 11:30

Connecting Landscaping and Human Well Being Design for Outdoor Comfort in tropical climates

Wolfgang Kessling

Partner and Principal
Transsolar
Germany

Synopsis:

The intensity of outdoor activities is one of the basic parameters which defines the urban social sustainability - the number of people and the time they spend outdoors in the streets, plaza, markets places, playgrounds, etc.. Outdoor activities are influenced by the availability of protected open spaces in the neighbourhood. High thermal comfort on an urban space will elevate urban sustainability, increase density of activity and social contacts, promote local business and reduce energy use and CO2 emissions. But first and foremost, design for outdoor comfort will improve microclimatic conditions for a healthy environment in cities.

In the context of rapidly growing cities designing performing landscapes gain more and more attraction in the professional community of landscape architects. Landscape architects play a role to overcome compromised critical infrastructure systems in the city. Designing for resilience, giving back space and function to ecological systems within the city, activating layers of green and blue infrastructure can counteract the impact of urban heat island effects and climate change.

Advanced Human-Biometeorological parameters support the understanding how climatic conditions and environmental parameters are perceived by people. Given a site and local climatic conditions, what is the combined impact of sun and wind, humidity and air temperature on people's outdoor comfort. What is the impact of dedicated strategies? What if conditions would be so and so? Tools and methodologies, developed to quickly link strategies to local climatic conditions, have proven to give powerful design advice. Modelling in detail the performance of landscape elements, location and extend of shading, trees, water features is useful to inform design decisions how to improve outdoor comfort considering the specifications of materials and elements of nature.

Also in humid tropical climates, elevated air speed can be combined with Dry Mist Technology to create human comfort also. Dry Mist technology targets basic human needs by improving micro climatic conditions to create a healthy and comfortable outdoor environment. The technology can be integrated into the design of public spaces, streetscapes, markets, playgrounds and parks and integrated with well-watered green areas to mitigate urban heat island effects on a local human scale.

In outdoor environments people have many adaptive choices to find thermal comfort. In indoor environments for some decades high comfort was only attributed to a very static mechanically controlled thermal environment. In tropical architecture increasingly, architects and landscape architects work beyond their disciplines to develop concepts of Breathing Architecture for buildings which offer an intense connection of indoor and outdoor spaces and embrace green and nature. Designing for adaptive comfort can reduce technical systems and energy demand by about 50% without sacrificing thermal delight in the tropics.

Examples of interventions include Gardens by the Bay (Singapore), MASDAR (Abu Dhabi), Heart of Doha (Doha), Installations of Dry Mist Technology (Singapore, Cayman, Milan) as well as the Floating University of BRAC (Bangladesh).

DAY 2 TIME: 11:10 – 11:30

Living Digital in Smart Cities

Professor Poon King Wang

Director
Lee Kuan Yew Centre for Innovative Cities
Singapore

Synopsis:

Discussions on smart cities and innovation tend to focus on technological innovations and the ecosystems that support them. Just as important, but less discussed, are how cities need to innovate in their social and economic institutions of work, education and healthcare. These build human capabilities for people to live flourishing lives, but are now under stress from social, economic, political and technological disruption.

*How we respond will determine whether our citizens and cities thrive or struggle. Drawing on the recently published book *Living Digital 2040: Future of Work, Education and Healthcare*, this presentation will share how taking a human, social and technological lens can help us develop practical policies and strategies to lift lives, often with the same technologies that are disrupting them. It will also share how we can draw strength from our human and collective capacity to innovate together and create better lives for each other.*

DAY 2 TIME: 11:10 – 11:30

Cities & Innovations, Smart Nation Track

How information technology and data analytics may provide insights into the design processes by better quantifying our understanding of the environment.

Adam White

Director
Davies White Ltd
United Kingdom

Synopsis:

The world we live in is changing – urban environments are under unprecedented pressure from urbanisation and increasing population. In the UK, more than eight out of ten people live in cities. Landscapes are increasingly being looked to, to help relieve pressures on key issues such as sustainability and health and wellbeing.

We can see this through the rise in the gross value added in the sector – it's estimated that in 2016 the UK landscape profession contributed £948m in aGVA (average gross value added), a 15.9% increase since 2010. Technology is changing the way in which our profession works and has been playing an increasing role in helping design, deliver and manage these more resilient landscapes.

The landscape profession is leading the way in using new technology and innovation to create stronger connections between people, place and nature across the UK and beyond. Digital skills – including virtual, augmented and mixed reality, sourcing and use of spatial data and digital collaboration are transforming the way the profession designs, manages and plans environments. It also has the ability to transform how we use, communicate, educate and move through a landscape.

Adam White, President of the Landscape Institute, and himself an award winning Landscape Architect will be sharing case studies of leading examples of information technology and data analytics from across the landscape profession. Adam will discuss:

- *Our profession is responding to new technology and its use*
- *Tools for better collaboration & community engagement*
- *Innovations in construction, 3D printing & design*
- *Collection and interpretation of landscape data*
- *Latest trends in visualization of landscape*

Adam will also offer perspectives from his area of expertise linked to the importance of play in the landscape – health benefits and better appreciation of the environment. He will also offer the Landscape Institute's latest thinking on equipping the profession with the skills needed for the future. Those working in landscape should be front and centre in this new world, given their appreciation and ability to consider and resolve environmental issues at both the large and small scale.

DAY 2 TIME: 11:10 – 11:30

The Digitisation of Vegetation: From Solitary Trees to Whole Forests.

Dr. Ervine Lin
National Parks Board
Singapore

Synopsis:

During the adoption of smart technologies in cities, an integral component that makes cities liveable cannot be ignored – vegetation. Yet the two, vegetation and the digital world, are often segregated due to gaps in the technology or knowledge required to unify the two seemingly opposing domains. The risk of inadequately integrating vegetation into the digital realm is that it would be ignored completely thus omitting any possible role vegetation has to play in urban planning, design or other forms of data analytics.

The current method of bridging this gap is to utilise Geographical Information Systems (GIS) to serve as a two dimensional (2D) record of vegetation. This occurs in the form of raster and vector maps which are derived from satellite imagery or ground surveys and provide information on the location, size, and density of this vegetation. These methods have proven to work and will continue to be further refined and developed but are inherently two dimensional in nature and are difficult to translate directly into a three dimensional (3D) space required when we start digitising the rest of the city in 3D.

One advancement that is helping to bridge this gap is the use of reality capture technology – specifically photogrammetry and laser scanning. While each of them have their own merits and limitations, it has provided a means to digitally record objects in the real world – such as vegetation – into a digital one thereby inverting the typical method of generating 3D models to represent reality. These technologies can allow us to digitise across multiple scales from a single seed pod up to a whole nation depending on which sensor is used.

However, capturing the data is only the first step and the captured 3D models are only useful as a visualisation tool if there is no other means to access that data. A much more challenging process is to be able to efficiently extract useful information from these scans that can either enrich existing databases or form the basis of further decision making processes for the respective stakeholders. This talk provides preliminary insights into how this can be done from the scale of a single tree to an entire forest and exposes both the limitations and potential uses of this technology.

Applications of Unmanned Aerial Vehicles Remote Sensing Technology in Landscape Architecture

Weijie Han,^a Yilan Wang,^a Wei Guo^{a*}

Beijing Forestry University, No.35 Qinghua east road, Beijing 100083, China

Abstract

Accurately acquiring information of the site is crucial for landscape architects. Since satellite remote sensing and GIS (Geographic Information System) techniques have been widely used in landscape architecture for decades, various kinds of satellite images and open source data have become an important way for landscape architects to acquire site information. However, the limitations of traditional satellite-based remote sensing images such as low spatial resolution, long image update period and cloud cover often lead to the information obtained not accurate and comprehensive enough to meet the needs of landscape planning and design and research. UAV-based remote sensing technology provides a new method to acquire the site information, which is flexible, efficient and free from the limitation of time, space and resolution, and can provide the latest high-resolution image data of the site at any time. This study briefly introduces the classification of UAVs and the types of sensors they carried, then it divides the application of UAVs in landscape into two aspects: aerial photography and aerial photogrammetry. UAV aerial photogrammetry technology, such as orthophoto maps and oblique photography, are highlighted, then it explores the various uses of UAVs, carrying different types of sensors such as thermal imaging sensors, hyperspectral sensors and LiDAR in landscape planning and research. Finally, some potential hot applications of UAVs in the field of landscape architecture are discussed in the hope of enlightening the relevant research.

Keywords: UAV; remote sensing; aerial photography; aerial photogrammetry; landscape planning and research

1. Introduction

With the rapid development of information technology, the future world is becoming more and more digitized and informatized, and the use of digital technology is gradually deepening into all

aspects of the landscape architecture industry. [1] As a part of the "Smart Cities", landscape architecture will eventually be incorporated into the entire intelligent system and become a "Smart Landscape." As the first step of landscape planning and design, the acquisition and analysis of site information is the basis for all subsequent

work. Accurate access to site information is crucial for landscape architects.

Remote sensing images and data are important carriers of site information. Since satellite remote sensing and GIS (Geographic Information System) technologies have been widely used in the landscape field for decades, various satellite images and open source data have become one of the most important ways for landscape architects to obtain on-site information. However, the early satellite remote sensing images were limited by the resolution and revisit period (for example, Landsat data spatial resolution 30m, access period 18d), it is difficult to meet the needs of small and medium-scale landscape design and research. In recent years, some large commercial companies have developed some new satellite sensors capable of acquiring high-resolution remote sensing image data within 10m, such as IKONOS, Quickbird, World View, Gaofen, etc. But these data cannot avoid cloud disturbances, especially in cloudy mountainous areas, and the acquisition cost is high.

UAVRS (UAV Remote Sensing) technology has the characteristics of high resolution, no period limitation, no influence

by clouds, so it has great potential in both commercial and scientific applications. In recent years, UAVs have appeared in the civilian field frequently. Some small and light UAVs have the advantages of flexible takeoff and landing, low operating costs, and being less affected by the weather. They are therefore widely used in many fields. For the application of UAV remote sensing technology in various industries, the predecessors have carried out many reviews: such as Colomina et al. [2] reviewed the application of UAVs in surveying and mapping; Zhiming et al. [3] reviewed the application of UAVs in landscape ecology; Jiaojiao et al. [4] reviewed the application of UAVs in urban planning; Zhang et al. [5] reviewed the application of UAVs in agriculture. Although UAVRS technology has a certain application in landscape architecture, it is relatively less mature than the above industries. The author combines his own practical experience to introduce and summarize the application of UAV in landscape architecture.

2. UAVRSS (UAV Remote Sensing System)

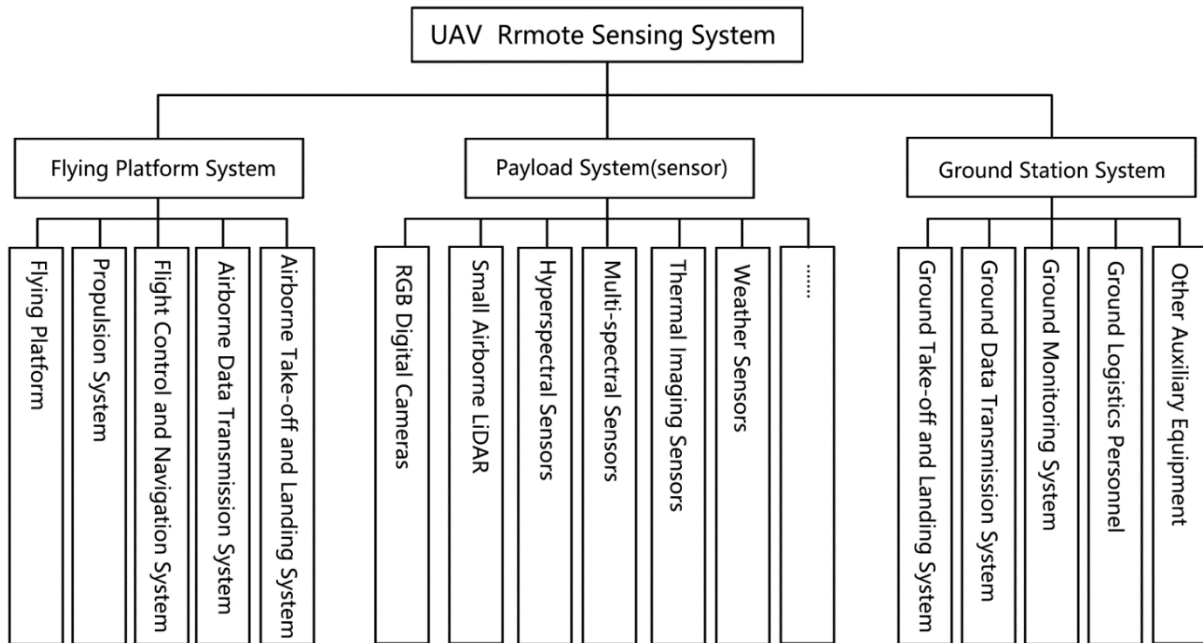


Fig. 1. Components of UAVRSS.

UAVRSS is an aerial photogrammetry system that uses UAV as a platform, loads various sensors as a payload, and flies at a height of several kilometers (military up to 10km or more) to obtain remote sensing images, video, and other data. [6] At present, mature and complete civilian UAVSS is mainly composed of three parts: flight platform system, payload system, and ground station system. (Fig. 1)

2.1. Common UAV types

There are many types of civilian UAVs on the market and there is no uniform classification standard. They can be divided into multiple types in terms of power, usage, control method, structure, range, and aircraft weight. For example, according to the structure can be divided into fixed-wing UAVs, rotor UAVs, unmanned helicopters; according to the weight of the aircraft can be divided into micro, small, medium, large UAVs; according to the control mode can be

divided into radio controlled UAVs, pre-programmed controlled UAVs, radio and programming mixed controlled UAV. [6] At present, small and micro-unmanned UAVs are most popular in the landscape industry. Small rotor UAVs are most commonly used with great distinctive feature of achieving target hovering and being suitable for small and medium-sized site information acquisition; Followed by is small fixed-wing UAVs , its flight range is generally within a few kilometers, faster than the rotor UAVs, longer flight time, often used for large-scale site information acquisition.

2.2. Common sensor types

The UAV is a flying platform, which can meet the needs of different tasks in various industries through combination with different types of cameras and sensors, and achieve very convenient and practical observation of the ground. Such as RGB digital cameras, small airborne LiDAR

(Light Detection And Ranging), hyperspectral sensors, multi-spectral sensors, thermal imaging sensors. (Table. 1)

accomplished by UAVs, and it is mainly used to acquire centimeter-level ultra-high resolution orthophoto maps and establish 3D models in landscape architecture.

3. Application of UAVRS Technology in Landscape Architecture

3.1. Application of UAV Aerial Photography in Landscape

Table. 1. Products of common sensors and their landscape applications

Types of sensors	Information obtained	processing software	Products	Landscape application
Single-lens RGB digital cameras	Single-angle photos, videos	Pix4D mapper, Smart 3D, ...	Aerial view photo, videos DEM, DSM, DOM	Current land use analysis, Elevation analysis, terrain analysis, plant identification, landscape evaluation
Multi-lens RGB digital cameras	Multi-angle photos, videos	Pix4D mapper, Smart 3D, ...	Real-Time 3D Model Aerial view photo, videos DEM, DSM, DOM	3D Digital Modeling, Simulated sunshine analysis, Sight analysis, Simulated hydrological analysis, 3D green volume calculation
Small airborne LiDAR	Point cloud	TerraSolid, ENVI LiDAR, ...	DEM, DSM, 3D Model	3D Digital Modeling, Elevation analysis, terrain analysis, Forest information extraction
Hyperspectral sensors	Full spectrum information	ENVI erdas	Hyperspectral image	Plant pest monitoring, Leaf trait index, Plant nitrogen content
Multi-spectral sensors	Multi-spectral information	ENVI erdas	Multi-spectral image	Plant pest monitoring, Plant invasion
Thermal imaging sensors	Temperature information	Pix4D mapper, Smart 3D, ...	Temperature image, Heat map	Urban Microclimate Analysis, Thermal emission monitoring, Plant leaf temperature

The application of UAVRS in landscape architecture can be roughly divided into two aspects: UAV aerial photography and UAV aerial photogrammetry. The UAV aerial photography is the simplest and most common application of UAVs. It just uses UAVs to take ordinary photos and videos without remote sensing image processing. The UAV aerial photogrammetry is more sophisticated than the aerial photography. It is essentially a surveying mission

The UAV aerial photography only performs primary operations such as photographing and video recording. The products are relatively simple, only ordinary photos and videos. In terms of flying platforms, consumer-level rotor UAVs are mainly used, such as the DJI quadrotor small UAVs, Phantom series and Mavic series; In terms of sensors, only the most basic single-lens digital cameras can meet the needs; In terms of ground station, use the radio remote

control as a control platform, randomly formulating route flight.

3.1.1 Get Aerial View Photos

Currently, the most used application is to take aerial view photos and videos. The aerial view provides information that is not visible from the conventional perspective. Most of the traditional site surveys rely on hand-held cameras to record the site information with single photo, which only presents partial scenes. UAVs can be used to take aerial photographs and videos of the site, so that landscape architects can more comprehensively obtain site information for



Fig. 2. Analysis based on aerial photographs.

analysis. (Fig. 2) After project completed, photos and videos from aerial view are also very useful for project display and promotion. Many government projects use UAVs to film videos.

3.1.2 Construction Management Supervision

In the digital management of architecture or landscape engineering, UAVs play the role of project managers' eyes in project supervision. Through UAV aerial photography, project progress information can be acquired intuitively, comprehensively, and in real time, which is an indispensable tool to realize building information management and intelligent building. (Fig. 3)

3.2. Application of UAV Aerial Photogrammetry in Landscape

UAV aerial photogrammetry is a true sense of UAVRS technology with more sophisticated application method, cause its relatively complicated operation and difficult to master, and involving knowledge and technologies of Surveying, Remote Sensing, GIS and other multi-disciplinary. In terms of flying platforms, due to the more



Fig. 3. Construction management supervision by UAV.

diverse and complex sensors that are required to be deployed, higher requirements have been placed on the load and stability of the flying platform. Professional-level six-rotor UAVs, eight-rotor UAVs, fixed-wing UAVs and the likes are the most commonly used; In terms of sensors, multi-lens sensors are commonly used, such as five-lens digital cameras; In terms of ground station, aerial photogrammetry needs to completely cover the target area and requires a certain image overlap rate. Therefore, it is necessary to pre-program the route design so that UAVs can autonomously fly according to the instructions, or they can use flight control software such as Pix4Dcapture, Altizure and other auxiliary route design software.

3.2.1 DOM and Its Application in Landscape

The DOM (Digital Orthophoto Map) is a remote sensing image with orthographic projection properties. It is an image data generated by correcting, mosaicking, and cutting aerial photographs or remote sensing images with DEM (Digital Elevation

specialized software to obtain DOM. Common UAVRS image rapid processing software includes: Bentley Context Capture (Smart 3D), Pix4Dmapper, ERDAS-LPS, Altizure, Datumate, Inpho, etc. The most commonly used software such as the Swiss



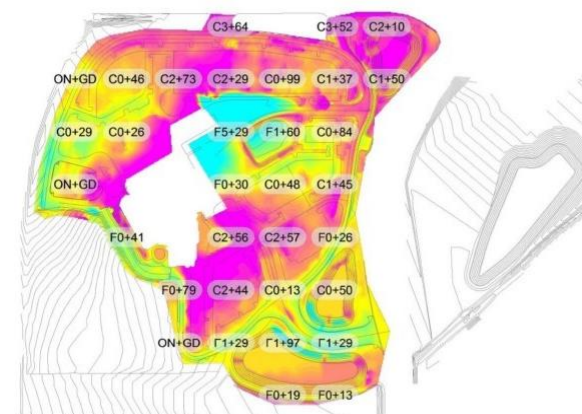
Fig. 4. DOM produced by UAV aerial photogrammetry

Model), and It is a kind of map with both the geometric accuracy and image features. The resolution of DOM is generally between 1cm to 5cm, which is much higher than the resolution of satellite remote sensing images. Simply put, the DOM produced by UAV aerial photogrammetry can be regarded as an ultra-high-resolution satellite image. (Fig. 4) UAVs can produce DOMs with ordinary digital cameras. The principle is simple, firstly, using UAV to fly according to programmed routes and take photos, secondly, using the coordinate data of some control points and the POS (Position and Orientation System) data of the UAV for aerial triangulation to get DEM, finally, orthophoto correction and mosaic cutting were performed on the photos with DEM to obtain DOM image data.

Remote-sensing image data acquired by UAVs is automatically processed by

Pix4D series includes Pix4Dcapture, Pix4Dmapper, and Pix4Dcloud. Pix4Dcapture can be downloaded to terminals such as mobile phones and tablets to connect UAVs for route planning; Pix4Dmapper can quickly analyze and process thousands of image data and automatically generate corresponding high-precision 2D image or 3D model data; [7] Pix4Dcloud can upload image data to the cloud, eliminating the user's concern about the lack of performance of the local computer.

After Pix4D processes the original



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 Fig. 5. Overlay of the construction DEM and the design DEM.

photographs taken by the UAV, the DEM, DSM (Digital Surface Model), and DOM can be generated. DEM data is widely used in the preliminary analysis of landscape planning and design, and its importance does not need to be described in detail. DSM is based on DEM and includes elevations such as ground buildings, bridges, and trees. It is mainly used in areas that require analysis of building height and trees cover. For example, the DSM captured by a UAV can record the changes in the amount of earthwork in different construction phases in real time, and guide the shaping of the terrain more precisely and economically. By overlaying the DEM at the construction site with the design DEM, the difference between the construction and the design can be more accurately reflected. For example, the green area in Figure 5 indicates that the construction elevation is in accordance with the design elevation; The bluish region indicates that the design elevation is lower, and the reddish region indicates that it is higher than the design elevation. The construction managers can appropriately adjust the construction according to this map to make it more in line with the design.

The biggest feature of the DOM is that it is no longer limited by the spatial resolution of traditional satellite remote sensing data, and its centimeter-level ultra-high resolution meets the needs of landscape architects for site analysis and research. Using DOM can even achieve a certain degree of recognition of plant species. Mora

et al. [8] used the DOM images acquired by UAV to perform vegetation identification and mapping on the river impact fan area in Adventdalen. The results showed that at the species level, Gramineae, Salix and some bryophytes could not be distinguished, but it can be well separated from other land cover; Di Chen et al. [9] based on high-resolution DOM images taken by UAV to extract the location and crown of the trees, using the 3D tree-crown volume formula calculates the 3D green volume of different trees and achieves a quantitative analysis of 3D green volume. Ting Liang et al. [10] used UAV data to extract orthophotos, water quality parameters, physical and chemical indicators of water and land use types, and assessed the health of river ecosystems in the mainstream of the Liaohe river nature reserve.

3.2.2 UAV Oblique Photogrammetry and Its Application in Landscape

UAV oblique photogrammetry is currently an emerging aeronautical photogrammetry technology, which has changed the limitations of previous aerial photogrammetry can only be taken from the vertical direction, the essence of which is to carry multiple sensors on the same flying platform, (Fig. 6) and photographing the ground objects from multiple angles (vertical and oblique angles). [11] At present, the UAV oblique photogrammetry technology is mainly used for real-time 3D modeling in a landscape.

Establishing a real-time 3D model with high accuracy requires a multi-lens digital camera (single-lens cameras can also perform oblique photography with a low degree of accuracy through surround



Fig. 6. The flying platform for oblique photography.

photography). The larger the number of lenses, the higher the accuracy of the model. Commonly seen in the market is a five-lens digital camera. As shown in Figure 7, the lens in the center can be shot vertically downwards to acquire DOM data, and the four-lens shots can be taken from four directions to acquire ground images at multiple angles. The UAV oblique photography takes a dedicated route. To establish a three-dimensional real model, the overlapping degree of the lateral direction needs to reach more than 50%, and the degree of heading overlap needs to reach more than 70%. The route planning can also be accomplished by software such as Pix4Dcapture.

The remote sensing image data processing for generating the real-time 3D model is also using software such as Smart

3D, Pix4Dmapper, etc. The principle is to perform aerial triangulation operation based on the control point coordinates and POS data, and then generate a point cloud data to build model. Take Smart 3D as an example.



Fig. 7. Five-lens digital camera for oblique photography.

This is an almost fully automatic 3D modeling software. You only need to prepare the multi-angle oblique photos, POS data and control point coordinates, and the software can automatically perform aerial triangulation calculation to generate dense point cloud data. Finally, it completes model mapping to generate a real-time 3D model. The 3D model made by oblique photography can measure the actual space distance of any two points, the actual surface area of any area and the actual volume of any object in the model. It is a truly digital sand table and can play an important role in landscape planning, design and research. (Fig. 8)

Jiazhong et al. [12] used the UAV oblique photography technology to establish a real-time 3D model of the design site through Smart 3D, and the model was

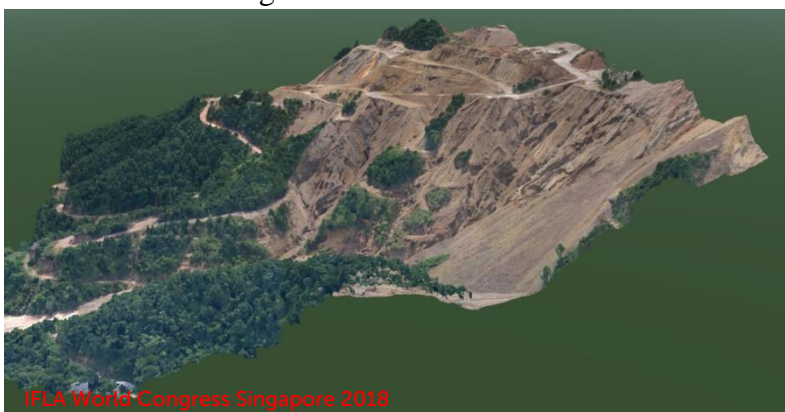


Fig. 8. A measurable real-time 3D model.

used to perform sunshine analysis, visual line analysis, and profile analysis of the site simulation. Finally, the design is displayed on the basis of the real-time 3D model, which truly shows the effect of the design plan. Wei Wang et al. [13] used the UAV aerial photogrammetry to acquire the DOM and the real-world 3D model of the site, and according to these digital model simulations, the hydrological analysis was conducted to obtain the catchment area and use it as a basis for flood prevention landscape design. Qingping et al. [14] used UAV oblique photogrammetry technology and Ground LiDAR to establish a real-time 3D model of Suzhou Suiyuan, and studied the application of digital mapping technology in Chinese classical gardens.

3.2.3 Application of Other UAV Airborne Sensors in Landscape

In addition to visible light digital cameras, small airborne LiDAR, hyperspectral sensors, multi-spectral sensors, thermal imaging sensors are also useful in landscapes.

LiDAR can obtain ultra-high-density point cloud data and complete more accurate DEM, DSM, and 3D models than RGB digital camera photogrammetry. However, due to the high cost, there are fewer applications in the landscape industry. Wallace [15] used LiDAR-equipped UAV to obtain point cloud data and DSM from the study area, and processed point cloud data to obtain information such as tree position, canopy, and canopy traits in the study area. Hyperspectral sensors and multi-spectral sensors can collect invisible spectral information. These information can indirectly reflect some of the physiological functions of plants, and can be used to analyze and study the spatial patterns of garden plant physiological characteristics and pests and diseases. Gen sheng et al. [16]

used visible light and near-infrared images acquired by UAVs to realize the identification of pines and trees by using weighted support vector data description and other multi-classification algorithms, and to study the spatial distribution pattern characteristics of pests and pine trees. Compared with traditional manual survey or aerial satellite image recognition, it has the advantages of low cost and high operability. The thermal imaging sensors can obtain the surface temperature map. Nishar et al. [17] tried to use UAVs equipped with thermal imaging sensor and RGB digital camera to obtain image information and thermal information for monitoring the surface temperature of the environment. Zarco-Tejada et al. [18] used the thermal imaging camera and hyperspectral camera mounted on the UAV to monitor the citrus orchard and obtained the crown temperature, the optical index of leaves and the chlorophyll fluorescence index, also made correlation analysis combined with data of the leaf stomatal conductance, moisture, etc. Finally, these physiological characteristics data were reflected in the spatial temperature map.

4. Conclusions

UAVs can be equipped with a variety of sensors, so it is possible to obtain low-altitude aerial remote sensing data of various types, high timeliness, high space, and high resolution, especially numerous aerial orthophotos, radar images, and hyperspectral image data. However, these aerial images of UAV have problems such as large data volume, high degree of overlap, large directional variation, and influence of terrain and UAV flight stance, which brings great challenges to data processing and interpretation of UAV remote sensing images. However, these will inevitably

promote rapid development of UAV remote sensing data processing, interpretation and analysis.

At present, the sensors carried by UAVs are mainly RGB digital cameras in the landscape industry, while the use of other types of sensors is less, bringing great potentials. For example, UAVs equipped with multiple sensors can be widely used in urban landscape unit extraction, urban heat island effect monitoring, urban microclimate measurement, city pattern change and landscape evaluation. The use of UAVs in landscape architecture started relatively late, and overall it is still at a relatively elementary stage of application. However, with the progress of digitalization and the construction of “smart cities”, the application of UAV remote sensing technology in landscape will have more possibilities.

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Geodesign tools to support “Design with Nature” in urban design: A case study of Hutchinson Island in Savannah, Georgia, USA¹

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Abstract

Ian McHarg introduced the polygon overlay operation to landscape planning in *Design with Nature* (1969). Since then, combining spatial information geographically with overlaid composite maps has become an essential method for multidisciplinary analysis in spatial planning and design. Recently, with the rapid development of computer technology applied to them, Geodesign tools are considered as promising support for more ecological landscape planning and design, especially in data-rich environments such as America. This Paper uses Hutchinson island in Savannah, Georgia, the USA as a research context to illustrate how the use of Geodesign tools in landscape planning and urban design could support decision-making for ecologically compatible solutions, mainly from following three perspectives: 1. Application of Geographic Information System(GIS) to hazard mapping helps to visualize the affected areas of flooding and surge due to climate change; 2. GIS and related visual media enable a better understanding of Savannah’s world-renown historic urban fabric for the future urban development; 3. Analyses using Geodesign tools help urban development foster solutions to or otherwise solve environmental problems that will come with urban expansion including SHEP(the Savannah Harbor Expansion Project).

Keywords: Geodesign; Spatial Planning; Visualization

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1. Introduction

In 1969, *Design with Nature* by Ian McHarg was published and gained an excellent reputation for the ecological view it promoted in the design profession. Based on McHarg's cross-disciplinary practice and critical inheritance of the arguments from earlier environmentalism [1], *Design with Nature* contributed systematic ecological analysis and design principles to landscape planning and design. These principles initially assisted landscape architects in getting complex geographic information layered and combined for the development of ecologically compatible solutions, and its influence soon went beyond landscape field to all spatial planning and design professions [2]. McHarg's theory which advocates multidisciplinary cooperation adopts and refines research methods from all related fields, creating a working framework to ensure the core value of ecological planning, "integration, synthesis and evaluation" [4]. The most renowned "layer-cake" method in the book formed the basis of Geographic Information System and other Geodesign tools that derive from it. Correspondingly, Geodesign tools ensure the possibility to achieve the goal of "Designing with Nature".

There are mainly two different views about the definition of Geodesign. Some are biased to seeing Geodesign just as a planning and design method that could couple the design proposals with impact simulations informed by geographic context¹.

Carl Steinitz of Harvard University regarded Geodesign as an operation method that intervenes surrounding geographic context for human's desired uses by "changing geography with design"[5]. Others consider Geodesign as a technical framework that integrates different geographic information to provide real-time analysis and feedback for synergistic spatial design. "Geodesign brings geographic analysis into the design process in which initial sketches are instantly vetted for suitability". This on-the-fly analysis equip the land use planners, civil engineers, transportation planners, and other involved practitioners with a tool to leverage geographic information in their design workflows"[6]. The latter opinion highlights the dynamic feedback between geographic analysis and design. Despite different perspectives, these two views both emphasize the crucial role of Geodesign in connecting spatial design with geographic information technology.

Urban design is the process of designing and shaping cities, towns and villages. It considers problems beyond individual buildings, dealing with groups of objects at a larger scale to make the urban environment more functional, exquisite and sustainable². Mumford regarded urban design as an effort of combining art and science[7]. Indeed, urban design involves analysis from different professions shaping urban form to elaborate as richly and as coherently with the lived experience of the inhabitants[8]. In this regard, the advantage of Geodesign that enables cross-disciplinary collaboration

1. M. Flaxman, the Geodesign Summit, Redlands, CA, 2010.

2. https://en.wikipedia.org/wiki/Urban_design

could be made the most of in urban design workflow.

This paper illustrates the contributions of Geodesign to urban design in a data-rich environment through the study of Hutchinson Island in Savannah, Georgia, USA. The study is based on the urban design studio instructed by associate professor Douglas Pardue at the College of Environment and Design, the University of Georgia and is further conducted using updated open public data.

2. Towards “Design with Nature”

2.1. *Design with Nature*

In *Design with Nature*, McHarg demonstrated that living environment in the context of industrialization was no longer as natural as it used to be, there is a conflict between the modern production methods and the natural environment. He insisted that instead of separating themselves from the natural world, humans must coordinate with it.

Virtually, in ancient times, human ancestors chose their settlements, most of which were adjacent to a river, according to their evaluation of the surrounding geographic environment. Since then, human learned to remake nature for subsistence resources and live in harmony with nature for sustainability. This is the initial version of the practice of designing with nature.

McHarg built his theory on ecological science and developed a set of design frameworks, drawing people’s attention back to the ecological wisdom that human has long used. Apart from just focusing on form, function and aesthetics, he advocated

more notice to ecological security, living environment and the balance between development and nature.[9].

2.2. *The Geodesign Framework*

Geodesign innovated the tools and workflow of spatial planning and design. The most widely recognized framework for Geodesign was the “four groups of people”- “six models”- “three loops” one put forward by Carl Steinitz. (Fig. 1.)

Among “four groups of people”, people of the place mainly play two essential roles of presenting design intents and reviewing the impact of design proposals. Scientist group includes both natural and social scientists, such as geographers, ecologists, economists, sociologists. Design professionals refer to experts from subjects such as urban planning, urban design, landscape architecture and architecture. People of information technologies focus on dealing with information processing and application of GIS.

The “six models” clarify six main tasks of Geodesign. Specifically, in representation models, the context should be described from dimensions of both time and space. In the following process models, the structure and functional relationships of inter-elements should be observed. The evaluate models assess the current situation of the study area to help determine, in the fourth model (change model), what policies or actions need to be taken for the changes at which time or which place. Afterward, impacts that resulted from changes mentioned above would be simulated and given to people of the place for decision-making in the last two models (impact models and decision models). The “four

groups of people” have their own tasks accomplished in corresponding steps of “six models”.

The "three loops" is virtually the workflow of “six models”. Firstly, the top-down loop, from the representation model to the decision model, explains why the study should be conducted. Secondly, the bottom-up reverse loop, from the decision model to the representation model, demonstrates how to carry out this study. Finally, another top-down loop determines what, when and where to study. “Three loops” makes the dynamic feedbacks between geographic analysis and design possible. Upon the accomplishment of all three loops, a compatible proposal could be made [5].

Compared to McHarg's theory that promotes multidisciplinary collaboration merely by using overlay operation, Steinitz's framework is a decision-oriented and multi-resolution design workflow that could propose and evaluate different scenarios for the particular context and the results are optimization outcomes. Although the framework is based on landscape design theory, it could be applied to all spatial planning and design professions for its technology-independence.

3. The Hutchinson Island(Savannah) Case

3.1. Background

The city of Savannah is located in Chatham County on the eastern coast of the State of Georgia. It used to be a strategic port city in the American Revolution and during the American Civil War. Today, the port of Savannah is one of the busiest

containerization cargo ports in the world which, to a certain extent, contributes to Savannah's status as a regional industrial center¹. Apart from the port, the historic district in Savannah enjoys a same excellent reputation. It attracts millions of tourists from all over the nation and the world.

Hutchinson Island lies in the middle of the Savannah River and is at a distance of about 800 feet (240 meters) across from historic Savannah. Until recently, most parts of the island were vacant land. The undergoing urban development proposed a major mixed-use project which contains the Westin Savannah Harbor Resort, the Savannah International Convention Center and some retail and residential properties.

There is a massive project, the Savannah Harbor Expansion Project (SHEP), on the Savannah River in the city administrated by the US Army. SHEP needs to regularly deepen the harbor and the associated shipping channel to allow larger, more efficient container vessels to use the East Coast's second busiest container harbor with less weight and tidal restrictions². The project has been a significant part of the city's development and has dramatic impacts on both economy and ecology of Savannah city and Hutchinson Island annually.

3.2. Methods

The study on the Hutchinson Island mainly followed the workflow of “six

1. en.wikipedia.org/wiki/Savannah_Georgia

2. www.sas.usace.army.mil

models” in Steinitz’s framework for Geodesign.

In the representation model, the primary focus was to build a database that could be operated and analyzed to help form a comprehensive description of the island. Data from online resources such as SAGIS (Savannah Area Geographic Information System) and site survey were gathered in terms of a wide range of aspects including ecology, geographic, economics and history.

In the process model, a series of mapping operations were conducted to examine the urban systems initially at regional and urban scales, then zooming in, to the island scale. By overlay (vector-based) and algebra (raster-based), data regarding different disciplines from the first model was integrated and illustrated on maps to demonstrate how different urban systems operate. (Fig. 2.)

Setting up indicators for assessments was the main focus of the evaluation model. The evaluation phase involved the “four groups of people”. Site visits enabled adequate interviews and communications with “people of the place” which helped understand design issues and objectives. Discussions with professionals from scientists and information technology experts defined the metrics, analysis methods and a set of common values. Conclusions for this stage could be summarized as follows:

(1) Design objectives:

- a) To overcome the flooding problem on the island for appropriate urban development;
- b) To bring popularity and dense to Hutchinson Island;

- c) To find a wise way to deal with dredge from the SHEP.

(2) Common values:

- a) New development on the island should worship the urban pattern of Savannah historic district;
- b) Dispersed SCAD (Savannah College of Art and Design) campus in downtown area fostering innovation industry is a valuable experience for urbanity;
- c) Natural process and ecological benefits should be maintained despite the urban expansion.

In the second half of Steinitz’s “six models”, the question of how the context could be altered in the change model virtually refers to “design” in the ordinary sense of the word. The main purpose of this model is to propose different scenarios of the site for tests in the impact model, tests are based on the relevant indicators and common values in the evaluation model. Finally, in the decision model optimization outcomes are supposed to be produced and presented.

In the Savannah case, some modification was made to change model and impact model according to the findings in the first three models. The study integrated evaluation process of the impact model into the change model. As mentioned above, the design intents and related constraints are mostly related to flooding and ecological conditions. Specifically, the general goal is to foster urban development (with the succession of old urban fabric) in flood-free areas on the island and protect the eco-environment at the same time.

Technically, simulation of ecological benefits on the island was classified with

Geodesign tools (mainly GIS) and was marked in different colors along with the affected area of flooding on the maps. These instrumental mappings were later used as a guide in the change model to help alter the context for a suitable medium between urban development and natural environment. In this case, the outputs fulfilled the evaluation measurements in the impact model and could be directly delivered for decision-making.

3.3. Analysis

In the integrated evaluation-change model, three analysis methods (based on Geodesign tools) were adopted as follows:

3.3.1 Hazard Mapping

Geodesign tools, such as GIS, have been employed in hydrological analyses for many years. Notably, the application of GIS to flood disaster management has drawn worldwide attention. The integration of hydrological data and spatial analysis in GIS makes it a powerful analytical tool for flood risk assessment, which could significantly improve the accuracy and efficiency of evaluation and prediction. From the 1950s, America began mapping the flood hazard national-widely, till the beginning of this century, the National Flood Insurance Program (NFIP) had made more than 90,000 flood hazard maps, covering about 19,000 communities, 389,000 square kilometers of the floodplain¹. Japan started the job in the year of 1995, after decades of effort, flood hazard maps of more than 180 rivers have been completed. England and Wales have published the 1:50000 scale flood hazard

map by the United Kingdom Environment Agency and established a Web-GIS based flood management system on the official website[10].(Fig. 3)

Geographically, Savannah lies on the Savannah River, approximately 20 mi (32 km) upriver from the Atlantic Ocean. Because of its location in the Georgia Bight (the arc of the Atlantic coastline in Georgia and northern Florida) along with the tendency for hurricanes to recurve up the coast, Savannah is prone to flooding. Five canals and several pumping stations have been built to help reduce the effects². The most recent Hurricane Irma passing by the city in 2017, with no exception, brought heavy rainfall and flooded parts of the city. Specifically, low-land topography on Hutchinson Island makes it barely possible to survive through flood and surge³.

According to the general geographic condition, the overarching task of urban design on Hutchinson Island is to recognize the potential hazard zone. This study took two main factors would affect the flooding risk on the island into account, topography and water system. With DEM data, the standard deviation of elevation could be calculated in GIS. A larger impact value was assigned to a certain point if the elevation was lower and the standard deviation of elevation was smaller, which means it is more likely to get flooded. The impact of the water system was represented by drainage density index. By integrated analysis of

1. Federal Emergency Management Agency

2. Georgiainfo.galileo.usg.edu

3. www.savannahnow.com

spatial and attribute data, the flood hazard map was produced. (Fig. 4.)

3.3.2 *Landscape Ecological Security Pattern*

In 1995, inspired by the traditional Chinese Game “Go”, Chinese scholar Kongjian Yu proposed the theory of landscape ecological security pattern. He illustrates that landscape elements in different forms of point, line and area play different roles in natural processes. The portion and location of these landscape forms are also significant to natural processes. The spatial pattern composed of different landscape elements in a certain proportion and location is called landscape ecological security pattern, which typically includes five parts: source, buffer, corridor, radiation and node. By identifying, establishing and protecting it, the natural process of the context could be efficiently maintained and the ecological benefits could be conserved [11].

The theory of landscape security pattern has been applied to guide landscape planning in numbers of cases, such as Yu KongJian’s practices of Magang Village in Guangdong and Xiangshan Ski Resort in Beijing. These two projects succeed in maintaining the natural process while providing more building land, which was of great meaning with limited availability of land in rapid urbanization [12]-[13].

Based on the research of ecological environment on Hutchinson Island, this study regarded the wetlands and lakes as essential ecological “sources”. Afterward, buffer zones were then identified and were divided into high, medium and low landscape security, according to the distance from the sources. The wider buffer zones

are, the higher landscape ecological security would be achieved. Similarly, with integrated analysis method in GIS, the landscape ecological security was simulated and mapped. (Fig. 5.)

3.3.3 *Space Syntax*

The application of space syntax to street network analysis enables a comparatively scientific understanding of the urban fabric. It simulates and predicts the flow of people and traffic by calculating the relevant characteristic variables and extracts the axes of the street network for the analysis of road accessibility. [14].

Savannah’s world-renown historic fabric consists of twenty-four wards that extended from the riverfront under the supervision of James E. Oglethorpe. The unique fabric makes significant use of the squares to create series of rhythmically placed open space, giving a wonderful sense of space in a solidly built townscape[15]. Its vestiges could be found even in contemporary planning. *Savannah East Riverfront Extension*, the winning project of 2010 Honor Awards for Regional and Urban Design, traced the history of the city, seeking experience and wisdom from the past. It transformed the old urban fabric into urban development that meets new social needs[16]. (Fig. 6., Fig. 7.)

Under the assistance of GIS, a space syntax analysis on the street network of Savannah historic district was conducted in terms of accessibility and stability for a better understanding of the Oglethorpe’s urban fabric. The old fabric’s value was proved again from a scientific view. Thus, the study convinced the future urban development to evolve the old urban

development wisdom for today's new needs on the island. (Fig. 8.)

3.3.4 Results

With the application of Geodesign tools, following urban design strategies for Hutchinson island were developed:

(1) Productive Dredging

The dredge from SHEP is now being deposited on the South Carolina side of Savannah River, which is costly and time demanding. This study proposed to use dredge from the SHEP to raise the elevation of some flooding parts of the island for a synergy of the harbor expansion and flood disaster management. Under the guidance of flood hazard map and landscape ecological security pattern, areas to be lifted up were selected among high eco-security and low flood risk zones.

(2) Urban Ecological Matrix

To enlarge ecological benefits and to higher the landscape security pattern. The new urban fabric was developed by connecting spotted squares of old urban fabric into corridors. Again, these green corridors were arranged along with the landscape ecological security pattern on the island. (Fig. 9.)

(3) SCAD Eco-Campus

The "Spot-Line-Area" developing mode of SCAD campus in downtown Savannah has been proved to be a success in bringing innovation industry along with urban vitality to the city. This study proposed a strategy to conserve and enhance the "source" elements of the landscape ecological security pattern on the island by building eco-campuses around them. Eco-campuses could enable development with low environmental impacts, which would help achieve a balance between ecological benefits and

urban development. Plus, the SCAD's potential in bringing urbanity to the isolated island would help the undergoing development get out of the struggle of attracting people from the other side of the river. (Fig. 10.)

4. Discussion

As illustrated in the Savannah case, Geodesign tools applied in urban design helped recognize values or risks scientifically by quantitative analysis. However, when it comes to issues that cannot be easily quantized such as urban vitality, urban aesthetics, and social fairness, conclusions were mainly made based on designers' experience and intuition.

In other words, under the framework for Geodesign, it would not be a big challenge for practitioners to achieve an ENVIRONMENTALLY NATURAL solution because most of the environmental analyses are based on quantitative features. However, to foster design solutions that should meet HUMAN NATURE needs better, designers need to establish comprehensive analysis-evaluation systems by quantizing intangible features, which calls for further inter-disciplinary collaboration in the future.

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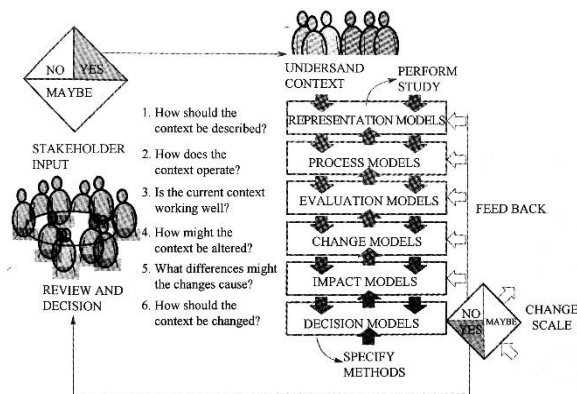


Fig. 1. Framework for Geodesign (Steinitz, *A Framework for Geodesign*, 2012)

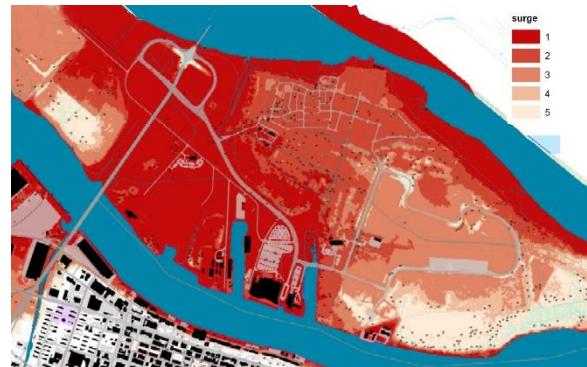


Fig.4. Flood Hazard Map of Hutchinson Island (Pardue, the UGA urban design studio)

Appendix



Fig.3. Flood Insurance Rate Maps (FIRM) (www.savannahga.gov)



Fig.5. Landscape Security Pattern of the island (by authors)

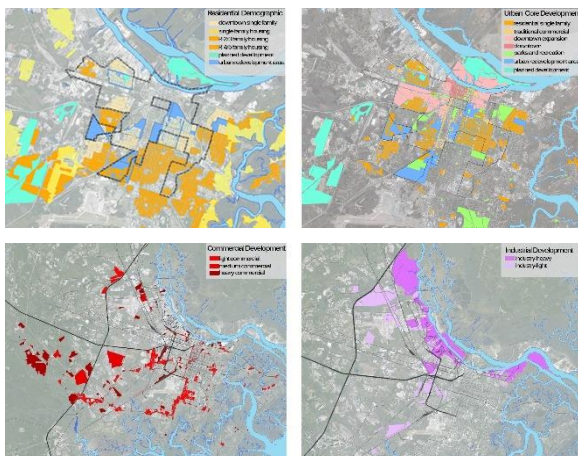


Fig. 2. Mappings illustrating different systems (By authors)

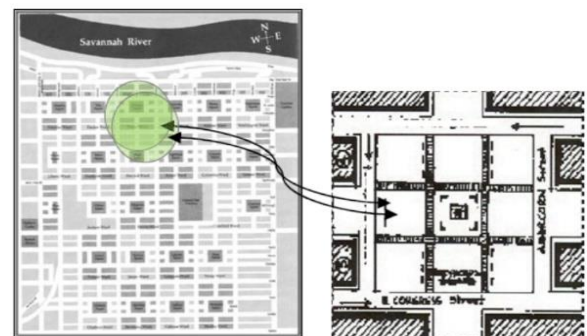


Fig.6. Oglethorpe's urban fabric and "wards" (E. Aga, *WIT Transactions on Ecology and the Environment*, 2010)

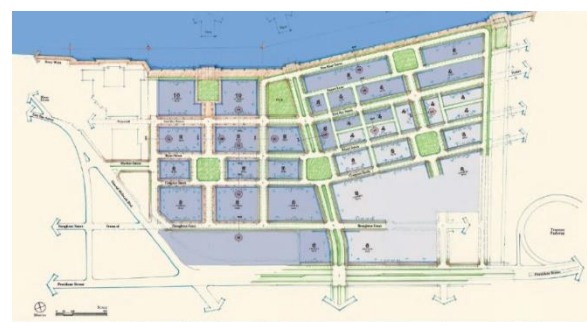


Fig.7. Savannah East Riverfront Extension (Sottile & Sottile, *Int. New Landscapes*, 2013)



Fig.8. Segment analysis of historic Savannah
(by authors)



Fig.9. Ecological Corridor
(by authors)

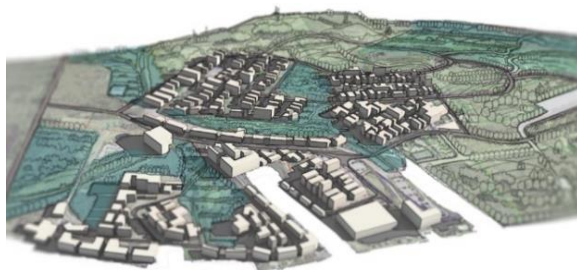


Fig.10. Hutchison Scenario
(by authors)

Transforming Data to Information:

Multi-Source Data Fusion with Landscape Information Modeling in Landscape Design Project

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Abstract

The advancement of data-driven design and construction process is reflected in the increasing importance of BIM in the whole AEC industry. In this context the landscape design professional practice is turning into a digitalized environment as well. The central element of such digital environment is an intelligent virtual model, which holds both the information of the existing conditions and the proposed project deliveries. The virtual model is built on various data sources, including satellite remote sensing, photogrammetry and LiDAR scanning. It contains also parametric 3d-models from different disciplines and their specialized software. Data of different sources reveals different features of the object. However, the lack of coordination and synthesize among data brings obstacles to operate an integrated modeling and analysis. The increased amount of data doesn't necessarily bring efficient information. To adapt to the digitalized working context with the variety of data, it is important for landscape design practice to achieve an integrated information operation. Under such background, it turns to be important research topic to develop technological approaches that produce multi-source data fusion for landscape design process. In this paper, such approaches is realized with a workflow of data processing in a Landscape Information Modeling (LIM). The workflow defines the approaches to achieve multi-source data processing for a project with the regards of the scale of site, the purpose of the analysis, the stage of the project's lifecycle. The outcome of the workflow is a 3D LIM model carrying the information that the project needs for analysis, design, documentation and performance analysis. The project of Jade Well Park in Pingtan, Fujian Province, China, serves as an empirical research case for this paper, in which a 3D LIM model is built with the fusion of various data sources. For the landscape design, the model provides information to support grading analysis, watershed analysis, wind protection performing analysis as well as the calculation of material quantity and design proposal visualization.

Keywords: Landscape Architecture, Landscape Design, Workflow, Landscape Information Modeling, Photogrammetry

1. Introduction

In the architecture engineering construction (AEC) industry, the advancement of data-driven design and construction process is reflected in the increasing importance of BIM (Building Information Model). In such context the landscape design professional practice is turning into a digitalized environment, as well. Digital design practice refers beside BIM or LIM (Landscape Information Modeling) also to algorithm based parametric modeling, simulation for comprehensive understanding of effects and performance of the design as well as for digital fabrication, for example 3D machine control systems for grading.^[1]

The central element of these forms of digital practice is an intelligent virtual model. This model holds the information of the existing conditions as well as the proposed design and project deliveries and planning documents as well as the data for machine control.

Such virtual model is built on various data sources. For the existing conditions and their analysis, data sources including that from satellite remote sensing, photogrammetry, LIDAR scanning are becoming common inputs to landscape design projects, besides traditionally used maps and survey drawings. Through the design process, various new data, the most of which is in form of parametric 3D-models from different disciplines and their specialized software, get accumulated in the model.

The increased amount of data doesn't necessarily bring efficient information from which design process takes advantage. On one hand, data of different sources reveals different features and potentials of the site. On the other hand, it brings obstacles to operate an integrated modeling and analysis

when the coordination and synthesize among the various data is inadequate. Only when the fusion of data is achieved in a proper way, can the design process be optimized with information input.

To adapt to the digitalized working context with the variety of data, it is important for landscape design practice to achieve an integrated information operation. Under such background, it turns out to be important research topic to develop technological approaches that produce multi-source data fusion for landscape design process.

2. Objectives

Data selecting principles, data processing approaches and the fusion of multi-sources data are discussed and studied in this paper. They are of the objective to enable landscape architecture studios and institutes to work with Landscape Information Modeling Workflow (LIM Workflow) in the digitalized working context.

In the increasingly digitalized working context, when data driven practice is rapidly developing in AEC industry, landscape architects have to face the tasks of information operation in daily work. If the technological approaches of information operation are not developed and applied in landscape architecture profession, landscape architects have to turn to engineers or experts from other professions to accomplish their own daily work. Therefore, it is of great significance for landscape architects to master tools such as BIM.

Under current circumstance, there are still obstacles for landscape architects to fully adopt BIM tools.^[2] But, when it is with proper organizational management and cooperation, a workflow of information modeling for landscape architecture can be achieved by using a combination of BIM

and GIS software^[3], which is known as LIM. Most of these software are accessible and familiar for common landscape architecture studios and institutes.

LIM workflow does not only empower the landscape architects to collaborate with different disciplines, but also allow the landscape designers to directly operate with information within the design process.^[4]

The core of the LIM workflow is an intelligent virtual model within which data of different sources are stored, processed, shared and computed.^[5] To optimize the workflow for landscape architecture practice, it is necessary to standardize the process of operating the workflow in terms of data selecting, processing and the fusion of data.

3. Methods

3.1. Workflow-orientated data sources selection

Data sources selection defines the data input and influence the data proceeding of the LIM workflow. To form a standard workflow that every participant in the design process is able to exchange information in a interoperable manner, the data sources is to be selected and formulated as the first step. The increased data and information input from the ongoing design process need be considered also as type of data sources. And it should be selected in order to keep the dynamics of the workflow.

From the practical point of view, the selection of the data source is not only a matter of technology but also that of legality and efficiency.

As the design basis of a project, the fundamental data of the site should be approved by the authority or the authorized agency. The additional data input should be accessible either through the open source

channels or from the market with the reliable quality. The cost have to be considered. The conditions of hardware, software and the team's capability influence the process of data processing and computing. It is necessary to count in these conditions when deciding the selection of the data sources. Therefore, the selection of the data source follows the principles of legality, reliability, accessibility, cost-controllability as well as computability.

With the above principles, the following data sources may be options for a landscape design project.

Table 1 Contents of data sources

Data Category	Data Sources
Fundamental data	Topo-map Satellite map
Additional data	Satellite remote sensing data Surveys Photogrammetry model LiDAR
Computed data	Architecture and MEP Model Infrastructure model Planting plans Landscape improvement model Irrigation plan Landscape lighting plan

3.2. Standardization-regulated data process

The process how data from the source system are loaded in to the federated model is in Data warehousing commonly known as

ETL (Extract, Transform, Load) or ELT (Extract, Load, Transform). The transformation work in ETL takes place in a specialized engine, in ELT the transformation occurs in the target system. The Extract step covers the data extraction from the source system and makes it accessible for further processing. This can be initiated by the source system (push) or by destination system (pull) after an update notification.

In the Transformation stage, a series of rules or functions are applied to the extracted data in order to prepare it for loading into the end target. The data transformation that takes place usually involves various operations, such as filtering, encoding, deriving, de-duplicating, validating, joining and splitting data. An important function of transformation is the cleaning of data, which aims to pass only "proper" data to the target.

Plans, models and maps from different sources are often using different coordinate systems, therefore re-projection to an appropriate geographic coordinate system is an critical transformation in order to see elements in the context of landscape models.

The load phase process the data into the federated model, updating the model as well as archiving the previous model.

The following list gives an overview about major data sources of a landscape virtual model.

- a. Satellite remote sensing data (DEM) and satellite map
- b. Topo-Map
- c. Surveys
- d. Photogrammetry model and LiDAR data
- e. Architecture and MEP Model
- f. Infrastructure model
- g. Planting plans
- h. Landscape improvement model
- i. Irrigation plan
- j. Landscape lighting plan

For each data source, the following processing methods are regulated as a standardization.

- a. Re-projection from WGS84 to the national coordinate system for planning
- b. Reorganizing drawing elements into layers based on their GIS-Code;
 - Extracting height information (points, contours, break lines) for creating DEM (Digital Elevation Model) in a separated drawing;
 - Extracting building footprints, putting them to right elevation, translating number of floors to building height;
 - Extracting land use and vegetation information
- c. Merging survey information with the information from Topo-Map
- d. Geo-referencing the photogrammetry model by reference points from the Topo-Map;
 - Extracting DEM from DSM (Digital Surface Model, bare ground surface) by filtering out objects;
 - Merging with DEM from Topo-Map
- e. Geo-referencing the building based on shared reference point with coordinates;
 - Filtering to relevant parts of the model (outer hull, openings, entrances)
- f. Pass through information, no transformation needed
- g. Converting 2D to 3D elements, moving elements on to the graded surface;
 - Deriving plan surface from Final surface and planting soil thickness
- h. Converting models from legacy data formats to parametric models
- i. Connecting with MEP model
- j. Converting 2D to 3D elements with elevation information and projecting photometric maps to surface

Through such a standardized data processing procedure, the following information can be harvested for the design process.

- a. Large and medium planning context
- b. Existing site condition
- c. Updated and detailed existing site condition
- d. Updated and detailed DSM (Digital Surface Model)
- e. Buildings
- f. Grading, paths and roads, carparks, pavements and retaining walls
- g. Trees, shrubs, groundcover, lawns and planting soil
- h. Staircases, walls and fences and pavilions
- i. Lamps and illuminance Maps

3.3. Federated-model-based data fusion

A central intelligent virtual model, known also as federated model is essential. The process of data input and multi-source data fusion is depending on the algorithm embedded in the modeling software. Generally, in the design process, the data fusion is computed on feature level and decision level. [6]

The significance of the federated model is to provide a digital base that data of different sources can be input, stored, transformed, exchanged and distributed among participants and participating disciplines through the process of landscape design. In other word, data is converted to information within the federated model.

According to the variation of the category of projects, the model can be various. For the project that covers bigger area, Autodesk Infracore model is a good choice to play the role of federated model. Because it has powerful capability to process GIS data and has the outstanding performance of real-time rendering, especially when the scene ranges cross different scales. For the project that closely related to the architecture, Autodesk Navisworks works in advanced effects as the federated model, because of its sophisticated

BIM features. For most of the landscape design project, Autodesk Civil3D model is a proper option to act as the federated model. The reason is that Civil 3D is powerful on dealing with terrain model, which is one of the most important elements for landscape architecture that every other element relates on. When operated in a data management server environment, Civil 3D can have even better performance as a federated model.

4. Results

4.1. LIM workflow for landscape design in the project Jade Well Park

The project of Jade Well Park in Pingtan, Fujian Province, China, serves as an empirical research case for this paper in which a 3D LIM model was created and managed in Autodesk Civil 3D based on a terrain model (DEM, Digital Elevation Model) derived from the topographic map issued by the Ministry of Land and Resources of the PRC. (Fig. 1)

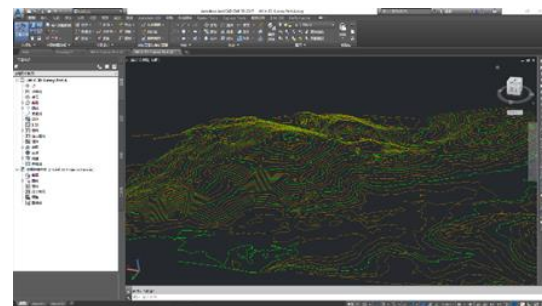


Fig. 1 Terrain model (DEM) derived from the topographic map

In the first step the model was extended with data from open source DEM (GDTM30m), urban planning and infrastructure data. The DEM and the mapped satellite imagery was created in Autodesk Infracore and projected in to Xi'an 80 coordinate system in which the

officially perimeter (redline) of the project was given.

As different analysis needed models in different scale and size, smaller areas with higher resolution closer to the site where nested in to the larger area and coarse resolution model.

For the process of determining the projects coordinate system and adding additional large scale DEM and satellite images with other projection we created a manual with step by step instruction.

The model also included existing and new planned infrastructure (roads) as well as land development information.

With this model we performed initial analysis of the site conditions for grading, watershed and microclimate (especially wind exposition) as well as analysis of the urban and ecological context of the project. It was also used to discuss initial design concepts by mapping hand drawings on to the surface, enhanced with simple masses for proposed buildings.

Additional survey and a photogrammetry model was carried out to update and detailing the model as the quarry operation was ongoing since the last update of the topographic map.

With the progress in the design detailed models where produced for landscape (grading, hardscape, softscape, retaining walls, stairs) with Autodesk Civil 3D and for the building with Autodesk Revit.

Integrating the design models with the existing site model and surrounding allowed analysis of design performance (wind protection, drainage) as well as the calculation of material quantity and design proposal visualization.

The virtual model also served the construction documentation and will allow digital stake out with GPS.

4.2. *Photogrammetry enhanced dynamic data fusion*

The model was built up on 200 photos taken on a site visit. These photos where processed to a Point Cloud. (Fig. 2)

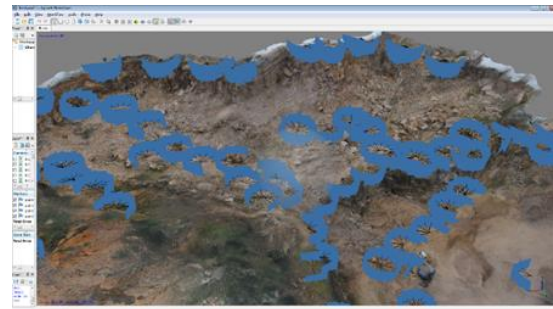


Fig. 2 Point cloud model built up on 200 photos

This point cloud is then calibrated by well-known reference points (from the topographic map) to the right size and position inside Autodesk Civil 3D.

From this point cloud we extracted a DEM by filtering out buildings, structures, cars and other non-ground data). The DEM extracted from the photogrammetry improved our terrain model in critical design areas. By comparing it to the DEM build from the topographic map we could quantify the fills of loose material.

4.3. *Information driven design solution*

Landscape as well as architecture design was done with BIM tools as parametric models.

In the landscape design grading, paths and retaining walls are dynamically linked to each other and the existing surface. We are using our own plug-in for parametric staircases and dynamic blocks for planting design containing all relevant information of the plant (name, size, phenotype).

For most of the landscape design features no additional data transformation was needed as there was created with same

software that manage the federated model. Only the planting design data needed a transformation by projecting the blocks to the final graded surface and adding 3D representation to them. (Fig. 3)

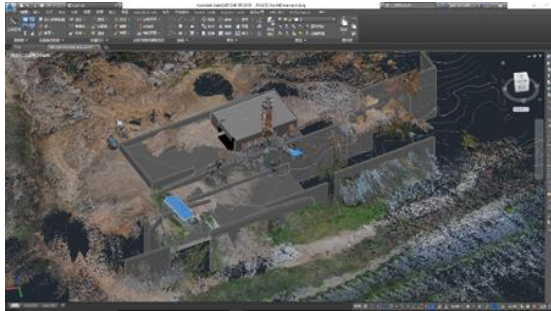


Fig. 3 LIM model built with Autodesk Civil 3D

The building model was extracted from Revit into a plain 3D-Autocad file, filtering out detail information and referenced in to the landscape model, vice versa the landscape model was referenced into the Revit model, making design changes for both design teams transparent and promptly.

We established a procedure for creating a shared base point in Autodesk Revit to ensure information transferred from there into Autodesk Civil 3D or vice versa ends up in the correct location. The ability to create a shared coordinate base point between Autodesk Civil 3D and Autodesk Revit is since version 2018 built directly into the software. In versions prior to 2018, this was available as a subscription add-on. (Fig. 4)



Fig. 4 LIM model built with Autodesk Infraworks

4.4. Performance analysis

Including the existing site condition, the design solution and the surrounding of the site allowed us to do several performance analyses: earthwork (cut/fill balance), storm water management (analysis of flow lines, catchment areas and run-off analysis for checking the swale as detention/infiltration systems) and performance of the wind sheltering. (Fig. 5, Fig 6)

The analysis for earthwork and drainage are performed directly within Autodesk Civil 3D. Our office standard includes templates for performing this analysis consistent and efficient.

For the wind sheltering performance the model was exported to Phoenixis.

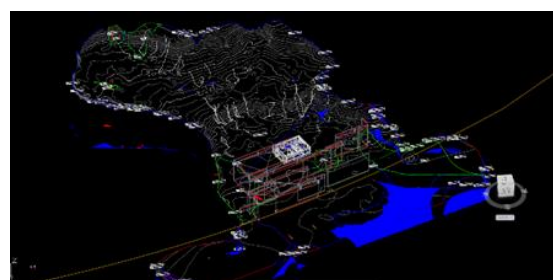


Fig. 5 Analysis of overflow and catchment areas

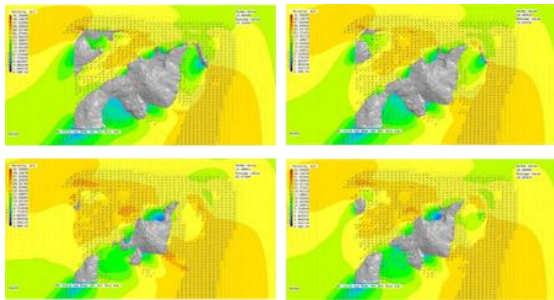


Fig. 6 Wind sheltering performance analysis

5. Conclusions

The data is not equal to the information. Data transforms to information only when it is processed to reveal the facts of the site, to evaluate the design proposals, and to support the decision making process.

This paper articulates an approach of multi-source data fusion by means of Landscape Information Modeling (LIM) workflow. It is based on the fundamental data. To one direction, it is integrated with satellite remote data and geographic information data to support the analysis to the site in a broader context. To the other direction, it includes data from photogrammetry, laser scanning, and additional surveys with a lot more details to support design decision making.

The LIM workflow is a dynamic process based on the federated model, in which data of various sources keep accumulating and computing. In accordance with the requirements of each specific design stage, and for each participating discipline the data is exchanged and distributed in different formats and at different levels of detail (LOD), which leads to various outcomes, such as topographical and ecological analysis, water catchment analysis, design proposal emerging, performance evaluating, visualization producing, construction documentation as well as the project's integrating delivery.

Such a workflow was experimented in the project of Jade Well Park in Fujian Province, China. The workflow is not emphasizing on specific software. Instead, its focus is on efficient management of the data and organizational processes to provide useful information for and during the design process. It is important that the data processing is operated in a standardized way. Data processing manuals and operation instructions are necessary to guarantee the outcome in the expected quality, even the specific processing procedure is customized according to the varying project typologies.

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Designing from the field

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Abstract

Landscape designs evolve from measurements taken of the site. Rather than to rely on datasets collected by government agencies or remote-sensing companies, it is becoming common practice for designers to personally gather the necessary information with the support of laser scanning devices. With point-cloud editing software it is now possible to sketch directly on the digital site and to develop a project referenced in its context. The workflow is not only time and cost effective, but allows to refine design criteria for a site-specific approach. The Rail Corridor in Singapore is taken as a case scenario and the workflow was applied during a joint workshop between the ETH Institute of Landscape Architecture in Zurich and the SUTD department of Architecture and Sustainable Design in Singapore. The workshop prescribed to work exclusively on the point-cloud medium and introduced the following questions for discussion: 1. The direct relation between site and landscape architectural design thinking. 2. Effectiveness of the point-cloud medium to communicate design intentions.

Keywords: digital design method; landscape architecture; physical modelling; terrestrial laser scanning; point-cloud

1. Introduction

Landscape designs evolve from measurements taken of the site. Rather than to rely on datasets collected by government agencies or remote-sensing companies, it is becoming common practice for designers to personally gather the necessary information with the support of laser scanning devices [1]. By strategically defining a set of scanning positions in the field, it is possible to compose a detailed point-cloud model that replicates with high fidelity the spatial configuration, allowing to articulate a

landscape architectural intervention that relates extensively to site-specific conditions. The point-cloud model goes beyond its strong aesthetic, as each point corresponds to an exact coordinate in space and geo-locates every landscape feature, regardless of scale and detail. In the process of a landscape architectural design, gaining topological understanding is key and lays the foundation for taking design decisions [2]. Point-cloud editing software allows to recognize landscape features in the datasets and to sketch directly on the digital site, developing a project referenced in its context. With the ability to personally collect, append, add

detail or update site-specific data as the project progresses, the workflow with data directly taken from the field has the advantage to adapt to new conditions while being time and cost effective [3].

Architectural and landscape architectural design informed by point-cloud datasets have the potential to reform the approach, sensitivity and criterion for a site-specific design. The application of the laser-scanning technology in landscape architectural design opens the possibility to a new language for information and communication. The evolution in both academic and professional sectors may shift the design approach from a foremost planar approach of the site involving CAD drawings and mapping tools, to an augmented spatial representation of the reality. To support this research for design, the 24km-long Rail Corridor in Singapore is used as a case scenario. The implementation of fieldwork-based design could make an essential contribution to the development of urban landscapes and play a significant role in the long-term strategy of metropolises.

2. Methods

2.1. Terrestrial laser scanning in complex environment

Laser-scanned point-clouds are at present the most accurate virtual models to represent the spatial qualities contained in a landscape, urban or rural as it may be. Digital landscape models derived from this technology come within millimeters of reality in all three X, Y and Z axes. Each set of coordinates may hold additional information such as color, refraction, heat - depending on the scanning sensor used to record the material space. The

unequivocal quality of the point-cloud model is to be an exact replication of the physical landscape, in which each object is a unique representation of its real counterpart.

Landscape Architects do not necessarily have a professional training in surveying, but a basic knowledge is sufficient to operate laser-scanning devices that are rapidly improving in ergonomics and portability. However, it is key to understand how to employ the instrument. Large sites can easily be covered in a few days of field work on flat unobstructed terrain, but in a dense urban landscape such as in Singapore, laser-scanning meets significant difficulties with a high number of objects occluding the laser beam and with a tropical vegetation difficult to penetrate. A variety of scanning modes can be exercised, each requiring a set of specific instruments and each resulting in different outcomes in terms of precision, detailing and density of datasets (fig. 1). A first surveying mission was conducted with a small team of researchers from the Future Cities Laboratory

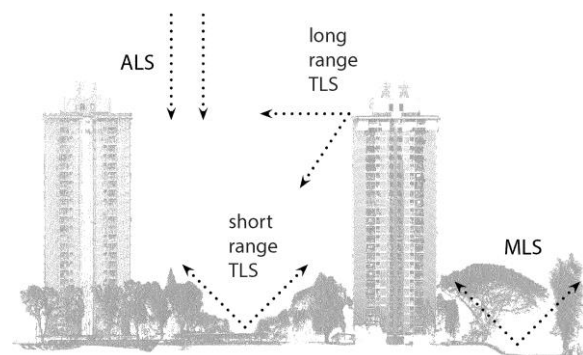


Fig. 1. Different scanning modes. Terrestrial Laser Scanning (TLS) is the most precise mode as it does not depend from an Inertial Measurement Unit (IMU) to reconstruct the scanned data. Other modes are Aerial Laser Scanning (ALS), recorded from unmanned aerial vehicles or from airplane, and Mobile Laser Scanning (MLS) recorded from vehicles and therefore limited to roads.

employing a long-range laser scanner¹ to scan 8 kilometers along the Rail Corridor in Singapore, from the Buona Vista MRT station to the Tanjong Pagar railway station at the southern end. For security reasons it was not possible to employ an unmanned aerial vehicle to fly over the dense urban environment and the aerial laser scanning was therefore simulated by scanning from the rooftop of HDB housing. The team individuated 30 buildings along the Rail Corridor that would give an appropriate wide-angle view towards the corridor and its context and would allow to assemble a complete model of the site.

The Rail Corridor evolves along a heterogeneous landscape, from dense urban areas in the Tanjong Pagar district to more vegetated areas after splitting with the AYE highway. Its former function as railway causes its edges to be segregated from adjacent areas by vegetation, infrastructure and topographical breaks. This situation results in an interruption that visually separates the interior of the corridor from the exterior. To cover both parts, the strategy was to set-up a high number of scanning positions along the corridor with a medium resolution of points in order to complement the void of scanning occlusions in other scans². The scanning angle also played a major role as the rays can best record the topography when coming from a high angle of incidence and when aligned with the corridor. The full operation succeeded in collecting more than

50 scanning positions from rooftops along the Rail Corridor.

2.2. *Reconstruction of a navigable model*

Assembling the individual point-clouds scans required a compute-intensive process before appearing into a final composite. The clouds contained minor amounts of stray points caused by reflective surfaces like glass or metal. A coarse cleaning was done manually to avoid a loss of true points from an automated filtering. Moving elements created little interference with the rest of the model and were kept as scanned, figuring as low noise from vehicles on roads and as duplicates from moving cranes in the harbor or on construction sites. The scanning conditions did not allow to employ registration targets and the separate scans were therefore assembled through a semi-automatic registration computed from overlapping landscape features.³

The point-cloud dataset quickly revealed that general assumptions about the site were wrong. The integrated GPS and levelling sensors of the scanner are not precise enough to level the data in centimeter precision on the whole length of the model. The idea was to straighten the pitch and roll axis by using blind walls of high buildings, assumed to be vertical. A detailed analysis proved impossible to determine a shared Z axis from facades, for every building had a slight and visually unperceivable tilt, presumably caused by shifting terrain or construction

¹ We employed the 3D terrestrial laser scanner VZ-1000 by RiegI with a measurement rate that reaches up to 122,000 points/sec at a radial range of 1400m, and a mounted DSLR camera to capture color information.

² The runtime of one scanning position was about 20 minutes, a compromise between time and resolution. Each scanning position had an average of 25 million points.

³ All processing tasks were accomplished with the open-source software CloudCompare 2.8, 2017. The registration ensued from a manual alignment and a fine registration with the Iterative Closest Point (ICP) algorithm. At the end, a subsampling of 5cm was applied to avoid an unnecessary high resolution in areas of no particular interest.

imprecision. The final solution was to adjust the orientation of the data using an integration method with a 3-years-old geo-referenced LiDAR dataset [4].

The substantial difference between using point-cloud data in remote-sensing applications and in landscape architectural design is the qualitative appreciation of the space, rather than its quantitative evaluation. This fact implies new requirements in visualizing data for which navigation becomes more significant than mapping and partly explains the technological lag since visualization is more resource-intensive than analysis. To navigate the composed point-cloud of 350 million points, we implemented a recently developed web application that enables interaction with gigantic datasets [5]. The application allows to quickly develop an affinity with the laser-scanned environment and to gain a precise understanding of the urban landscape along the corridor. The application allows to instantly read features of the point-cloud, determining water flow directions by measuring the height difference in water channels and topography, to compare the height of buildings or to discover unique characteristics, like existing breezeways through vegetation or topographic traces from former infrastructure. Such visual analysis enables designers to take game-changing decisions early in the design process and to work with rich micro-topography, vegetation patterns and other existing landscape features.

Because of their particle structure, point-clouds are well adapted to segmentation in

the form of sections, classifications or cut-out objects. This property allows to place sections in real time throughout the model and examine them separately, exposing the inner structure of the landscape where ground, plants, buildings can be recognized as distinct features (fig. 2).

2.3. Rapid manipulation of the site

A second surveying mission took place during a joint workshop week of two design research studios working on the shared objective of developing urban landscape typologies along the Rail Corridor that could mitigate the urban climate.⁴ The workshop started with a field exercise that consisted in familiarizing the students with the site and the procedure of laser-scanning. The goal was to densify the first dataset employing short range Terrestrial Laser Scanners in order to develop a detail design.⁵ Twenty new

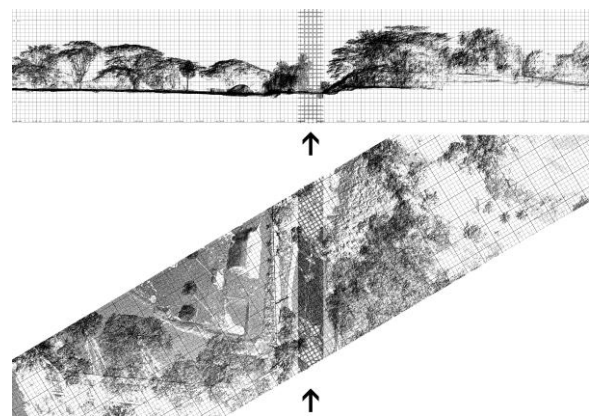


Fig. 2. The point-cloud model helps to read the spatial configuration of a site. Orthographic projections in plan or section show that topographical and vegetation features are clearly recognizable along the Rail Corridor (arrows).

⁴ Two design studios with bachelor and master students in architecture were launched at the beginning of 2018 at the Swiss Federal Institute of Technology in Zurich under the guidance of Prof. Christophe Girot and at the Singapore

University of Technology and Design under the combined lead of Prof. Joshua Comaroff and Philipp Urech.

⁵ We used two laser scanners with a maximum range of 300m for the detail scanning: ScanStation P40 by Leica and Focus3D X330 by FARO.

samples were recorded from the ground in three predetermined locations of interest with an increased resolution and with overlapping areas that allowed the fine registration. Three days of scanning and processing were sufficient for increasing the detail of the sites, each on an area of 500 x 500 square meters (fig. 3: top image).

The fourth day involved modeling with the point-cloud dataset and implementing a simple design concept within the urban context. The assignment consisted in using the software CloudCompare as a 3-dimensional sketching tool to extract and assemble landscape typologies and to reshape the landscape of the corridor in a local setting. The typological transfer allowed to quickly test and discuss variations by rearranging previously extracted landscape elements and by composing a new meaning. Reading the site through the scanning exercise and the resulting virtual models allowed the students to refer to site-specific findings that could be included into the manipulation of the landscape. The proposals had to include principles of cooling strategies such as ventilation, shading or new edge conditions in contact with green cooling areas.

3. Results

Laser-scanned data is commonly considered a “raw” source that needs to be filtered and translated in secondary forms, such as terrain models or elevation grids, before being manipulated by end users. The results presented at the closing of the workshop week included plans, sections and axonometric projections developed exclusively with point-cloud data and demonstrated that the raw medium is well

suited to directly operate on the site in short time and with high specificity towards the existing situation. Representative qualities of point-clouds for landscape architecture have been proven to be efficient, especially for sections and elevations [6]. The medium was indeed highly efficient to explain before-and-after situations of the design concepts and to easily decompose them into a series of sections illustrating the intricate urban situation. The visual representation met difficulties where the point density was not controlled with care, resulting either in loose graphics with a low density of points or in clamped colorings on sections represented with an excessive depth. Another risk in visual communication is that point-clouds

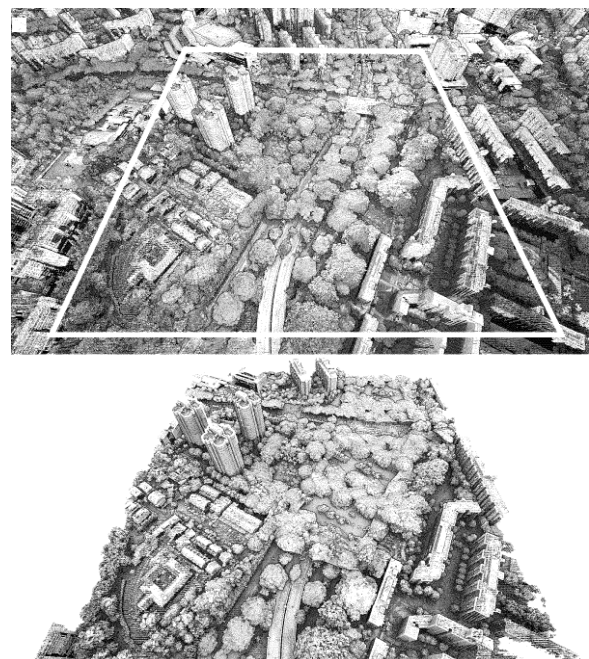


Fig. 3. Working exclusively with point-cloud data (top image) in a 12-hour charrette, students have developed design concepts such as a park covering parts of the AYE highway to increase livability and cooling in the adjacent areas (bottom image). Students ETH: Julian Fischbacher, Niels Galitch, Zofia Roguska; Students SUTD: Abhipsa Pal, Wei Qi Leong, Xin Hui Neo.

may confuse the reader with unorganized information, when the project is not distinguishable from its context or shown from an ineffectual perspective. Successful presentations were able to choreograph views and projections that were communicating clearly their design intentions.

3.1. Further editing potential

Software solutions like CloudCompare are suited to manipulate point-clouds and to realize minor manual modifications, but are not adapted to develop large-scale projects for which modelling and cloning tools are necessary to represent the extensive construct of a landscape architectural design. The workshop was an experiment part of a design semester that addressed the Rail Corridor as a whole on a large scale. In subsequent steps, the 3D modelling was refined with a workflow that draws from the topological information retrieved from point-cloud datasets. The initial condition of the site is built by extracting, filtering and meshing the point-cloud in the specific locations where the intervention will take place. From there, designers manipulate all elements relevant to their project, reshaping the topography and defining planting schemes that confer to their intervention a spatial presence. Finally, the tailored design is reconnected to the unchanged context (fig. 4).

4. Conclusion

For any architectural, urban or landscape architectural project, the site plays a primordial role and must be understood with transparency. The point-cloud medium brings the site closer to the designer as the laser-

scanned samples represent literally a cast of the reality that lays the foundations for a site-specific design. “Designing from the field” complements the thinking through physical modeling and brings the act of designing closer to the reality of the place.

By combining datasets collected with various laser-scanning procedures it becomes possible to address the high spatial complexity of the landscape at multiple scales within the same model. The datasets have the potential of refining the designer’s choice and of enhancing his sensibility in any kind of environment ranging from bare topography to dense vegetation or to highly urbanized land. The simple modelling approach experimented in the workshop can be transposed with the right tools to vast extents, amalgamating the rationale of the topography to the intelligence in the shape of the design. Landscape architectural design thinking will evolve accordingly, linking scientific and qualitative approaches in the same model.

The point-cloud medium is not only efficient as modelling input, but proves to be a valuable support for the site reading, during



Fig. 4. Bird-view perspective of a landscape architectural design proposal on the Rail Corridor near Queenstown. The visualization is entirely based on a 3-dimensional point-cloud model. Students: Nabila Larasati Pranoto and Melissa Li Ping.

the design development and for communicating design intentions. The representation of landscape design is a consolidative part of the design process and the increasing sophistication of visualization tools opens opportunities for the designers' creativity. In fact, visualizations of landscape architecture shall not only be an aesthetic and atmospheric composite, but need to work as a structural expression of the place, where the detailed foreground of the image relates to the entire landscape. In a traditional design process, the visualization is composed in a concluding effort to represent the final version of the design. The workability and the strong aesthetics of point-cloud models could shift the spatial appraisal of the design to an earlier stage and propose a faster feedback loop in which design decisions are being taken.

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Intelligent landscapes: information modeling for a new generation of flood control strategies in São Paulo City, Brazil

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Abstract

If landscape can be featured as more or less intelligent according to its capacity to respond to multipurpose and variable requirements, the ideal framework to enhance the intelligence of landscape is to acknowledge it as a soft system with complex, open organisms that can adapt to changing circumstances and work with the rhythms and pulses of human settlements, especially of large urban sites. This assumption meets in the concept of green infrastructure a novel approach. Through its focus on quantifiable phenomena and its internalization of new ecology principles of adaptation, resilience, and disturbance, green infrastructure possesses the potential to grapple with rapidly changing climate, resource scarcity, and shifting cultural values. This potential is the utter ability of adaptation, it is intelligence and it finds in today's information modeling technology a promising field of research and practice that enables complex simulations of how proposed solutions respond to specific challenges. If we understand landscape as a technological soft system, it may be evaluated through mathematical and computational models as much as any built infrastructure. However, instead of rigidity and sterility, green infrastructure provides a living and adaptive support to urbanity with greater social and aesthetic values. This approach has been examined in the Jaguaré Creek Revitalization Project, a pilot plan for a tributary watershed that corresponds to 1/10 of the total 270km² drainage area of Pinheiros River, one of the two main watercourses crossing the Greater São Paulo. In addition to strategies for water quality improvement such as non-point source pollution mitigation, waste recycling and sewage collection and treatment, the Project addressed flood risk management by identifying priority areas for flood control through hydrological simulations of the watershed. Considering 100-year flood events and their consequences on runoff and river flow, the retention volumes have been determined for each inline or offline reservoir along the Jaguaré Creek. One of these facilities is presented in this paper as a prototype evaluated not only for its volume capacity but also for its performance as a water landscape and a stormwater Best Management Practice (BMP). To integrate these abilities, computer-aided parametric modeling, using software such as AutoCAD, Rhinoceros®, its algorithmic modeling plugin Grasshopper and a Computational Fluid Dynamics (CFD) plugin, offered new ways of investigating landscape performances and

experimenting design. This functionality allowed a greater freedom of design, which corresponds to the water landscapes of anastomosing rivers with changing and waving forms and variable depths adapted to the dynamics of different water flows, to slowness and to phytoremediation. In this research, the principles of information modeling and simulation have been examined in landscape design through international cooperation between the University of São Paulo and Cornell University, with the contribution of the Federal University of Ceará. Applied to a case study in the City of São Paulo, this work points towards an innovative and prospective tool to deal with issues of urban water management and represent a practical reflection to advance in the experimental field of LIM – Landscape Information Modeling.

Keywords: Landscape Information Modeling (LIM); flood control; green infrastructure; São Paulo.

Introduction

Intelligence is the ability to adapt to change. This quote is not properly sourced, but it has been widely referenced to the brilliant theoretical physicist and cosmologist Stephen Hawking. In this metaphysical definition, intelligence has enabled human civilization to evolve. And if we consider landscape as the most complete artifact of mankind [1], with current challenges of climate change, water collapse and humanity crises, adaptation is a key tenet for its planning and design.

Although landscape is not a sentient being by itself, there has always been a demand for it to behave as an entity with responsiveness and adaptability, which are direct attributes of intelligence. Thus, landscape can be featured as more or less intelligent according to its capacity to respond to multipurpose and variable requirements. This theory assumes that the ideal framework to enhance the intelligence of landscape is to acknowledge it as a soft system with complex, open organisms that can adapt to changing circumstances and work with the rhythms and pulses of human settlements, especially of large urban sites [2].

This assumption meets in the concept of green infrastructure a novel approach. Through its focus on quantifiable phenomena and its internalization of new ecology principles of adaptation, resilience, and disturbance, green infrastructure possesses the potential to grapple with rapidly changing climate, resource scarcity, and shifting cultural values [2]. This potential is the utter ability of adaptation, it is intelligence and it finds in today's information modeling technology a promising field of research and practice that enables complex simulations of how proposed solutions respond to specific challenges, considering time, phasing and entropy [3]. If we understand landscape as a technological soft system, it may be evaluated through mathematical and computational models as much as any built infrastructure. However, instead of rigidity and sterility, green infrastructure provides a living and adaptive support to urbanity with greater social and aesthetic values.

In this paper, the principles of information modeling and simulation are examined in landscape design through international cooperation between the University of São Paulo (Faculty of Architecture and Urbanism and Polytechnic School) and Cornell University (Department of

Landscape Architecture), with the contribution of the Federal University of Ceará (Department of Architecture, Urbanism and Design). Applied to a case study in the city of São Paulo, this work points towards an innovative and prospective tool to deal with issues of urban water management and represent a practical reflection to advance in the experimental field of LIM – Landscape Information Modeling.

1.1. Sao Paulo's unintelligent urbanization

If landscape intelligence directly corresponds to its ability to adapt to changes, then rigid, monofunctional gray infrastructures of the twentieth-century urbanization were never intelligent, although they have had their historical time of importance and efficiency. Urban waters are an undeniable indicator of this lack of adaptation and, therefore, of cities' unintelligent development. From initial settlements to great metropolitan areas, water bodies have shifted from resource providers to drainage and sanitation accessories as their behavior, performance and landscape were significantly modified with unaffordable costs to society, economy and environment, beyond the lack of resiliency and (biological, aesthetic, and social) diversity (Fig. 1). From main support for ecosystem dynamics, water has been the target of most impactful transformations: rectified and channeled rivers and streams, landed ponds, and over all, the progressive imperviousness of urban territory led to unprecedented changes in hydrology and intricate issues concerning water quantity, as to flood risk management, and quality, as to pollution mitigation.

The City of São Paulo is representative of this model of influence and urbanization. The fast transition from rural to urban especially in the last century has brought serious consequences to landscape and environment. From 31,000 in 1872, the City of São Paulo has grown seven times in population until the end of the 19th century and became the most important metropolis in South America in the first half of 20th century and this number already outraged 11 million [4]. Along this shift, urban development considered hard engineered and massive construction works as a symbol of prosperity, despite of occupying and transforming relevant environmental landscapes into a road and street system under expansion that often matches what once belonged to water (Fig. 2).

Conversion into gray infrastructures has especially disturbed the hydrological cycle and natural processes chained to it. With the combination of complete artificial management of stormwater, imperviousness and rapid runoff conveyance, streams and river channels have been more likely to overflow, aquifer recharges have decreased, and drainage infrastructure has been over demanded while its longevity and efficiency was reduced. Beyond the issue of stormwater volume, São Paulo has serious concerns about the quality of its waters. The former combination of drainage solutions also increases the pollution discharges that flows into surface water resources, which accelerates environmental deterioration and gradually prevents streams and rivers to be restored and perform as a multifunctional infrastructure, embraced by city population. Today, São Paulo's greater rivers, Tietê and Pinheiros, are reflections of this unintelligent process. Mostly channeled and

heavily polluted, their waters carry significant load of domestic and industrial sewage and other non-point sources as well (Fig. 3). Their tributary creeks are also mostly seen as obstacles, instead of being a source of civic pride, identity, territorial organization or connection.

1.2. Opportunities for landscape infrastructures

In São Paulo, the overlapping of unaccomplished urban plans, misappropriated investments, and compromised decision making with progress at any cost resulted in channeled rivers to serve an extensive system of marginal roads of great relevance for economy and transportation. Historically, there has been a failure to prioritize the opportunity for a green metropolitan infrastructure, which today requires corrective and adaptive action to reclaim river landscapes and functions. As to flood risk management, public administration has lately invested in centralized compensatory solutions and implementation of detention reservoirs, commonly known as *piscinões*, that form a network of monofunctional engineering structures without any connection to people or landscape (Fig. 4).

In the other hand, since flood resilience is mandatory and will demand the construction of more reservoirs, there is a unique chance to adapt open spaces, with emphasis on strategic remaining floodplains within the urban fabric, to enhance runoff slowness and stormwater retention, treatment and infiltration. From a range of available technologies, this work examines Best Management Practices (BMP) to access flood control due to their suitability to green infrastructure principles, such as

multifunctionality, connection, biodiversity, esthetics and resilience [5]. Considered as Nature Based Solutions (NBS), BMP represent a more efficient and cost-effective approach to development than traditional approaches [6]. When based on bioremediation, they are also able to improve water quality and mitigate diffuse pollution. In this sense, applying a simple organic matrix, composed of vegetation, planting soil and a discretionary layer of bedrocks for runoff retention has been proved to be efficient in reducing loads of nonpoint source pollutants [7].

Strategies for intelligent flood control landscapes

2.1. Landscape as technology

The ability of landscape to react and work as a framework to urban resiliency depends upon a new concept to assess, plan and design the support of ecology in cities. This original theory has reached a promising field through data processing and artificial intelligence [3]. This approach found a unique testing opportunity at the Jaguaré Creek Revitalization Project, a pilot plan for a tributary watershed that corresponds to 1/10 of the total 270km² drainage area of Pinheiros River, one of the two main watercourses crossing Greater São Paulo. An extensive analysis of the Jaguaré basin [8] estimated the pollution loads discharged into the creek through land occupation pattern and a system of BMP was then proposed to improve water quality and deal with flood risk control. Beyond strategies for water quality improvement, such as non-point source pollution mitigation, waste recycling, sewage collection and treatment, the project addressed water volume issues

by identifying priority areas for flood management through hydrological simulations within the watershed. Considering 100-year flood events and their consequences on runoff and river flow, the retention volumes have been determined for each inline or offline reservoir along the Jaguaré Creek, and one of them has been selected for the pilot parametric prototype presented in this research.

A new generation of flood control infrastructures or new *piscinões* have been explored in Jaguaré. Over four years members of the research team conducted fieldwork, developed methods and workflow, and analyzed existing strategies and conditions. This culminated with a three-day workshop and symposium in Cornell University (Ithaca, NY) held in April of 2017 that brought together geographers, engineers, policy makers, hydro-ecologists, and designers to identify key design principles (Fig. 5).

From these principles two strategies were subsequently articulated and tested to implement the principles: the anastomosing retention reservoir and the phenotypes. These strategies stand as the working conclusions to this research that are informing final reports for the government agencies and non-governmental organizations interested in the possibility of rethinking the river infrastructure of São Paulo in relation to its urban communities, human and ecological. The strategies are:

2.2. Anastomosing retention reservoir

An anastomosing river has two or more interconnected channels that enclose flood basins (Fig. 6). This definition combines floodplain geomorphology with river channel pattern to appropriately capture the

intent behind a site-specific approach to new retention basins (Fig. 7). Instead of the conventional solution of detention reservoirs in geometric volumes conformed by flat surfaces - the dreadful *piscinões* - a research hypothesis was adopted that takes advantage of the forms that are naturally given and adapt to variable water flows. The form of anastomosed channels, with the successive branching or multiple channels that are separated and recombined, were given by an input of parameters for a digital modeling with the use of algorithm, in constant iteration with the previously intuited forms.

The process of developing the algorithm was divided into three stages: 1. understanding the problem; 2. elaboration of a prototype; 3. openness to generalizations. The initial stage was defined by the apprehension of the geometric patterns that constitute the specific landscape language (Fig. 8). The later phase dealt with the decomposition of the design language's logic and its translation into the computational environment. This stage aimed to reproduce a logical reasoning mediated by the computational tools of the Rhinoceros software and its plugin, Grasshopper. Given the complexity of the forms involved, a typological decomposition was performed, aiming the restitution of the geometric patterns from less complex elements.

2.3. Landscape phenotypes

The biological concept of phenotype is particularly apt for this approach, as it grants primary agency to the landscape itself and its dynamics, emphasizes transferability and empirical characteristics, and allows for an understanding of form. This frame has led us to a working definition of landscape form which was not only shape (the literal

geometry) but also pattern (distribution of geometry across spatial scales) and process (distribution through time).

An analysis of existing river landscape phenotypes includes but is not limited to those found historically within the São Paulo region and the Tietê or Jaguaré basins. This is in part because the processes of making are political-economic and technological as much as they are hydro-geological now. The rivers and their landscapes have fundamentally changed. These are hybridized with the forms and structures already present in the city; the drainage culverts, flood walls, and revetments. Many of these formal types can be found when studying anastomosing rivers.

Rather than reasoning by analogy such as the building of scaled digital and physical models, this strategy focused on reasoning by analysis. In this study we generated phenotypes that we expected to produce desirable effects in relation to water flow if they were used in the river channels, in the detention basins, or in floodable zones immediately adjacent.

We were able to generate these studies within a modeling environment that also accounted for more conventional urban design and landscape architectural elements. This workflow allowed us to quickly ask multiple questions of the forms in relation to both river design and urban landscape design. Moreover, the studies were relatively fast, allowing for a wide range of options to be studied before final designs are chosen for more expensive and precise scenario modeling using hydrodynamic software (Fig. 9).

Accomplishments towards landscape intelligence

Advances in both strategies evolved in parallel, however, results display an opportunity to be further explored and combined into a single tool, in which phenotypes can collaborate to model anastomosing reservoirs. Focusing on flood risk management, landscape has been investigated and experimentally designed through responsive information modeling, which demonstrated specific strengths/weaknesses for both methods:

2.4. Intelligent reservoirs

Designer intervention was performed mainly by manual sketches of the sinuous channels within digital environment and the connection of these geometries with algorithm functions (Fig.10a). This approach aided the transition of experienced users to traditional CAD software, requiring less training for the algorithm operation.

The anastomosed axes of the reservoir were divided into two categories: the primary ones, which derive from the inflow and outflow points of the original channel; and the secondary ones, whose affluent points have been determined by the algorithm itself and which necessarily connect to the main axis. Firstly, the algorithm required the insertion of the primary axis, which automatically altered the initial topography to a new situation. This, in turn, redirects the flows of surface runoff and regions of greater or lesser slope, requiring, therefore, a new iteration of analyzes and simulations. In a second moment, the algorithm performs an analysis of the concentration of rainfall trajectories on the surface and detects the highest concentrations at the edge of the

intervention area. These points identified the secondary paths, requiring the sketch of curvilinear axes that, in their projection, intercept the main axis (Fig. 10b).

By crossing the main axes and the secondary axes, a series of formal treatments and analyzes specific to computer graphics determined suitable regions within the limits of the reservation area to model new meanders in order to enhance water flow slowness and retention. These new 3D surfaces were distinguished between small reservoirs (submerged) and small isles (emerged) (Fig. 10c).

In the last steps of the algorithm a cloud of points was generated by a decomposition of the main and secondary axes as well as the meandering regions. In addition, the points referring to the edge of the intervention area and original topography in the urban environment (Fig. 11a) were also added to this grouping. The cloud resulting from this overlapping was used to define a final topographic surface (Fig. 11b).

For the calculation of the retention volume, the surface was extruded down, generating a complex shaped solid, called a closed brep. From this moment, by means of boolean operations of form subtraction, it was possible to identify and calculate the volumes retained in the small reservoirs of the meanders, as highlighted in Figure 11c in white. The calculation was performed automatically by the algorithm.

2.5. Intelligent slowness

The concept of the phenotype study was centered on form as an abstract idea with specific intention to recover the complexity of water flow. The development of the prototypical forms and the use of Rhinoceros Computational Fluid Dynamics

(CFD) enhanced the comprehension of how these 3D shapes change flow vectors in the modeling/simulation environment. These forms were also built parametrically, creating a feedback loop between changes of flow and form. From all possibilities, two forms were chosen for further experimentation (Fig. 12).

The *cresant* was selected for three main reasons: 1. with simple variations to its baseform it allowed a wide range of performative effects; 2. the shape was clearly intentional and easily produced a pattern that would be recognizable to users or maintenance workers; 3. it might function out away from the bank as a low-flow obstruction. Different flow scenarios were used to analyze the performance of variations of this phenotype. The variations could be set from the start or induced through material choice and flow force over time. In each case the form produced an elongated zone behind.

The *teeth* were chosen for two main reasons: 1. while the form didn't change it allowed us to easily question relations between forms; 2) the shape would easily attach to banks and provide physical access for recreation or maintenance. To analyze the performance of variations of the phenotype, we searched for useful formations by running multiple flow scenarios and comparing outputs with the understanding that every form was different. The number and sizing of the obstructions has been formulated to not cause a difference at a large scale, but to produce micro-topographies and areas of slower water at a smaller scale.

Conclusion

When examining the design process for a new generation of flood control strategies in São Paulo, the water space has been adaptively and intelligently remodeled for reservation and flow discipline purposes, relying on the sophistication of natural systems. This approach presented an expected difficulty to be reproduced efficiently by digital artificial tools, which has been overcome once the design strategy was determined: the curvilinear language of anastomosed river channels.

Regarding fast manipulation and adherence to performance criteria, this work investigated the definition of an artifact based on information technologies and capable to assist the design process, not only to provide an automated modeling of formal structures but mostly to provide feedback on the performance of the researched solutions. The resulting system was able to grant a series of information that guided the proposal translation, and yet it allowed manifestations of manual expressiveness.

By combining performance with computational design, this work has reached a prospective language for landscape architecture in balance with the requirements of hydraulic engineering, social use of open spaces, urban governance and biodiversity. An innovative tool morphology for retention reservoirs was capable to integrate the diverse functions that are expected for urban spaces, such as areas that combine the role of infrastructure with the needs of social and aesthetic use and that stimulate more vibrant and valued urban landscapes.

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Appendix (artwork/figures)

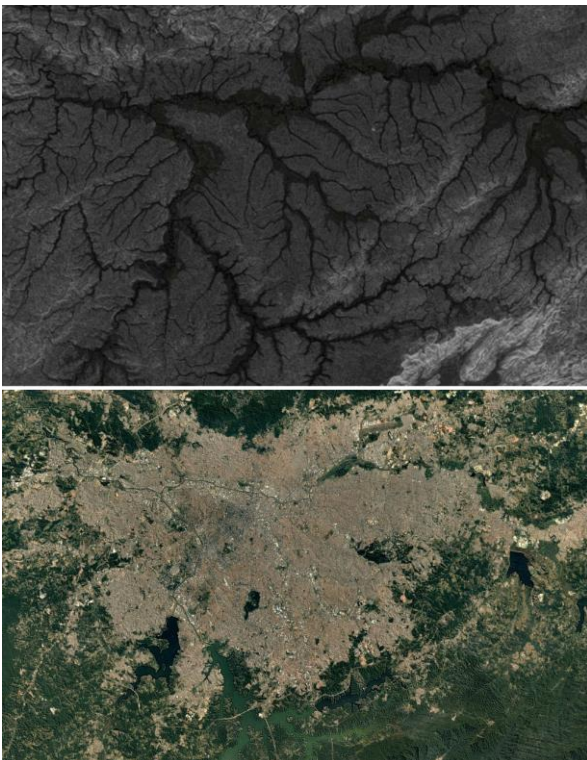


Fig. 1 – The territorial condition of São Paulo: a megacity built on hills and river

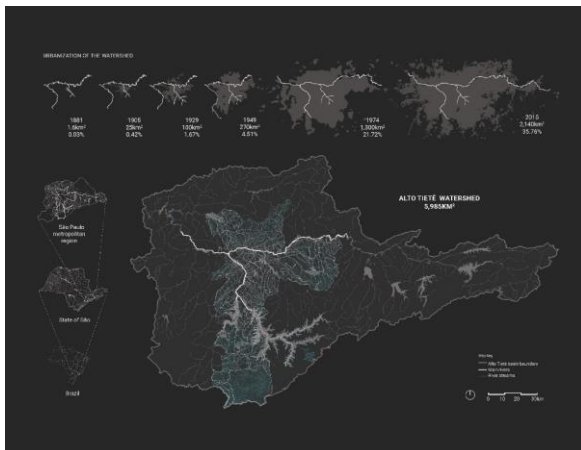


Fig. 2 – Water x urbanization: São Paulo City (in blue) is located within the Alto do Tietê watershed. It is one of the only Megacities in the Americas to be situated in the highlands. This means that floods come quickly and frequently during the rainy season, now that over 1/3 of the entire watershed has been subjected to urbanization processes over the last 130 years.

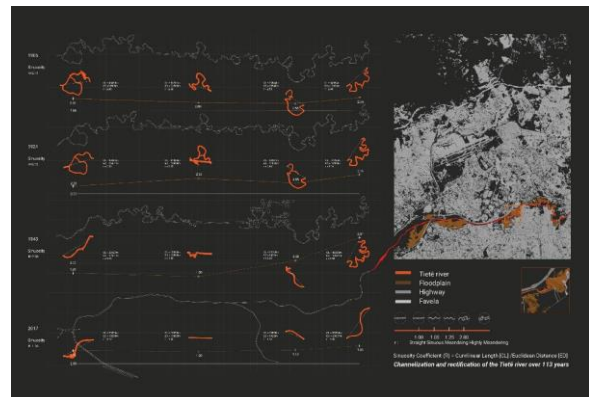


Fig. 3 – Most of São Paulo’s growth occurred during the twentieth century, when channelization and rectification of water bodies was a dominant paradigm. Because of this, the rivers of the city, including the Tietê and Pinheiros, have been subjected to immense pressures resulting in a near complete loss of floodplain and geometric complexity over almost the entire length of the rivers.

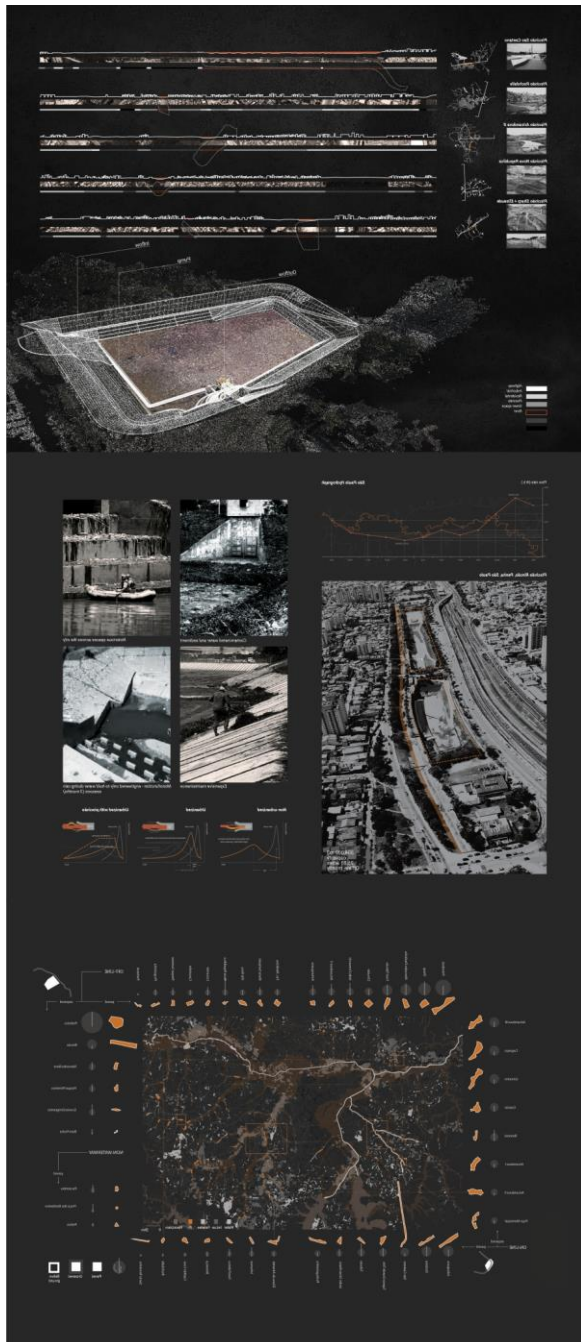


Fig. 4 – *Piscinões* are distributed throughout the Metropolitan Region of São Paulo (RMSP), mainly on the urban fringes in former floodplains. These landscapes tend to be occupied by other marginal uses, such as industry and informal settlement. Based on their material qualities and relationship to a water source, *piscinões* can be divided into roughly four categories: inline-paved, inline-unpaved, offline-paved, and offline-unpaved.

9 PRINCIPLES

LEVERAGE THE ENERGY OF RIVER TO BUILD COMPLEXITY
 The creation of simple forms that gain complexity over time leverages the generative capacity of landscape to minimize construction costs and allow room for adaptive management.

CONNECT TO EXISTING PEDESTRIAN OR NETWORKS
 Improvements to the river infrastructure should increase local mobility, offering gathering space and increasing connectivity.

EMPHASIZE CONFLUENCES
 Areas where streams join larger rivers are subject to flooding but they are also areas of special interest. Because they flood they already receive infrastructural. These should be emphasized to include social enhancements.

CREATE MICROTOPOGRAPHIES FOR VEGETATION
 Small bedforms and edge conditions that created protected zones for vegetation should be accounted for an encouraged.

DESIGN AREAS RESPONSIVE TO DISTINCT FLOW CONDITIONS
 River channels and detention areas should be designed to account for different behaviors in low flow and flood conditions.

USE DEFORMABLE GEOMETRIES
 Materials and forms that are intended to adapt and change over time should be utilized. This mimics natural performance and can minimize maintenance while enhancing visual appeal.

DRAMATIZE RIVER FLOW AT POINTS OF SOCIAL INTEREST
 Creation of riffles, braided channels, protected eddies, and other enhancements at street ends or confluences can enhance the visibility, appeal, and use of channels and piscinões.

EMPHASIZE ACCESS
 Provide visual or, when possible, physical access to areas of the rivers and detention basins for local residents.

PROGRAM FOR A DRY SEASON USE
 The basins should be designed and programmed to be useful during the dry season, whether through recreation programming or, more likely, water quality and habitat provision.

Fig. 5 – Key design principles for Jaguaré pilot project.

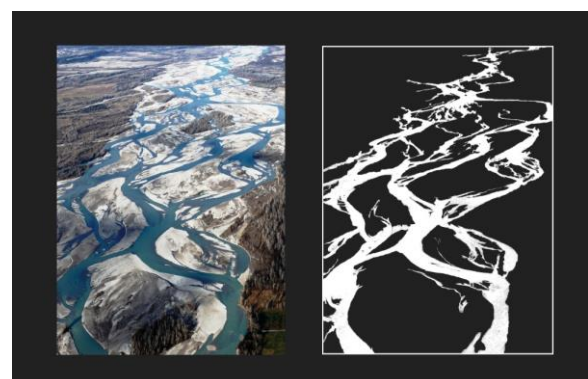


Fig. 6 – Profile study of an anastomosing river.

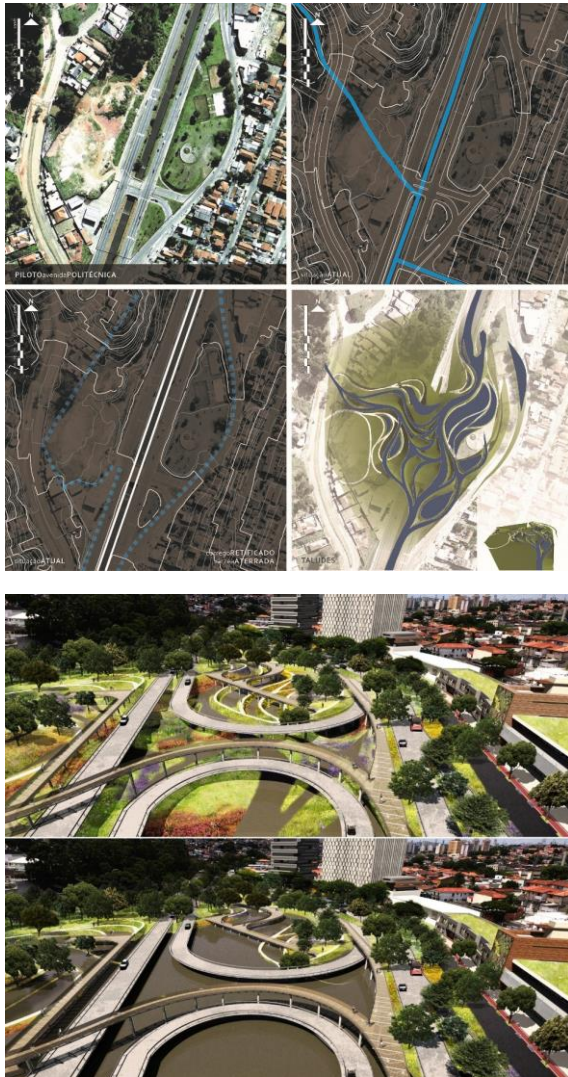


Fig. 7 – Site-specific approach to new a retention reservoir.

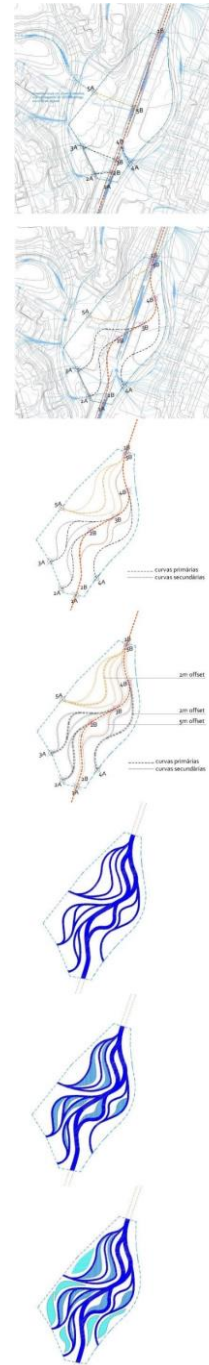


Fig. 8 –
 Typological
 decomposition.

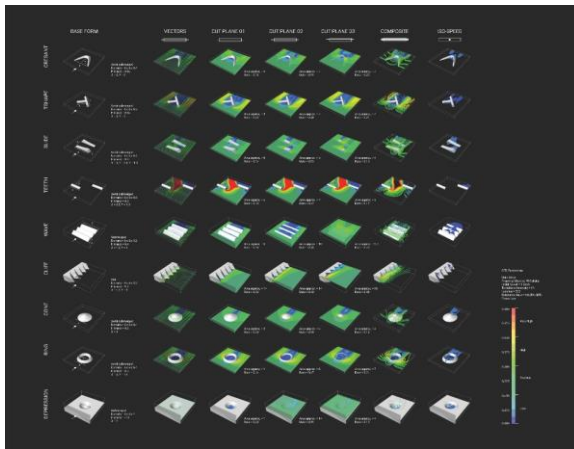
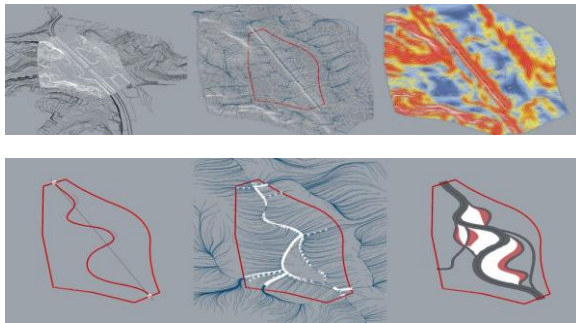
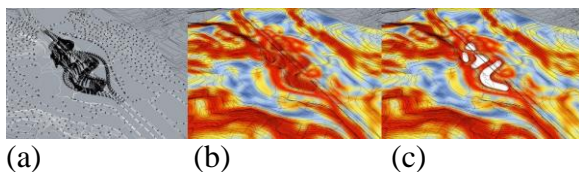


Fig. 9 – Phenotype studies for water flow analysis.



(a) (b) (c)
 Figure 10 (a;b;c) – Designer's intervention:
 (a) elaboration of a new primary axis; (b)
 analysis of surface runoff behavior; (c)
 meander generation and definition of small
 reservoirs and isles.



(a) (b) (c)
 Figure 11 (a;b;c) – Final steps: (a)
 tessellation of topographic surface by points;
 (b) new topography with empty and full
 reservoirs (c) (white sections).

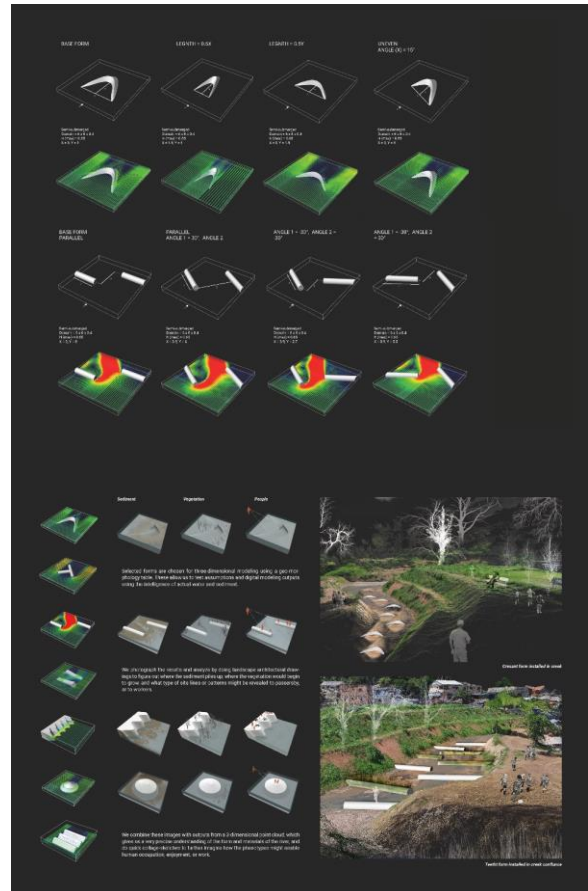


Figure 12 – Further studies for phenotype application.

Assessment of the structural connectivity of green spaces to identify stepping stones for garden city development of Quezon City, Philippines

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Abstract

With the construction of MRT 7 in Quezon City, domino effect of the urban development is anticipated to grow exponentially, threatening the natural environment in the city. The removal of 1,858 trees to pave way for the MRT line can possibly lead to loss of natural habitats and further landscape fragmentation which will go against the goal of the city government in creating a garden city. The major challenge is how to create ecological network when La Mesa Nature Reserve which is 55% of the city's total area of green spaces is located only in the northernmost part of the city and is separated from other ecological cores by the MRT line and wide highways traversing the city.

Using aggregation metrics, the landscape texture of Quezon City is assessed to evaluate the connectivity between the ecological cores. With GIS tools, a resistance weight, a structural connectivity index and an ecological barrier effect index, the needed area for stepping stones to form greenways are identified. This study helps shorten the distance between urban green spaces and offer a spatial-planning strategy to increase the green space connectivity in Quezon City.

Though further analysis may be necessary, the results give indication on possible paths of stepping stones necessary for creating ecological connectivity.

Keywords: Geo-design, Biophilic City, Urban Ecological Network, Stepping Stones, Ecological Connectivity

1. Introduction

As a result of urban expansion, fragmentation decreases ecological connectivity, increasing isolation of habitats and loss of green spaces. The movements of organisms and the resultant flows of ecosystem services are shaped by landscape connectivity. Therefore, conservation of green space connectivity through ecological networks in rapidly expanding cities is needed to protect the biodiversity in urban

area. Connectivity is key to how landscape functions ecologically. It is a particularly critical issue in urban areas because these typically comprise very large numbers of, often small, habitat patches separated to varying degrees by impermeable surfaces and barriers (i.e. buildings and roads).

Connectivity can be categorized into two: Structural and Functional. Structural connectivity pertains to the underlying landscape geometry, such as corridor width

and distance between patches, whereas functional connectivity seeks to consider the specific needs and behaviors of a target species or species group [1]. Studies of structural connectivity in urban settings have highlighted its importance and utility as an aid to planning [2] [3].

1.1. Statement of the Problem

Assessing connectivity for developing an ecological network by using efficient models is essential to improve these networks under rapid urban expansion. Thus, this study answers the question how can ecological connectivity be strengthened between ecological cores of Quezon City?

1. How dense are green spaces in Quezon City?
2. What are the current ecological connectivity values of green spaces in Quezon City?
3. Where should stepping stone corridors be established to create higher ecological connectivity values between ecological cores?

With those questions in mind, this study aims to develop the ecological network between the ecological cores of Quezon City through addition of stepping stone corridors. To achieve this goal, the following objectives are set in place:

1. Locate the green spaces in Quezon City and determine its density
2. Compute the current connectivity value of green spaces in Quezon City
3. Identify the locations where stepping stones should be added to create connectivity between ecological cores

The results of this study can improve not only the ecological health of cities, but also the quality of life for human urban residents through the provision of bird interactions and other encounters with nature.

This study provides examples on how combining models can contribute to the improvement of ecological networks in rapidly expanding cities and demonstrates the usefulness of such models for biodiversity conservation and urban planning. Not only will this help the garden city development of Quezon City, this will also serve as a reference for students and professionals who are studying landscape architecture, urban planning, and other relevant fields.

1.2. Review of Related Literature

Connectivity analysis of green spaces in urban landscapes has recently been one of the main steps in urban planning especially in high-density cities. One example is the study by Tian et al [4] where they analyzed the relationships between the connectivity index of green spaces and green cover, elevation, building density, and population density using GIS tools and different landscape indices. The target species in the study were humans. The results indicated that low connectivity usually occurs in both old and new town centers with high building density and low green cover, and in areas occupied by land uses with a high resistance weight.

In another study by Nor et al [5], three areas in Southeast Asia (Kuala Lumpur, Malaysia; Jakarta, Indonesia and Metro

Manila, Philippines) were assessed to model connectivity for the two bird species: Eurasian tree sparrow (*Passer montanus*) and Yellow-vented bulbul (*Pycnonotus goiavier*). The approach identifies potential priority corridors for ecological connectivity networks. The study combined circuit models, connectivity analysis and least-cost models to identify potential corridors by integrating structure and function of green space patches to provide reliable ecological connectivity network models in the cities. Same as the study of Tian et al [4], this study used relevant parameters such as landscape resistance and green space structure (vegetation density, patch size and patch distance).

The two mentioned studies above, as with many other studies that used connectivity index, considered the building footprint as one of the barriers in ecological connectivity. It was also considered as one of the barriers in measuring connectivity as indicator of City Biodiversity Index (endorsed by the Convention on Biological Diversity in 2009). In the study done by Deslauriers et al [6], they applied these barriers in analyzing the ecological connectivity in Montréal and Lisbon. Railway lines were considered as connectors in Montréal but these were barriers in Lisbon. Depending on the policies in the location, the barriers can sometimes be connectors in the ecology.

2. Methodology

This study had three major steps for obtaining the goals and objectives: Ecological Patch Mapping, Application of

Landscape Metrics, and Analysis of the Maps.

First, the green spaces of Quezon City were identified through creation of polygons in Google Earth Pro. The view was set at the range of 2.4-2.7km altitude and the green spaces more than 5000 square meters (sqm) were identified. These were then categorized into different land covers. Table 1 shows the different land covers identified in Quezon City.

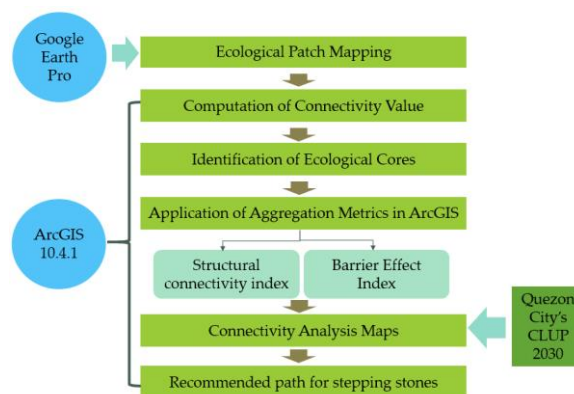


Fig. 1. Methodological Framework

Land cover	Description
Forest	more than 500sqm, crown cover at least 10% of the area
Closed	greater than or equal 70% canopy cover
Medium Closed	40-70% canopy cover
Open	10-40% canopy cover
Grassland	predominantly vegetated by grasses
Lawn	planted grass

Agriculture land	distinctive geometric fields and road patterns
Swamp	dominated by woody plants

Table 1: Land Cover Classifications found in Quezon City

After identification of the green spaces, the kml file from Google Earth was transferred to ArcGIS 10.4. The connectivity value was then computed by using the below formula from the City Biodiversity Index [7].

$$Indicator\ 2 = \frac{1}{A_{total}} (A_1^2 + A_2^2 + A_3^2 + \dots + A_n^2)$$

where A_1 to A_n represent the sizes of the natural areas, from natural area 1 (A_1) to natural area n (A_n), n is the total number of distinct natural areas and A_{total} is the total area of all natural areas. This measures effective mesh size of the natural areas in the city. A_1 to A_n may consist of areas that are the sum of two or more smaller patches which are connected. In general, patches are considered as connected if they are less than 100 meters apart.

However, exceptions to the above rule include anthropogenic barriers such as roads (15 meters or more in width; or are smaller but have a high traffic volume of more than 5000 cars per day), rivers that are highly modified and other artificial, barriers such as heavily concretized canals and heavily built up areas, and any other artificial structures that the city would consider as a barrier. For the purpose of this study, only the roads were considered as barriers. The building footprint of the city was ignored as barrier, because this study recognizes the potential of sky-rise greenery especially green roofs as stepping stone corridors.

By creating a 50-meter buffer on each patch and then identifying the patches which connect to each other, the connectivity value of the city was determined. Figure 2 shows the green spaces that are ecologically connected when the buffer was applied.

After knowing the status of the connectivity of the patches, the ecological cores were identified depending on the area, edge density, and land cover. Edge density was computed by getting the quotient of the parameter of the patch over the patch area. Table 2 shows the weights attributed on the parameters for determining the ecological cores. Those with the highest points were chosen as the ecological cores.

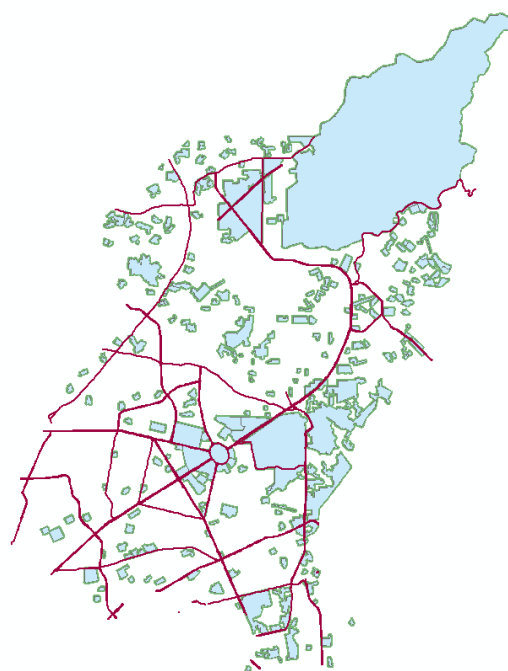


Fig. 2. Connected Green Spaces when the buffer of 50m was applied to each patch

The study proceeded with the analysis of their connectivity through the use of several indices under Aggregation Metrics which refers to the tendency of patch types to be spatially aggregated; that is, to occur in large, aggregated or "contagious" distributions. Structural connectivity index and an ecological barrier effect index were then applied in ARCGIS with use of different spatial analysis tools. The models used came from the proposal of Tian et al [4] which is detailed below:

Barrier effect index was calculated using the Cost Distance module in ArcGIS. The barrier effect index (BEI) was modeled as follows:

$$BEI_i = \ln((d_i - d_{\min}) / (d_{\max} - d_{\min}) + 1)$$

where, for the given area, BEI_i is the barrier effect index; d_i is the path distance; and d_{\max} and d_{\min} are the maximum and minimum path distances, respectively.

Land Cover	Weight
Closed Forest	7
Medium Closed Forest	6
Open Forest	5
Grassland	4
Swamp	3
Agriculture land	2
Lawn	1
Area (sqm)	
30,000,000 - 25,000,000	5
24,999,999 - 20,000,000	4
19,999,999 - 15,000,000	3
14,999,999 - 10,000,000	2
9,999,999 - 5,000,000	1
Edge Density	

0-99	8
100-199	7
200-299	6
300-399	5
400-499	4
500-599	3
600-699	2
700-799	1

Table 2: Parameters used to identify core areas

In addition to the barrier effects, travel cost and time consumption are also important factors affecting the connectivity of urban green spaces. The nearest neighbor distance (nd) between different green spaces is calculated by analyzing the distances between the centroid of one piece of green space and the centroid of the nearest green space. For a given region j , the DI is modeled as

$$DI_j = \ln((nd_j - nd_{\min}) / (nd_{\max} - nd_{\min}) + 1)$$

where DI_j is the total distance between different urban green spaces in region j ; \ln is the average Euclidean distance from the centroid of one piece green space to the centroid of the nearest green space; nd_j is the summation of all average Euclidean distances from the centroid of one piece of green space to the centroid of the nearest green space in region j ; and nd_{\max} and nd_{\min} are the corresponding maximum and minimum distances between different urban green spaces in the given area, respectively. The ecological barrier effect index (EBEI) is then formulated by summing BEI and DI. For the given area, the ecological barrier effect index is modeled as follows:

$$EBEI_j = \sum_{i=1}^n BEI_{ij} + DI_j$$

where $EBEI_j$ is the ecological barrier effect index between different urban green spaces

in region j ; BEI_{ij} is the barrier effect index in region j ; and n is the number of green spaces in region j .

For structural connectivity index, it is modeled as

$$CI_j = 10 - 9 \ln((EBEI_j - EBEI_{\min}) / (EBEI_{\max} - EBEI_{\min}) + 1)$$

where CI_j is the structural connectivity index of green spaces in region j , where the value of CI ranges from 0 to 10; and $EBEI_{\max}$ and $EBEI_{\min}$ are the corresponding maximum and minimum ecological barrier effect indices in the given area. The resulting maps showed the possible areas for installation of greenways that will connect the ecological cores of Quezon City.

3. Results and Analysis

After identifying the green spaces of Quezon City via Google Earth Pro, the below data were captured:

Total number of green spaces: 273
 Total Area of Green Spaces: 47,916,678 sqm
 Total Area of QC: 165.33 sq km
 Green Space Density: **28.98%**

The green space density of Quezon City is relatively good considering that it is highly-densed with commercial and residential areas. However, this does not mean that all the green spaces offer good ecosystem services. It must be pointed out that 55% of these green spaces is La Mesa Nature Reserve alone which is located at the northernmost part of the city. Thus, it is a challenge to connect this area to other green spaces of the city to create an ecological

network that can distribute the biodiversity all over the city.

For further assessment of the patches, the land covers were identified. Majority of the green spaces are open forests (See figure A1 in Appendix A). These spaces are mostly man-made landscapes like residential areas where trees are planted only on the sides of the roads. This further highlights the need to connect the open and medium forests to the closed forests in order to have a richer and well-distributed biodiversity in the city.

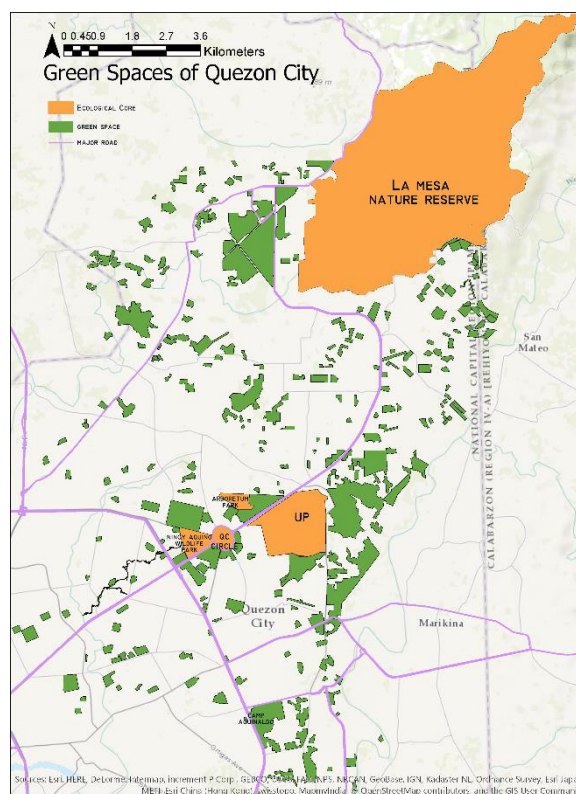


Fig. 3. Top 5 Ecological Cores of Quezon City

With a high density of green spaces, a relatively high connectivity value was also captured. Based on the City Biodiversity Index, the highest point is given to a city

when its connectivity value is greater than 1500 hectares. When the connectivity value of Quezon City was computed, only the major roads with greater than or equal to 15m width were considered as barrier. The building footprint was ignored, and this resulted to a value of 1483.154 hectares. This connectivity value shows a potential for buildings to serve not as a barrier to movement of species but as corridors to other green spaces by redesigning them with skyrise greenery e.g. green roofs, vertical gardens.

When the ecological cores were identified, five patches stood out: La Mesa Eco Park, UP Diliman, Arboretum Park, QC Circle, Ninoy Aquino Parks and Wildlife Center, and a private land with closed forest near UP Diliman. Table A1 (See Appendix A) shows the corresponding weights of these green spaces.

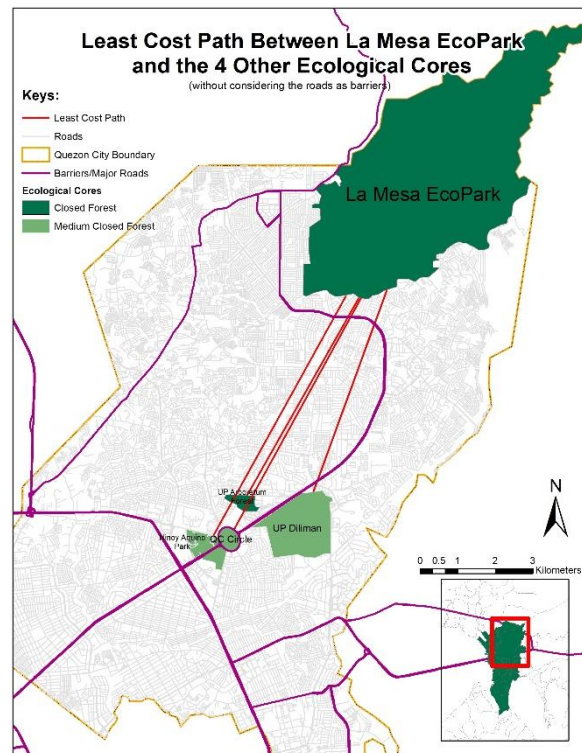


Fig. 4. Identified least cost path without considering the presence of roads as barriers

Figure B1 (See Appendix B) display the distributions of the distance index (DI) between different urban green spaces and the connectivity index. Distance Index displayed that Districts 1, 4, and 3 have higher values of DI than other areas. However, Connectivity Index indicates that the spatial pattern of green space connectivity differs among districts. The southern part of Districts 3 and 4 have extremely low connectivity of green spaces.

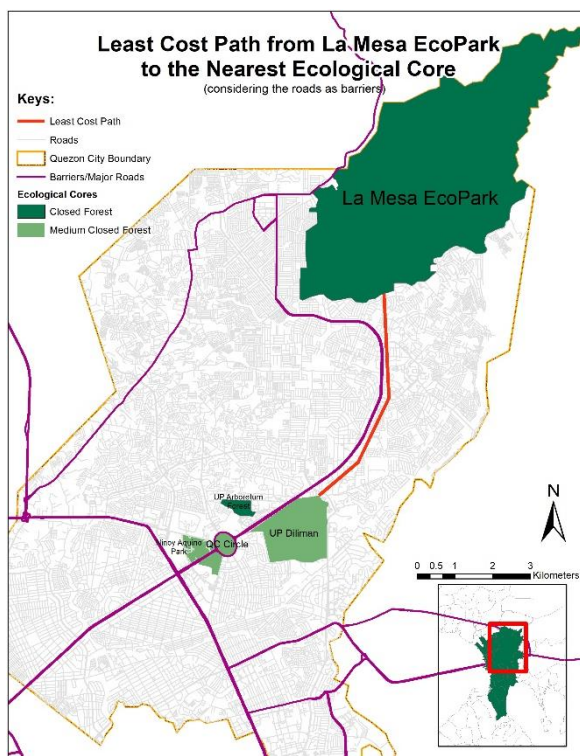


Fig. 5. Identified least cost path considering the roads as barriers

In Figure B2 (See Appendix B), connectivity and least-cost path analysis were used to identify the potential corridors to connect green space patches for ecological connectivity networks. The approach identifies and assess optimal corridors in urban environments under current and future development scenarios. In such a rapidly evolving, heterogeneous and highly fragmented landscapes, the identification of corridors which should be prioritized is important to better design, preserve and can improve ecological networks. These networks of multifunctional ecosystems are undoubtedly crucial for nature conservation and human well-being as well, since they support biodiversity, ecological processes and services in urbanized landscapes.

4. Conclusion and Recommendations

The approach identifies potential priority corridors for ecological connectivity networks. The study combined circuit models, connectivity analysis and least-cost models to identify potential corridors by integrating structure and function of green space patches to provide reliable ecological connectivity network model in Quezon City.

The landscape metrics allowed the assessment of connectivity of green space structure revealing the potential corridors and least-cost pathways for bird species at the patch sites. The implementation of improvements to the identified corridors could increase the connectivity of ecological corridors. Moreover, eco-bridges can be constructed between ecological cores that are separated by major highways to create connectivity.

Urban planners could encourage installation of vegetated roofs on buildings near larger green spaces, directly supporting ecological land use connectivity designs. Green roof organisms likely contribute to urban metapopulations, being colonized by individuals from the larger urban population as well as colonizing other nearby areas. With an increased focus on ecology in urban planning, structures could be arranged intentionally to encourage interaction between patches and promote gene flow and migration, thereby increasing habitat resilience and supporting all aspects of urban biodiversity: ecosystem, species, and genetic diversity.

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Appendix A: Green Spaces in Quezon City

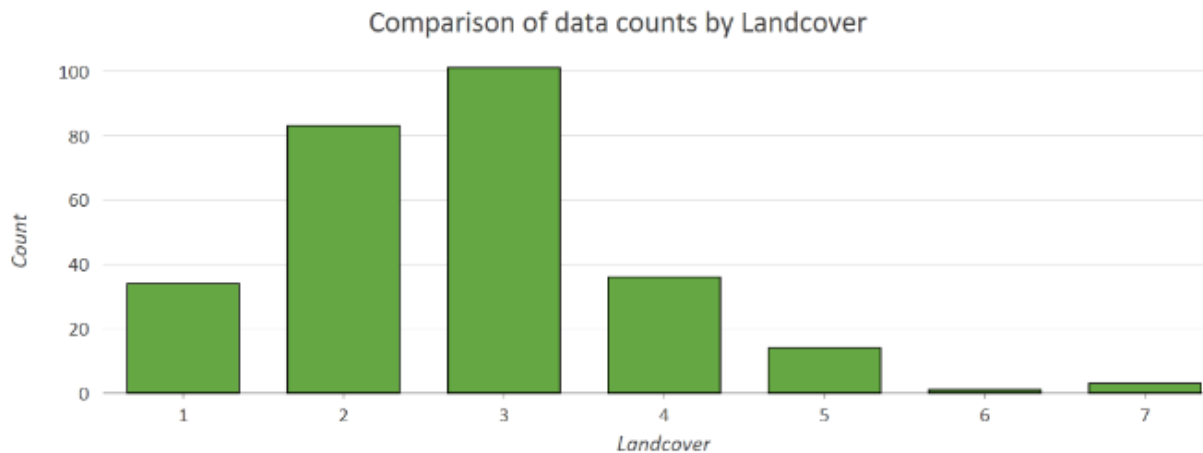


Fig. A1. Comparison of Land Cover

Legend:

- 1 – Closed Forest
- 2 – Medium Closed Forest
- 3 – Open Forest
- 4 – Grassland
- 5 – Lawn
- 6 – Swamp
- 7 – Agricultural Land

Space Name	Land cover	Perimeter (m)	Area (sqm)	Edge density	Land cover weight	Area weight	Edge weight	Total weight
La Mesa Nature Reserve	Closed Forest	28627.0412	26258075.72	10.90218548	7	5	8	20
Arboretum Park	Closed Forest	2382.189571	253626.1397	93.92523868	7	5	8	20
UP Campus	Medium Forest	6761.918802	2513940.77	26.89768543	6	5	8	19
Ninoy Aquino Parks and Wildlife Center	Medium Forest	2802.1066	455437.3433	61.52562238	6	5	8	19
QC Circle	Medium Forest	1907.343354	280846.3547	67.91412179	6	5	8	19

Table A1: Top 5 ecological cores and their corresponding weights

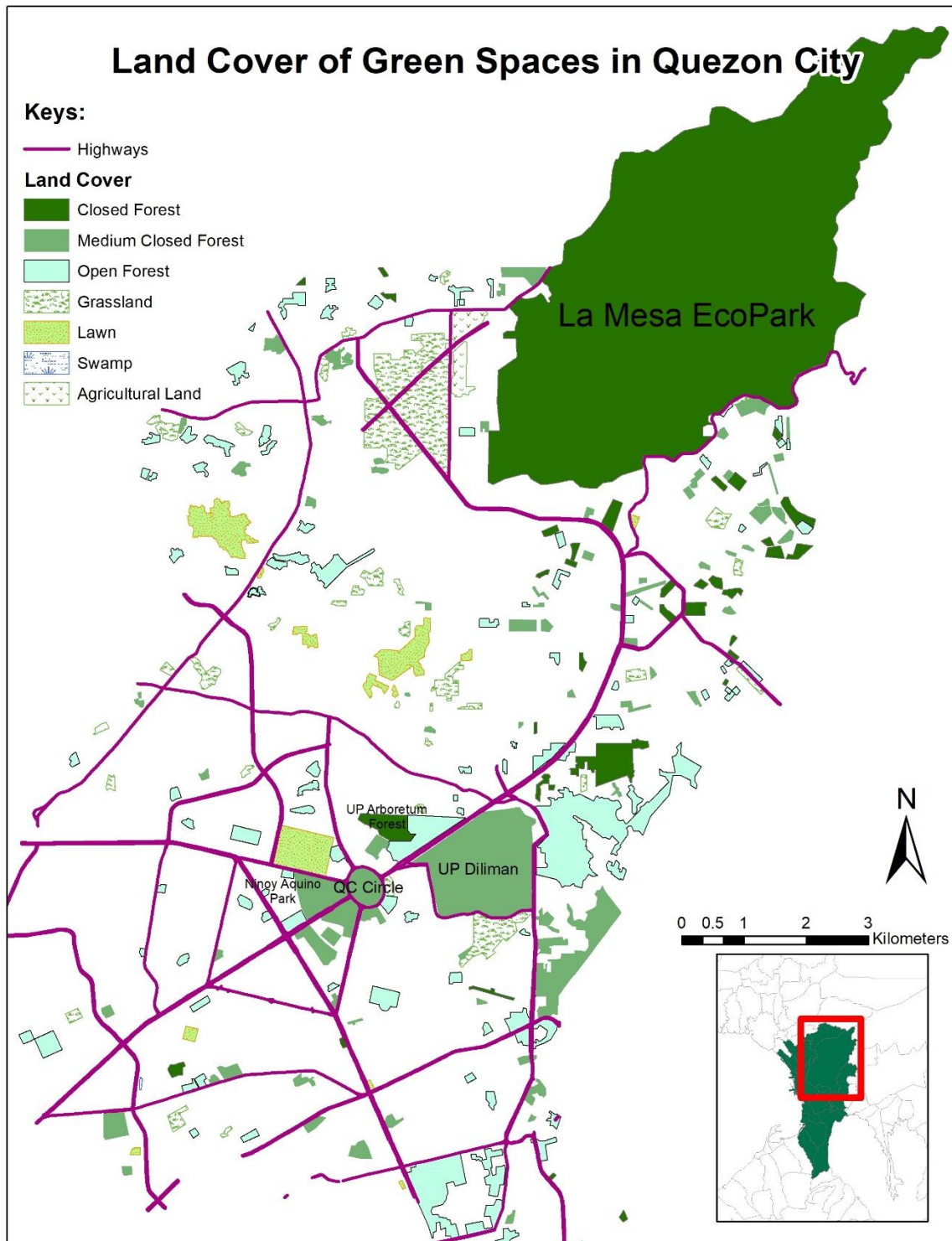


Fig. A2. Land cover of the identified green spaces

Appendix B: Processed Maps

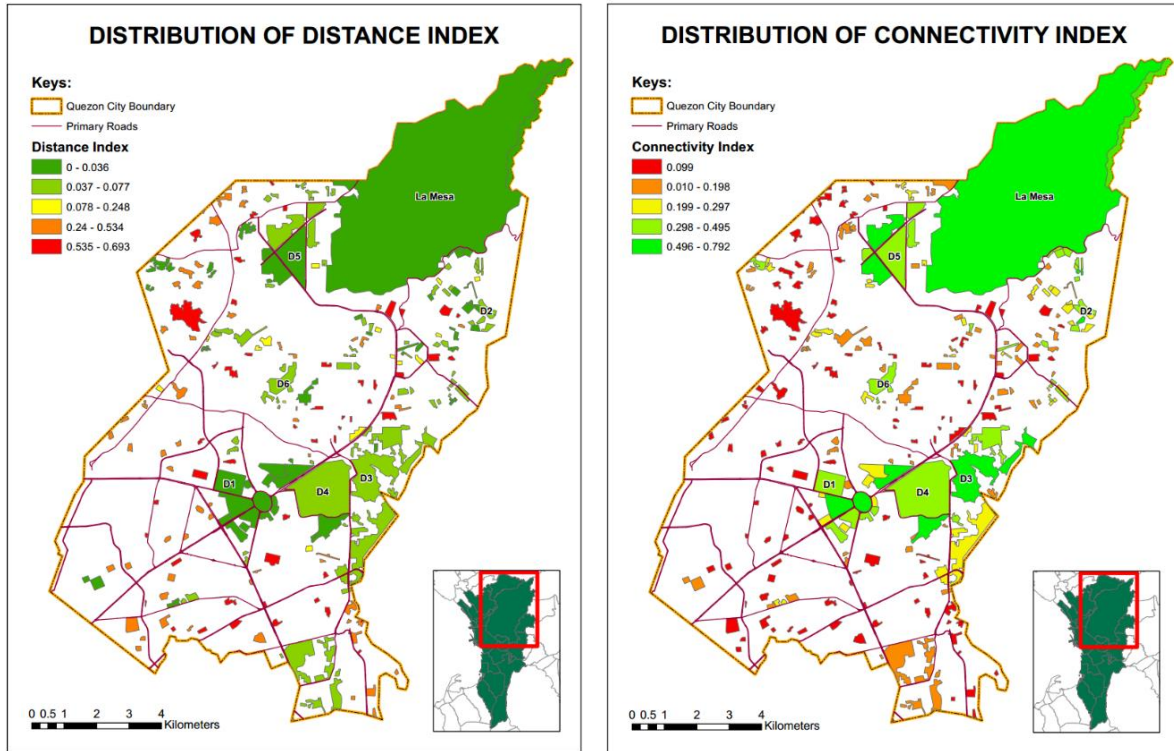


Fig. B1. The distribution of the distance index and connectivity index

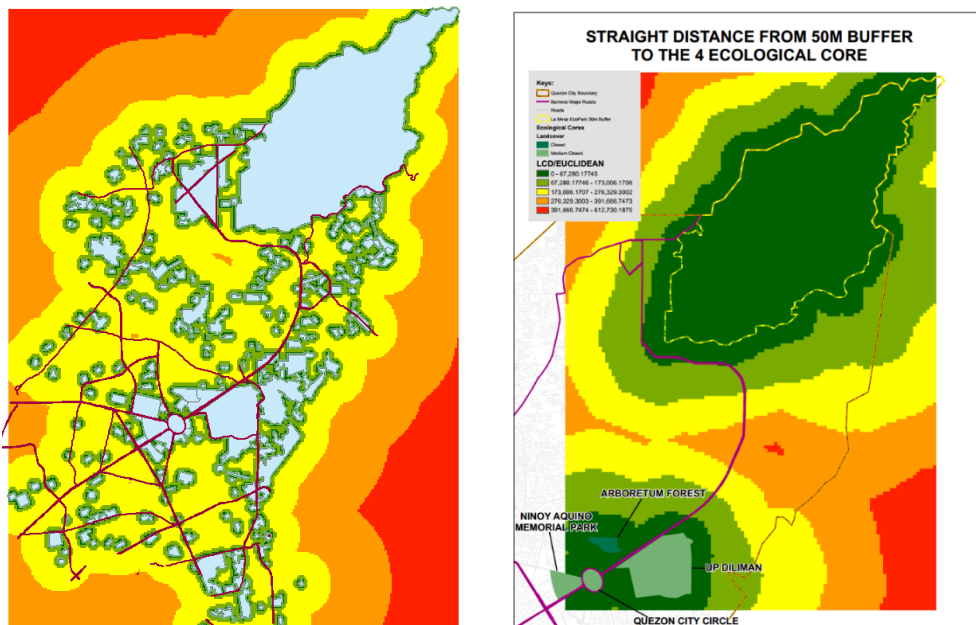


Fig. B2. The maps show the shortest path for establishment of corridor between the ecological cores without considering the roads as barriers

Smart Library for Landscape Information Modeling(LIM)

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Abstract

Recently, there have been movable and changeable architectural structures adapted to climate and environment such as dynamic façades. The landscape architecture, on the other hand, though it is a field dealing with living things, rather than nonliving things, has been limited to a fixed vision. Planting, which is more sensitive to seasonal changes than any other material, shows an everyday change in forms, colors, and texture. Yet, a sense of season is lacking when you observe bird's eye views and perspective drawing in landscape design. The most important reason for such a phenomenon is the absence of landscape architecture libraries. Therefore, designers make an error related to seasons by using a 3D image of unidentifiable trees when making a bird's eye view and perspective drawing or they do so in the process of editing and retouching images using Photoshop. To solve the problem of the absence of planting libraries, Speed Tree and Autodesk 3D Max were used for creating trees that reflect seasonal changes. Unlike the previous 2D images or 3D animations, Speed Tree and Autodesk 3D Max, which give a seasonal sense to the images by using a compatible game engine (Unreal Engine4), can visualize seasonal changes through VR. The purpose of this research is not just to produce new models. It is to find a new way available in the various digital content fields like virtual reality so that it will be used as new landscape design tools and plant libraries can be created. Research Methods analyze LOD when producing models after collecting tree species data and analyze their seasonal characteristics. Research site is the roof garden placed on the top of Graduate School of Environmental Studies(GSES) building, Seoul National University, and *Acer palmatum* is selected as a species for the modeling. This research will be a baseline in planting libraries and also proposing as a new landscape design tool. However, this research shows the limits of professional techniques in software because of its difficulty and complexity. Nevertheless, it has a provision as a new tool for landscape design when the problem of technological development is solved.

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Keywords: VR(Virtual Reality), 3D Planting Library, Seasonable Change, Speed Tree, 3D MAX ;

1. Introduction

Recently, there have been movable and changeable architectural structures adapted to climate and environment such as dynamic façades. Adding ‘movement’ to settled structures or spaces, which is the so-called Movable Architecture, has been proposed in relatively various ways for some time [1]. Likewise, there have been efforts attempting to make dynamic façades by using material and technology in a given set of boundaries and conditions. The landscape architecture, on the other hand, though it is a field dealing with living things, rather than nonliving things, has been limited to a fixed vision. As landscape architecture whose materials are mostly living things, is a field sensitive to the passage of time, its degree of changes as time goes by, is greater than that of sculptures or architectural structures. Thus, the flow of time acts as a great possibility in landscape architecture[2]. Planting, which is more sensitive to seasonal changes than any other material, shows an everyday change in forms, colors, and texture. Yet, a sense of season is lacking when you observe bird’s eye views and perspective drawing in landscape design. It is mainly because the images ignoring a seasonal sense are designed by designers who make a bird’s eye view and perspective drawing with a fixed viewpoint.

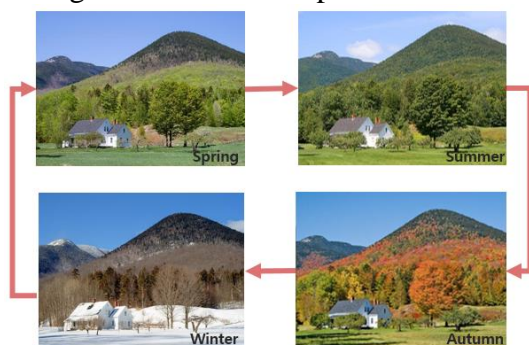


Fig. 1. Landscape seasonal change

2. Case Study

Seoulo 7017 is an elevated, linear park in Seoul, built atop a former highway overpass. The path, which opened in May 2017 and whose length is one kilometer lined with 24,000 plants, is similar to New York City’s High Line. Since Seoulo 7017 promotion image is different from its actual image, people who had a look at the promotion image became confused when they actually made a visit. Though its promotion image includes colorful flowers and flourishing trees, the reality is nothing at all like it. The gorgeous looking flowers, which in fact, look unrealistic in Seoulo 7017 promotion image, were elaborately photoshopped with computer graphics by using a picture taken at the actual spot. It only aimed to attract people to the location and as a result, a seasonal sense was completely neglected. As Seunghwan Oh, a professor of photography at Kyung-Sung University pointed out, the vision with a touch of computer graphics of an actual picture and disharmony of reality and virtual reality will destroy the idea of vegetation colors and season that people have [3]. Accordingly, the difference between the unrealistic image made in order to encourage people to take a walk and the reality has sharply come into view.



Fig. 2. Difference between computer graphic and real image of Seoulo

3. Purpose

A major cause to such a problem is the absence of landscape architecture libraries. It is because in the field of landscape, non-geometric landscape elements, such as plants, topography, and water, make it difficult to establish a material library due to the lack of information and technical skills [4]. It is difficult to establish libraries because landscape plant species are diverse in trees, shrubs, herbaceous and groundcovers. Also they look different every season. Therefore, designers make an error related to seasons by using a 3D image of unidentifiable trees when making a bird's eye view and perspective drawing or they do so in the process of editing and retouching images using Photoshop. To solve the problem of the absence of planting libraries, Speed Tree, a software which enables designers to get realistic models of tree shapes and make changes to them, is a great tool with strong potential to be utilized by landscape architects. Also, a comparative analysis between Speed Tree and Autodesk 3D Max, when making an image of the same tree Unlike previous 2D images or 3D animations, Speed Tree, which gives a seasonal sense to images by using a compatible game engine (Unreal Engine4), can visualize seasonal change through VR. The purpose of this research is not just producing models. It is to find a new way available in various digital content fields like virtual reality so that it will be used as a new landscape design tool and plant libraries can be created.

4. Methods

This research analyzes LOD when producing models after collecting tree species data and analyzing their seasonal characteristics. Tree models are made in two

ways. First, using Speed Tree for Unreal Engine4 version, a suite of 3D-modeling tools that combines the efficiency of procedural modeling with the flexibility of hand modeling, we made a 3D model of a tree considering seasonal and visual characteristics of a real tree. Second, with Autodesk 3D Max, a popular 3D software generally used by many, make a tree modeling of the same tree made by Speed Tree. After the modeling, the tree model will be exported to Unreal Engine4 and blueprinted to express the seasonal change.

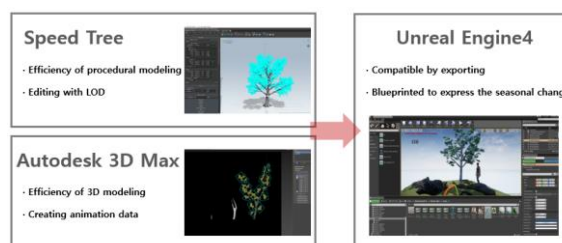


Fig. 3. Software used for methods

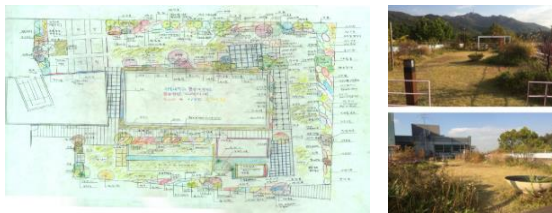
5. Site

Research site is the roof garden placed on 4th floor of Graduate School of Environmental Studies(GSES) building, Seoul National University. GSES is located in Seoul where there are clear seasonal change. This site is located in 7b plant hardiness zone which means that the plants can withstand a minimum temperature of -14.9°C to -12.3°C. The latitude and longitude geographical point is Latlng (37.462119,126.954198) in Google maps. 10 species of tree, 20 species of shrub and more than 60 species of herbaceous are planted in roof garden.

Fig. 4. GSES roof garden

6. Selection of Plants

After selecting the tree model, it is planted in the GSES roof garden. Especially, the selected tree should have clear characteristics of seasonal changes, it should be something like the evergreen tree. *Acer palmatum* is a maple tree that grows in Korea, Japan and China. *Acer palmatum* is a small deciduous tree or a large shrub with a broadly spreading crown. The plant can be grown as a small single-stemmed tree or a large multiple stemmed shrub. The form of the tree is broad-



rounded, with a layered branching structure. *Acer palmatum* has clear characteristics of seasonal changes. In the spring, new shoots grow up, and slowly, the size of the leaves increases in the summer. Then, the color of the green leaves slowly turns into red in the fall. Finally, in the winter, the leaves fall to the ground.

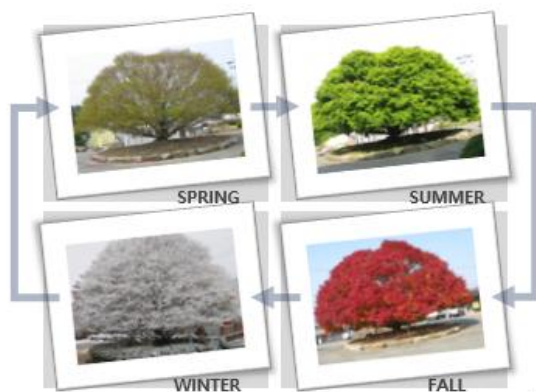


Fig. 5. Seasonal change of Maple tree

7. Speed Tree Modeling

7.1. Generation

Speed Tree is based in procedural modeling by controlling the generation. Models are built by creating a hierarchy of objects that create geometry. These objects are called generators. Each generator creates one or more components of the model based on its properties [5]. Procedural modeling allows the creation of the trunk, branches and leaves step by step. It is easy to edit the LOD (Level of Detail) because of its separated layers.

7.2. Trunk

Nodes are what a Generator makes as part of procedural modeling. Every single individual piece of geometry in the tree is a single node [5]. Nodes can be added and deleted for the users to control the trunk form very flexibly.

7.3. Branches

Maple tree forms straightened trunk height to crown base with a broadly spreading crown. Large branches separate into small twigs, and maple leaves start to show in these twigs. Speed Tree provides for the users to make a detail design by controlling the LOD properties.

7.4. Leaves

Meshes are managed in the Mesh Asset Bar. This is where users can import meshes, create new meshes and modify parameters about meshes. Users can model a mesh in any 3D software, such as Autodesk 3D Max. Transforming the mesh makes the images more three dimensionally realistic leaves. Material tools provide for the users to

manage the leave images such as mapping the texture and colors.

7.5. Limitation of Speed Tree

Tree models are available to use in various digital content fields like Unreal Enging4 by exporting in format of SRT. However, it is difficult to immediately induce seasonable changes The reasons for the limitation of Speed Tree are as follows:

1. Speed Tree can't make animation data on its own. The meaning of animation data is the growth of tree and the scale of the leaves which gets bigger or smaller. Unlike Autodesk 3D Max, there is no animation data which induces the tree to go through seasonable changes.
2. Tree models made by Speed Tree can be exported to Autodesk 3D Max. However, there are too many leaves and branches to create new animation data for each. As the leaves and branches are made randomly, it is almost impossible to create their own animation settings for activation

To improve the solution of these limitations, one can make model and create animation data by using Autodesk 3D Max. Then export the data to Unreal Engine4 to activate seasonable change.

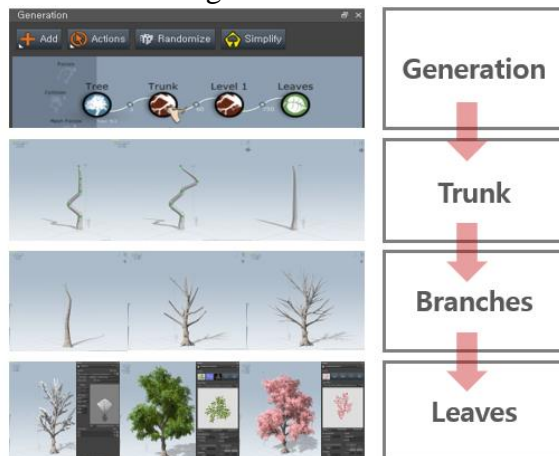


Fig. 6. Process of Speed Tree modeling

8. Autodesk 3D Max and Unreal Engine 4

8.1. Autodesk 3D Max - Modeling & mapping

First, modeling needs to be made in Autodesk 3D Max. Making two different structures is to create different animation.

1. Big structure model (trunk and branches)
2. Small structure model (twigs and leaves)

Big structure model can be used from Speed Tree because of its single structure. After the modeling, Maple tree bark will be mapped. Mapping is a method of projecting pictorial information (materials) onto surfaces. On the other hand, small structure must be made only in Autodesk 3D Max because of creating different animation for the movement of the whole twigs and leaves

8.2. Autodesk 3D MAX - Bones system

A bones system is a jointed, hierarchical linkage of bone objects that can be used to animate other objects. Bones are especially useful for animating tree models that have a continuous skin mesh [6]. Users can animate trees with forward or inverse kinematics. By making bones system in a big structure model, it is easier for users to control the growth direction.

8.3. Autodesk 3D MAX - Animation data

Animation is based on a principle of human sight called persistence of vision. Viewing a series of related still images in quick succession, perceive them as continuous motion[6]. Each individual image is referred to as a frame. Unlike big structure model, small structure model is hard to

animate in bones system because of its large amount twigs and leaves. Small structure model needs different methods of controlling animation data in order to control each twigs and leaves. After creating animation data, small structure models will be placed near the big structure model where the leaves will be grown, by copy and paste. Making different types of small structure can help the tree look more natural and not artificial.

8.4. Autodesk 3D MAX – Key animation mode

Key animation mode can animate the position, rotation, and scale of an object, and almost all other settings and parameters, by adding new tracks [6]. Track is a continuous frame which controls the time. Users can edit the time at some point to make the tree animated. In other words, it is possible to control the tree movement in each frame. Using key animation mode can make Maple tree leaves grow from inside to outside and top to bottom.

8.5. Unreal Engine 4 – Material

Export the model and animation data from Autodesk 3D Max to Unreal Engine4 in fbx format. Before animating the tree, material blueprint must be set in Unreal Engine4 by material and mapping source we made in Autodesk 3D Max. This process can make the color of the leaves color by preparing each material and mapping source.

8.6. Unreal Engine 4 – Key animation

In order to get started with animations, user will need to first add an animation track. After adding an animation track, the timeline will become active and user can begin adding Animation Keys that are associated with values that shift over time[7]. Import the animation track that was made in Autodesk

3D Max and edit to see the tree movement in each frame.

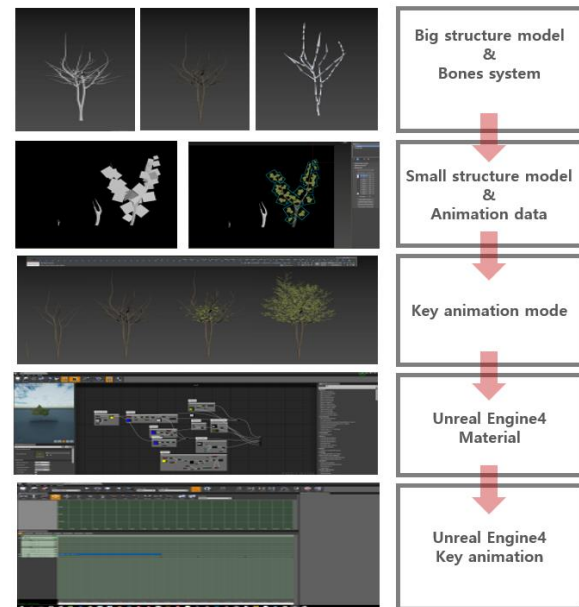


Fig. 7. Process of Autodesk 3D Max and Unreal Engine4

9. Discussion & Conclusion

In this research tree models are made in two ways. First, use Speed Tree, suite of 3D-modeling tools that combines the efficiency of procedural modeling and Autodesk 3D Max, creating modeling and animation data. Autodesk 3D Max was used to export the data to Unreal Engine4 because of the limitation of Speed Tree. By using Unreal Engine4 blueprint, the tree model showed the visualization of interactive seasonal changes that 2D images or 3D animations couldn't express before. This research will be a baseline in planting libraries and also proposing a new landscape design tool. However, this research shows the limits of professional techniques in software because of its difficulty and complexity. Nevertheless, it has a provision as a new tool for landscape design when the problem of technological development is solved.

10. Future Research

This research is on-going, and we aim to establish more planting libraries by adding diverse trees, shrubs, herbaceous and groundcovers. We are trying to add more species to those planted in the GSES roof garden and show the whole realistic landscape scenery that reflects seasonal changes. Furthermore, we are planning and developing UI (User Interface) programs to give seasonable change in the environmental factors such as terrain, water, soil, wind and climate. We are also attempting to find a way for Speed Tree animation data to activate Unreal Engine4 by making new programs. VR has a great potential provision as technical development proceeds, and it will be an innovative landscape design tool to create new ways of representing nature.

Acknowledgments

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Calibration of the Model ENVI-met V4 for Predicting the Microclimate Variation in an Urban Park

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Abstract

Urban parks have various spaces that produce an environment with specific microclimatic conditions. The microclimates have impacts on human comfort, thereby affecting the utilization of urban parks. However, it is difficult to measure the microclimatic variations of the holistic parts within a park. ENVI-met offers an opportunity to feign different planning scenarios in order to optimize planning decisions. It has been widely used in the literature and calibrated by field measurements.

This work presents the ENVI-met V4 calibration for predicting the microclimate variation in Deacheong Park, which located at Gangnam district, Seoul, South Korea. Both the fixed and mobile weather station on field campaigns and microclimate measurements were carried out during 12th August 2017 to represent a typical summer day. Our research results show very similar results between measured and simulated data of air temperature showing as root square error (RMSE) 0.76 °C, mean average error (MAE) 0.65 °C, and the index of agreement in 0.74. In addition, 3 nesting grids on each side were suggested for reducing the boundary effects and providing a better performance of the model. Our study indicates that ENVI-met model is capable of simulating the microclimatic variations in urban green spaces. It can be referenced in the practical work of parks design by predicting scenarios for real cases.

Keywords: ENVI-met model; Urban park; Microclimate; Numerical simulation

1. Introduction

Numerical models have been successfully used for understanding and predicting the variations of urban meteorological environment [1,2]. For instance, the development of MUST scheme was able to predict the detailed urban surface temperature distribution for individual buildings [3]; Jeong and Yoon (2012) used Hoyano model to evaluate the interaction between building types and outdoor thermal environment [4]; moreover, ENVI-met model was widely used for analyzing the impacts of landscape elements on microclimates [5,6]. Aforementioned numerical simulations are considered as appropriate ways to obtain the prediction of environmental performance characterizing an urban space and improve the outdoor environment. However, for getting more accurate output, it is necessary to calibrate models by comparing the simulated results to the in-situ measurements.

For this study, we focus on ENVI-met which is a three-dimensional microclimate numerical model. It is able to simulate the interactions between surface, plant and atmosphere in urban environments [7]. It offers an opportunity for research to conduct at the resolution between 0.5 to 10m with a maximum of 240 grid cells in the horizontal direction and a temporal resolution of 10s (<http://www.envi-met.com>). When using numerical models, the input weather data and parameter setting affect the accuracy of the results [8,9]. Therefore, an urban outdoor environment in fine scale can be examined by ENVI-met.

Although the ENVI-met model has been widely implicated in previous studies, there

is limited information on the detailed process of its validation. Therefore, the objective of this research is to calibrate the ENVI-met for an urban park by contrast the simulated data with field campaigns. The calibrated model can be used for further study on setting different scenarios.

2. Methodology

2.1. Study area

Our study was conducted at Daecheong Park which is located in the Gangnam district (37°49'26.4"N, 127°08'26.0"E), Seoul (Figure. 1). It is a neighbourhood park, covering a land area of 14,089 m². The canopy cover in this park consists of deciduous and coniferous trees, and shrubs of *Buxus koreana* with ~50cm. We conducted our in-situ measurements on 12th August. The day was rainless and cloudless, which represents a typical hot summer day in Seoul.

There were three principles that followed in selecting the site for our study. First, the park is not connected with the other big green areas, as those may affect the measuring results. Second, there should be a different distribution of tree canopy cover in the park, so that we are able to detect a diverse thermal environment. Third, because the topography is an important factor for the meteorological environment, the park should be flat. Therefore, Daecheong Park is suitable as the subject for this research.

2.2. Validation of ENVI-met

The study combined the fixed and mobile weather station on field campaigns. For the fixed measurement, the data was collected automatically at the 1-minute intervals by Watchdog Mini-stations (Spectrum Technologies USA Inc., USA) on three sampling: Sampling point A was set on the roof of a building of three stories that is located at the northern corner of the park with about 10m in height; Sampling point B was set at the 2 m height at the open space of the park; Sampling point C was mounted on tree trunk at the 1.5m which in the centre of the park (Figure 2). For the mobile measurement, three TR-72wf Thermo Recorders (T & D Corporation, Japan) attached to a metal pole at 0.1, 1.5 and 2 m above the ground was used for recording the air temperature and relative humidity by moving around the study area. The air temperature and relative humidity were collected by TR-72wfs at the 1-second intervals during 4 specified periods across the day: 9:00, 11:00, 13:00,15:00. A GPS (GARMIN GPS 60CS) system was also attached to the pole for recording the geographical coordinates of each sampling point.



Fig. 1. Selected site for in-situ measurements: **a** aerial view of the Deacheong Park; **b** sampling point A; **c** sampling point B; **d** sampling point C; **e** mobile measurement: a GPS and 3 TR-72wf sensors attached to the metal pole at 0.1, 1.5 and 2 m above the ground.

The input parameters for setting the ENVI-met model are showed in Table 1. Furthermore, the input parameters of precise locations, heights, trunk heights, trunk diameters and canopy diameters of the trees and the building height surrounding the Deacheong park were defined by field survey. For increasing the stability of the simulation for elements close to the border, nesting grids should be set to each side of the modeled area. However, the amount of nesting grids has an impact on the accuracy of the simulations, thus we tested models with 1 and 3, respectively.

Hourly averaged air, surface, and soil temperatures were retrieved from the fixed micrometeorological stations at the sampling point B. Specific humidity values were obtained at 2500 m for Phoenix from the University of Wyoming (2013) Department of Atmospheric Sciences [10]. Wind speed data at 10 m above ground along with data for the most frequent diurnal wind direction.

Table 1. The input parameters for setting the ENVI-met model.

Items	Input data
Simulation day	12 August 2017
Simulation time	08:00-18:00
Grid size	200*200*20
Input dimensions	dx=1m, dy=1m, dz=2m
View of rotation	322° to the North
Initial temperature	28.3°C
Relative humidity at 2m above ground(%)	51.8%
Wind speed at 10 m	1.79m/s
Wind direction	145°
Specific humidity in 2500m	7.29 g/Kg

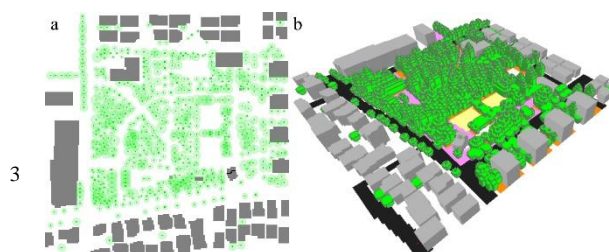


Fig. 2. **a** The input area domain for ENVI-met; **b** 3D version of input model

2.3. Data analysis

The accuracy of the simulated results was evaluated by root square error (RMSE), mean average error (MAE), mean bias error (MBE) and Willmott's index of agreement, which is a statistical index of model performance.

3. Result

3.1. Comparison of the observed and modeled air temperature for fixed measurement

The comparison between the observed value of fixed measurement and the modeled temperature at corresponding height was shown in Figure 4. It seems that the ENVI-met tends to over-predict the air temperature for both open space and under canopy. The difference between simulated values and measured values under canopy were higher than that at open space.

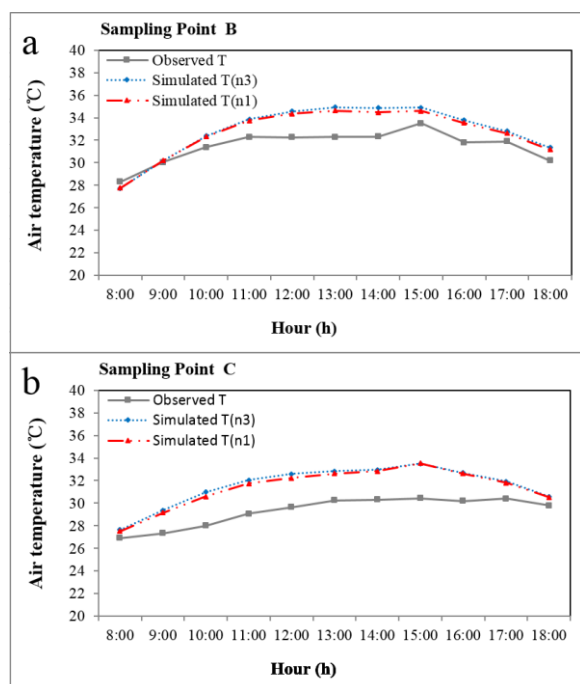


Fig.3. a hourly mean temperature of the open space (sampling point B); b hourly mean temperature under the tree canopy (sampling point C).

We compare the accuracy of simulated results between the model with 3 nesting grids and 1 nesting grid. The result showed that there are little differences between the model with two models, the indexes of agreement were all over 0.7 (Table 2). However, 3 nesting grids were selected for further assessment as the it helps to increase the stability of the simulation for elements close to the boundary of the study area.

Table 2. Quantitative measures of the performance of the ENVI-met model with different nesting grids based on observed and simulated air temperature.

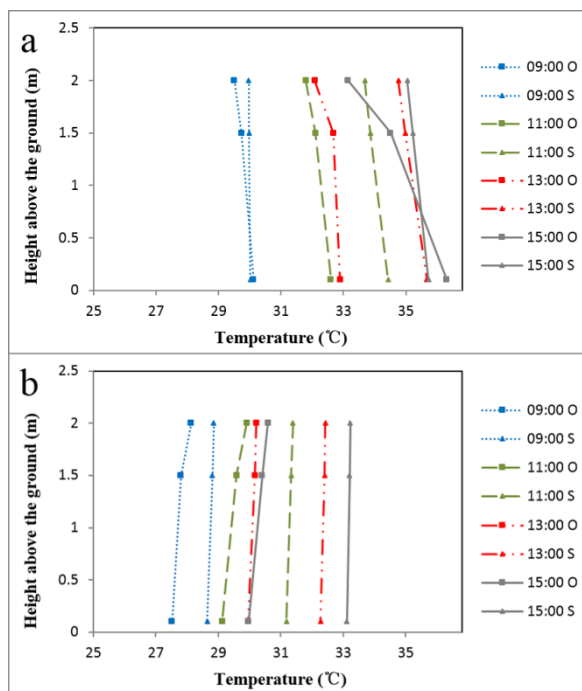
	Sampling point B		Sampling point C	
	NG=1	NG=3	NG=1	NG=3
MBE(°C)	1.19	1.27	2.08	2.01
MAE(°C)	1.29	1.04	2.08	2.01
RMSE(°C)	1.46	1.59	2.22	2.16
d	0.84	0.80	0.71	0.70

a. d is dimensionless difference measure of the index of agreement; NG: the number of nesting grids.

3.2. Comparison of the observed and modeled air temperature for mobile measurement

The vertical observed records of the temperature were compared to the simulated temperature with similar height in the model (Figure 4). Even though ENVI-met overestimated the temperature, it enables to perform a similar vertical gradient when compared to the observed data. In the open space, the temperature is higher when closer to the ground surface. Conversely, the temperature under the canopy was lower when it reached closer to the ground surface.

Finally, the accuracy of simulated results in vertical distribution was also evaluated by using Willmott's index of agreement. The MBE for all comparisons shows that the model generally over-predicted temperature



by 0.51-2.55 °C (Table 2). MAE ranged from 0.59-2.55°C. The larger error occurred during the afternoon (i.e., 13:00 and 15:00). In general, the simulated air temperature fits

Fig.4. Mean vertical temperature of Deacheong park at 0.1m, 1.5m, and 2m. a) Mean temperature of the open spaces; b) Mean temperature under the tree canopy. O: observed result; S: simulated result.

well with measurements as the acceptable magnitudes of index of agreement by 0.69-0.88.

	2m	1.5m	0.1m
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Table 3. Difference measures of ENVI-met model temperatures with observed date at different time periods.

	09:00	11:00	13:00	15:00	09:00	11:00	13:00	15:00	09:00	11:00	13:00	15:00
MBE (°C)	0.59	1.68	2.45	2.09	0.62	1.76	2.26	1.58	0.51	1.94	2.55	1.09
MAE (°C)	0.59	1.68	2.45	2.09	0.65	1.76	2.26	1.58	0.72	1.94	2.55	1.68
RMSE (°C)	0.63	1.71	2.47	2.12	0.76	1.78	2.28	1.83	0.85	1.96	2.58	2.03
d	0.69	0.79	0.80	0.81	0.74	0.83	0.79	0.85	0.83	0.88	0.87	0.88

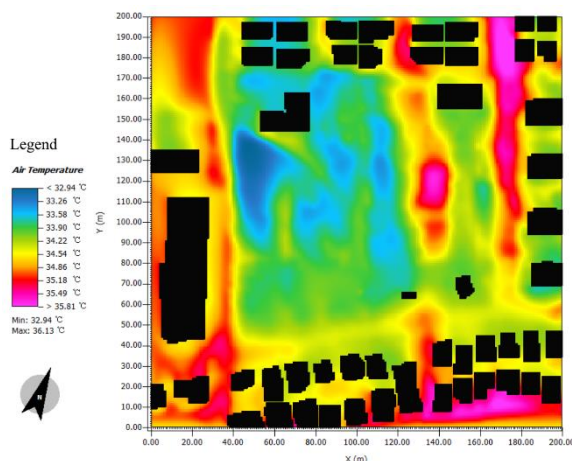
4. Discussion and conclusion

ENVI-met model reasonably

Fig.5. Simulated result from ENVI-met model: air temperature distribution at 15:00.

approximates the observed data for this study, similar weather conditions were presented throughout the experimental day. However, diurnal predicted air temperature was higher than the recording of in-situ measurement. This contrasts with previous studies that found ENVI-met to underestimate the diurnal air temperature [11,12]. This is likely caused by the added nesting grids, as no objects can be placed inside the nesting area due to solar radiation that can reach the surface undisturbed which often results in an unrealistically high temperature of the ground surface in the nesting area. This is especially true when non-evaporating surface materials have been used [13].

In this study, the 3D urban microclimate



model ENVI-met (version 4.0) was used for evaluating the thermal environment at a neighbourhood park during a typical hot summer day. The results show that the ENVI-met model had a good performance

on simulating both the horizontal and vertical distribution of air temperature. Furthermore, the predictive ability of the software on other factors such as mean radiant temperature and human comfort index are also needed.

Acknowledgments

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Mapping the Equivalent Vertical Sunshine Duration Curve of Outdoor Space beside Buildings for Dynamic Landscape Planting Design

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Abstract

Dynamic shading behavior between buildings and other objects has been suggested as one way of changing microclimate and the change in microclimate that would in turn reduce the demand for heating and cooling. Understanding the dynamic shading behavior is an important aspect of the correct consideration of the sunshine in a built environment. Clearly, in order to reach the ideal landscape model for planting design, the light environment for plant growth also has to be taken into consideration. This study of dynamic sunshine distribution takes university buildings as a case to discover and discuss the light comfort zone for plant growth in the area adjacent to the buildings. In addition to simulating a shadow map that displays the duration of shadow at ground level a further number of shadow maps are constructed to represent the shadow patterns and durations at different heights above the ground. These are analyzed to gain an understanding of the vertical distribution of sunshine and its duration. Therefore we developed a novel concept, equivalent vertical sunshine hours curve (EVSH Curve), for different seasons and heights to review the required sunshine conditions for greening around a building. At the same time the behavior of the non-symmetrical light environment was observed on both sides of the portico due to the influence of nearby buildings. A more comprehensive deeper investigation of the light environment will indicate a more appropriate planting design for a greening place in a built environment.

Keywords: sunshine duration curve; planting design; vertical light environment;

1. Introduction

Sunlight is one of the essential elements in the ecosystem, and it has been proven that the quality, intensity, and duration of light directly impact plant growth. The quality of sunlight refers to the color or wavelength reaching the plant's surface, and output peaks of sunlight on the ground should also be in the visible range. The intensity and duration of sunlight varies significantly under different conditions, such as latitude, season, region, and even the geographic location. In response to the above characteristics of sunlight, plants control their internode length, leaf size, count, and the density of their chloroplasts. Plants also determine the optimum timing for flowering and other physiological processes (Levitt, 1980;

Boardman, 1977) from those characteristics of sunlight. Therefore proper and effective usage of sunlight always has been an important consideration in horticulture and landscape architecture (Robert, & Gillespie, 1977).

Recent studies of sunlight in the residential environment have been focused on techniques for reducing the intensity of the urban heat island effect and reducing the energy consumption of buildings

(Wong, & Chen, 2009; Rosenfeld, Akbari, & Romm, 1998). Simulation models and experiments have indicated that the use of vegetation could be an effective approach for changing the microclimates of outdoor and indoor environments (Burbia, & Bucheriba, 2010; Argiro, & Marialena, 2003). Akbari and Taha conducted a large-scale simulation and reported that increasing the vegetation

surrounding a city by 30% and the vegetation around houses by 20% would decrease the costs for cooling in the city by 30-100% (Akbari, & Taha, 1992). Small-scale controlled experiments also have demonstrated that trees placed along the wall of a house can reduce cooling costs by 26 - 47% in a region that has a mild climate (Akbari, Kurn, Bretz, & Hanford, 1997). In a region in which the climate is hot and humid, shade trees can provide as much as 80% of the desired cooling effect (Limor, & Hoffman, 2000). Further studies demonstrated that trees planted with different layout in a yard and at different distances from a building could change the indoor environment, e.g., reducing the harvesting of the heat energy in sunlight by the structures, decreasing natural ventilation, and so reducing the use of air-conditioning (Stavarakakis, Zervas, Sarimveis, & Markatos, 2010; Yang, 1997). As we noted above, the relationship between buildings and trees is an important consideration, and most of the earlier investigations were focused on the beneficial influences of trees on the microclimates of buildings.

Conventionally, greenery was often provided around buildings in spaces where sunlight was often obstructed and so the plants encountered environmental stress for their growth. The lack of sufficient sun exposure slows the rate of photosynthesis and the production of chlorophyll in ground plants. Long-term deprivation of sufficient light exposure will result in unhealthy plants and unfavorable conditions for the differentiation of flower buds (Cain, 1971) and the development of fruit (Seeley, Micke,

Kammereck, 1980) that influence ornamental quality and the greening effect, but few studies have addressed the location and growth condition of trees subject to the shading effect from nearby buildings. Yezioro and Capeluto et al. (Yezioro, Capeluto, & Shaviv, 2006) evaluated the ratio between the insulated area and the total examined area for a period of a year at an urban square with a specific width, length, and height. The recommended insulated and shaded areas of such a design were presented, and the best locations for deciduous plants and evergreen trees were indicated. Wan and Jun (Hongbing, Jun, Yonghong, & Li, 2010) performed a case study to optimize the planting design between residential buildings and meet good daylighting requirement. The proposed model helps us to determine which trees to plant between buildings and to realize good daylighting in a built environment. Lin et al. (Lin, Ling, & Chang, 2007) calculated the distribution of sunshine duration around buildings on a university's campus. According to different plant distributions, such as orientation or the distance to the building, the shading impact of nearby buildings on the growth conditions of the trees was demonstrated. The result illustrated the conventional "symmetric" or "row" plant design was usually unable to allow a light environment fit for plant growth. Unlike non-living objects such as statues, street lamps, chairs and ponds, plants grow and alter as time passes. When striving to create a "comfort zone" for human beings, the comfort zones for plants should also be understood and taken into consideration in order to create a mutually beneficial environment for plants and human beings.

2. Method

In this work, we developed a visual and directly perceivable method, namely the equivalent vertical sunshine hours (EVSH) curve, to demonstrate the sunlight environments at different seasons and heights, and we further analyzed the distribution and duration of sunshine as these are influenced by adjacent buildings. This approach was intended to discover and present the information required to design optimal planting schemes for different seasons and at different ages. If the EVSH curve used for this study can, in fact, be used to predict the growth restriction and condition of the plant and give advice on ex-ante evaluation of planting design, this approach can become a much needed tool for “sunlight prediction first; plant choice second; design last”.

The evaluated area of sunshine conditions was the main campus of National United University, Miaoli County, Taiwan (24°N, 120°E). Since the shadow map was highly related to the arrangement of the buildings, partial campus layout including height of the building is illustrated in Figure. 1. The main research area for determining the duration of sunlight that the plants received during different seasons was the greening place in front of the three-story building (building 1), and a detailed map of the investigated area is shown in Figure. 2. There were ten *Juniperus chinensis* planted in front of the building, and the growth performance characteristics of each plant such as, bend direction and shoot tip displacement are illustrated

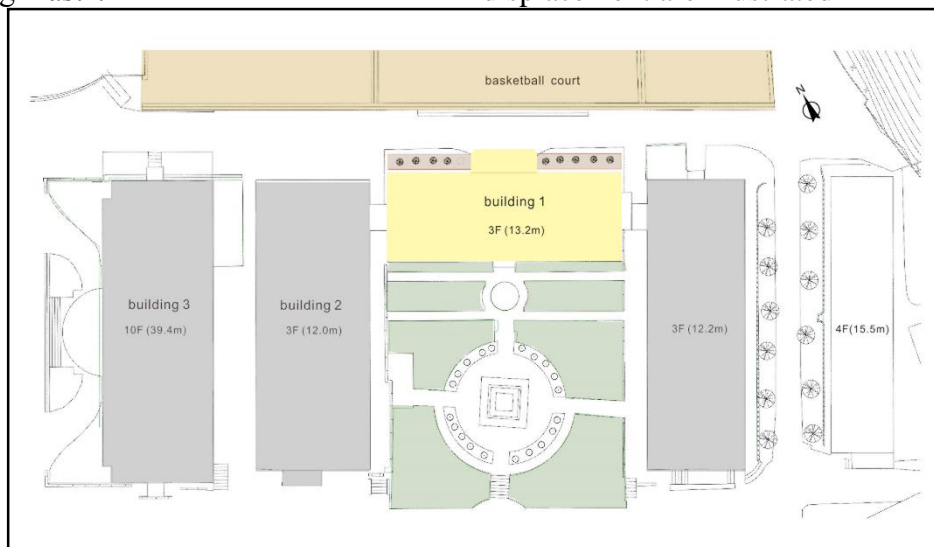


Figure 1. The partial campus map of the buildings at National United University.

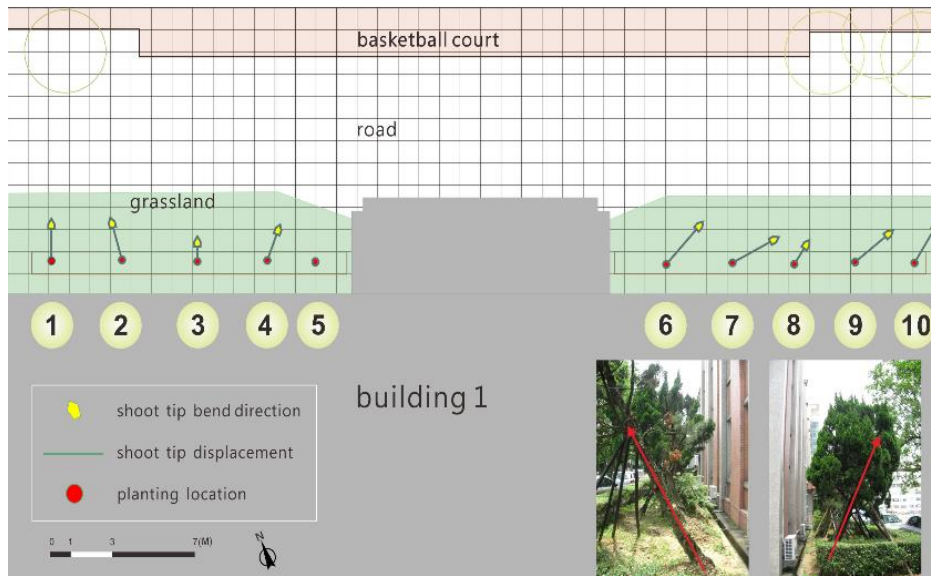


Figure 2. Planting arrangement in front of the building 1. There are ten *Juniperus chinensis* planted in rows on the north side of the buildings, and because of the non-uniformity of the light environment at the area, phototropism results in severe tilt of the trunks, as shown in pictures.

2.1. Simulation of a building's shadow at different elevation

For easy comprehension by designers, we drew shadow graphs at different elevations, i.e., ± 0 m, +1 m, +3 m, +5 m, and +10 m by using the Revit software. The setting of four different elevations above the ground level (± 0 m) was based mainly on the circumstances that +1 m is the average shrub height; +3 m and +5 m are the average heights of a small arbor, and +10 m is for a mature arbor. The open space on the north side of buildings was delimited and divided into a 1 m x 1 m grid. We decided to determine the number of hours of sunshine in each grid.

2.2. Accumulation of grid sunshine hours

Shadow distributions at five elevations were determined every hour from sunrise to sunset at the vernal/autumnal equinoxes, and at the summer and winter solstices respectively, and then the two-dimensional sunshine hour distribution of each equinox or solstice at different height was obtained by calculating the shadow distribution on the grid. The sunshine hour map with different elevations at winter solstices for example is shown in Figure 3. The two sides of a building's portico are generally key greening places because that is where people enter the building and form their first impression of the building. So we also conducted further analyses of sunshine hour distributions 1.5 m

away from the right and left sides of the portico.

2.3. Overlapping and transforming the top view into a section view

Through use of overlapping sunshine hour distribution with various height from 0 m to 10 m, sunshine hour distribution near two sides of portico were transformed from top view to section view referred as the EVSH curve, as shown in Figure 4-6. The curves represent the influenced "equivalent" sunshine duration range as modified by the shadow of the buildings

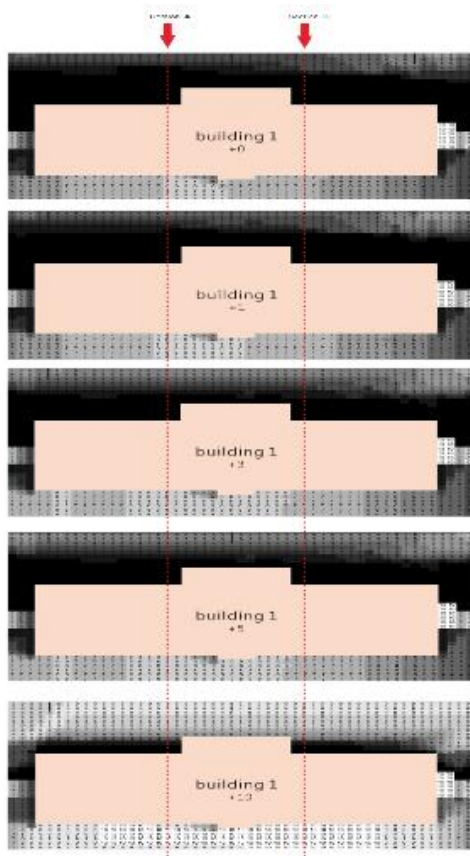


Figure 3. Sunshine duration maps with different elevation around the building 1. (a) at ground level (b) at an elevation of 1 m (c) elevation of 3 m (d) elevation of 5 m (e) elevation of 10 m. The line on the map is the border between section A and B.

2.4. Ranges of sunshine for plant growth

The average sunshine duration in Miaoli County, Taiwan, at vernal/autumnal equinoxes and the summer and winter solstices are 12, 13.6, and 10.5 hours respectively. In this work, we take three sunshine duration ranges namely 1-4 hr, 4-7 hr, and 7-11hr for sun-shade plant growth under most conditions in winter, vernal/autumn, and summer as points of departure when we discuss optimal locations and arrangement of plants. In turn those findings will be captures into design guidelines.

3. Results and Discussion

To analyze the influence of sunshine duration at equinoxes and solstices, the EVSH curves of two sides of the portico are discussed in the following sections.

3.1. EVSH curves of section A and B at vernal/autumnal equinoxes

As illustrated in the Figure 4(a), the EVSH-4 curve of section A showed that the point which gets four hours of sunlight is located 3 m away from the building, but the

point that also got four hours of sunlight moved inward by 1.5 m at a height of 10 m. The number of hours sunlight that a curve depicts is given by the number following the capital letters EVSH. In the same manner, if a plant requires seven hours of sunshine at the ground level, it must be shifted 6 m outward, reaching 9 m away from the building. In contrast, the points of EVSH-4 and EVSH-7 at the height of 10 m are 1.5 m and 3 m away from the building, respectively, and their relative distance is 1.5 m, which is much shorter than the relative distance at the ground level. In other words, the height of the plant should be more than 10 m to receive 7 hours of sunshine at the distance of 3 m. The distribution of the EVSH-7 curve of section B is approximately the same as in section A, sketched in the Figure 4(b). However, when the elevation is less than 5 m, the EVSH-4 is significantly different from the EVSH-4 curve of the section-A.

3.2. EVSH curves of section A and B at the summer Solstice

As illustrated in the Figure 5, the shadow area of the three-story building was narrower than it was at vernal/autumnal equinoxes due to a higher solar elevation angle at the summer solstice. The EVSH-7 curve in section A was revealed in Figure. 5(a) and one can observe that the point to get 7 hours of sunshine on the ground was 2 m away from the building, but at a height of 10 m, the distance is reduced to 1 m. Similarly, the point to get 11 hours of sunshine on the ground was 6 m, whereas, at a height of 10 m, the required distance was only 2 m. Therefore, 2 to 6 m away from building is the region that has 7-11 hours of sunshine on the ground at the summer solstice, and there is a 4 m difference between height at ground and 10m

of the EVSH-7 curve. Figure 5(b) indicated the EVSH curve of section B; the distribution of the EVSH-11 curve is approximately the same on both the east and west sides, but the distribution of EVSH-7 curves on the two sides were different.

3.3. Deduction of "light comfort zone" from EVSH curves by comparison of two sections of the overlapping diagrams

In Figure 6(a), one can observe the point of the EVSH-1 curve of section A on the ground was 8 m outward from the building. The points of the EVSH-4 curve on the ground and at a height of 10 m were shown to be 13 m and 3.5 m away from the building, respectively. It means that there is 9.5 m difference in the EVSH-4 curve between ground level and at the height of 10 m. In section B as illustrated in the Figure 6(b), the curve of EVSH-4 is approximately the same as the section A. Due to the influences of the portico and the ten-story building, the distance of EVSH-1 was 1.5 m further away than it was for the section A.

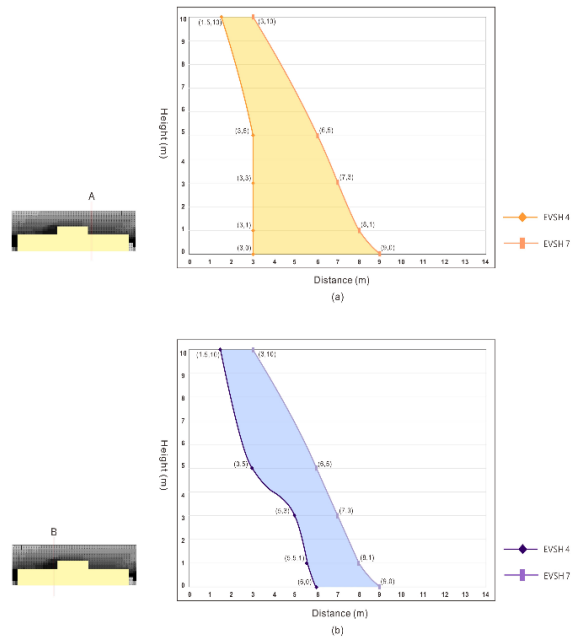


Figure 4. The EVSH curve at the vernal/autumnal equinoxes. (a) section A and (b) section B. The equivalent vertical sunshine hours were 4 and 7 respectively.

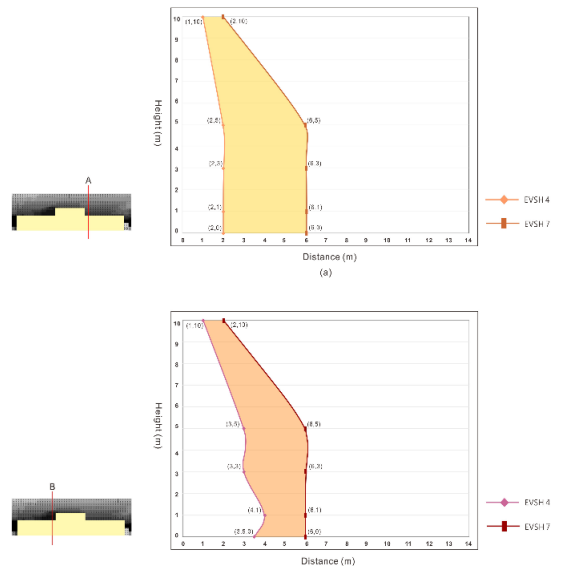


Figure 5. The EVSH curve at the summer solstice. (a) section A and (b) section B. The equivalent vertical sunshine hours were 7 and 11 respectively.

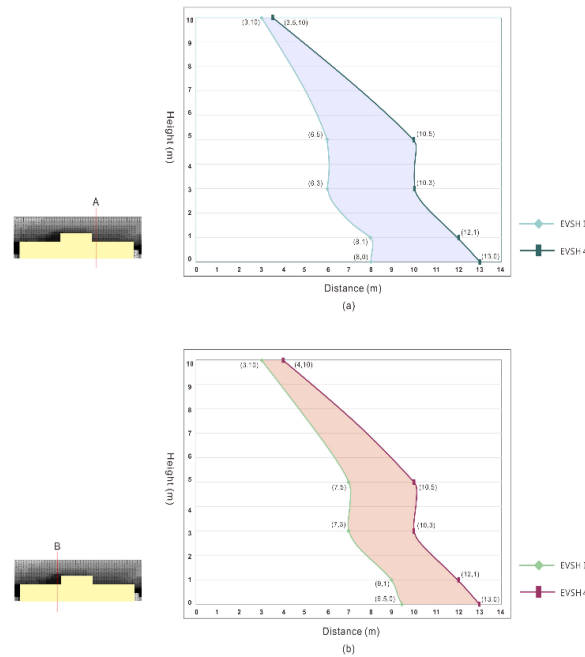


Figure 6. The EVSH curve at the winter solstice. (a) section A and (b) section B. The equivalent vertical sunshine hours were 1 and 4 respectively.

3.4. Deduction of "light comfort zone" from EVSH curves by comparison of two sections of the overlapping diagrams

When the sunshine duration maps of the section A and B are overlapped, as shown in Figure 7, one can easily observe the difference between the two. At vernal/autumnal equinoxes, the distributions are obviously dissimilar at the section A and B of the portico. As we can see in Figure 7(a), the sunshine hour distribution near the section A of the portico was influenced by the shade effect of the three-story building itself, but it was rarely affected by the portico itself or the ten-story building. The recommended

planting location at equinoxes for a popular shrub, with a growth height of less than 1 m, is 3 m away from the building on the section A. However, if one would like to set the plant on the section B of the building, the location of the plant stand should be set at least 6 m away from the building so that the plant has at least the required four hours of sunlight as also can be observed from Figure 4.

In comparison with the vernal/autumnal equinoxes, at the summer solstice a smaller area was covered by the building's shadow and the variation of the shadow pattern by the portico was less notable at heights less than 5 m, as shown in Figure 7(b). However, shadow patterns at heights greater than 5 m

were different between the section A and B; this was attributable to the extension of the shadow of the ten-story building at the afternoon. Another intriguing point was the elevation of 1 m at the section B of the portico where the more shaded area was observed. It is counterintuitive that less area would be shielded as the height increased. Actually, the real condition can be obtained only by careful consideration of the buildings located farther afield.

Taiwan is located in a subtropical region, and high temperatures usually persist throughout the summer. It has often been suggested that creating shade by planting trees was a useful approach to change the microclimate of the adjacent buildings. When the proper amount of shade is provided by buildings, it is advantageous for the plants. As shown in Figure 7(b), placing plants 6 m away from the building does not allow the building to provide sufficient shade for the shade plants, so it was preferable to locate shade plants within 6 m away from the buildings.

At the winter solstice, the duration of the sunshine on the north side of the building was insufficient when it was originally determined. Taking 4 hours as the expected value, the distance required was at least 13 m away from building, reaching to the basketball court, as shown in Figure 7(c).

Due to the low solar elevation angle in winter, most sunlight is blocked by the building, and a great increment of shadow length was observed; therefore, the shadow created by the portico was minor, and the difference of the sunshine hour distribution at the section A and B was not significant. On the other hand, in order to make better use of sunlight and to save heating energy, generally, it was realized that placing deciduous plants alongside a building would not block the natural lighting of the windows in winter.

Through the analysis of the distribution of sunshine duration from vernal to autumn, we can conclude 5 m away the building was the better location for planting a sun-shade tree. Moreover, shrub should be planted 2-3 m and 4-6 m away from the building at the sides A and B respectively to obtain the same sunshine hours. As noted above, this design approach was a not symmetrical layout. If plants are planted without considering the duration distribution of sunshine, the growth conditions and the ornamental quality of the plants could not achieve the desired effect. This approach helps for the rapid creation of unique and imaginative landscape designs, and decreased costs for maintenance.

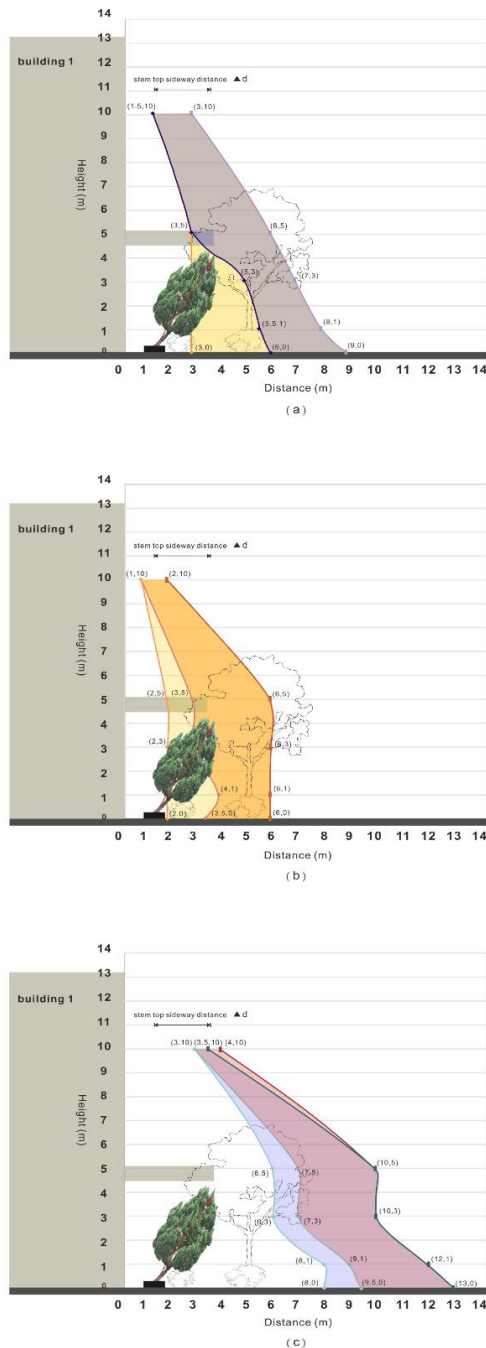


Figure 7. The overlapped EVSH curve of the section A and B at different seasons. (a) at the vernal/autumnal equinoxes (b) at the summer solstice (c) at the winter solstice. Drawing outlines represent the better location for planting a sun-shade tree or a shrub.

4. Conclusions

In the northern hemisphere, most areas on the north side of buildings are faced with the problem of insufficient sunlight. However, a green and beautiful entrance scene can be constructed successfully so long as ornamental plants with shade tolerance are placed at proper distances from the building. In this work, we present the EVSH curve as a novel concept to review the required sunshine conditions for greening around a building. The EVSH curve can also be applied in reducing the maintenance cost of the plants in the built environment and for mastering the guidelines of "sustainable landscape design" before the commencing with the construction. In particular involving the concept of the EVSH curve for the layout design of roadside trees, flower beds, and plaza greenery in urban environment, one can determine the relevant conditions in advance as follows: (1) Sun plants or shade plants to be selected (2) The proper planting distances from buildings (3) Plant height and expected growth height (4) Planting seasons and ages of tree.

Three of the findings from simulation and on-site observation are worth summarizing:

4.1. Visualized quantitative data was beneficial for landscape design in helping to make decisions according to local conditions

Planting design and arrangement in accordance with local conditions are important. Conventionally, the meteorological data in a contained environment such as a greenhouse was monitored on a regular basis in order to know the optimal region for the trees and flowers. However, due to the city's varied topography and building patterns, weather conditions may vary from block to block. It is always laborious and costly work to acquire long-term meteorological data in a built environment to determine the optimal species of plants adapted to the different light conditions. The computer simulation techniques involved in making such an extrapolation can be quite effective and accurate. In the study, the visualized sunshine maps reveal that not only shade effect of the three-story building (building 1) but also the shade effect from building 2 and 3 should be taken into consideration; moreover, sunshine hours at different elevations were also displayed for evaluating their growth conditions. As far as the case is concerned, arbor planting in a symmetrical configuration did not coincide with the symmetrical sunshine condition. At the left side of the portico side B, the sunlight distribution resulted in an adverse situation for the growth

of grass and shrubs, and one solution for the situation was to cultivate ornamental plants with shade tolerance.

4.2. Vertical elevation effect on the light environment: arbor-shrub-grass

Generally, the canopy layer of arbor is the main area for photosynthesis, and the direction of plant growth is also modified by the light environment. In this case, the *Juniperus chinensis* lean outward to the EVSH curve; moreover, the sparseness of branches and leaves of *Juniperus chinensis* can be observed in the shaded area, as shown the pictures in Figure. 2. The multi-layer planting approach was a promoted index in the field of green building design. In order to reach the maximum greening effect, the comprehension of the vertical sunshine distribution is an essential task during the design, and the developed EVSH curve could provide an alternative approach to expand the design in scope and depth based on this quantitative analysis in the future.

4.3. Construct a plant "Light Comfort Zone" to promote "the optimal 4-D design"

Since four clearly distinct seasons is the characteristic of the climate of subtropical zones, the impacts of creating shade in sunshine conditions obviously vary with the different seasons. The four dimension (4-D) light environment including space and the seasonal change for plant growth is worthy of detailed analysis. In summer, the overheated period in Taiwan lasts 2-3 months. If one can take the advantage of the shading effect from the buildings, it would be possible to

transform limits to positive potentialities for plant growth. To reveal the facts hidden in the ecosystem by observation is one meaning of the "visual ecology" in a built environment (Robert, Thayer, 1976). It is a powerful method to construct a mutually beneficially environment between nature and design.

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FUTURE RESILIENCE



[FEATURED SESSION SPEAKERS]

DAY 1 TIME: 14:00 – 14:20

The Ripple Effect - Building the Future of Resiliency

Ming-Jen Hsueh

Landscape Architect
Sasaki Associate
United States of America

Synopsis:

The world is growing fast, especially in the urbanized areas. Urbanization is a complex phenomenon that involves change in multiple dimensions, including a growing number of people who live in urban areas, the expansion of built environments, and changing norms, cultures, and ways of living. It is a complex and connected network in which every decision has far-reaching consequences. It is also a living system in which ecology, economic exchange, policy, and social justice inform and intersect one another. Our environment is reacting to the rapid changes we have made, as a result, the projection and prediction of impact have surprised us more frequently in reality than ever before. None of the major challenges of modern cities facing, whether it is poverty, environmental degradation, social segregation, transportation or inequality, exist in isolation of the others. Globalization not only reflects the interconnected economic and social system, but also changes the scale of the event and of vulnerability. It leads to a re-thinking of the scales of resilience as a chain of network.

Sometimes, the projection in sea level rise and the growing urban phenomenon do not correlate to scale of living in people's daily life. It has to be geographic sensitive when we talk about the future of resiliency. It is important to think regionally yet with a systematic network in mind. We also need a plan that looks beyond preparation but also mitigation and resiliency in many aspects. The plan will build a consensus and facilitate among different agencies and for the public to have a right channel to understand the complex issues and prepare accordingly. As a result, the messages and delivery for such a comprehensive issues have to be carefully thought through to have a more inclusive dialogue, especially for the group that is most vulnerable when the event arises. A community's connection to place is at the very heart of resilience.

Although the message should be as simple as it should be, we do need layers of strategies that is interdisciplinary and looking beyond the conventionally defined resiliency in the urbanized areas, to investigate the potential issues that is caused by the climate change or other human factors. The urban resiliency is a transformative concept that requires the new approaches to address both the flexibility and efficiency without compromising. It also should be an integrated concept that pushes the boundaries of understanding in the contextual conditions across social, ecological, economic and systems that allow agencies to adapt and learn. In the lecture, Ming-Jen will share cases in Boston and other global cities who have taken on these unprecedented challenges.

DAY 1 TIME: 14:20 – 14:40

Living Infrastructure + Resilience

Gena Wirth

Design Principal
SCAPE Studio
United States of America

Synopsis:

Gena Wirth, Design Principal at SCAPE, will talk about SCAPE's work advancing coastal resilience through the design of living infrastructure. She will feature two projects, Living Breakwaters and Public Sediment, that shift the infrastructure planning paradigm toward the design of living and adaptive systems that can respond to uncertainty and environmental change.

SCAPE's work is inspired by pre-industrial age agriculture, aquaculture, and technology and reinterprets these systems to inform future relationships with the land and water. Living Breakwaters is inspired by the historic oyster reefs of New York City, where subtidal reefs and leased oyster beds once extended across the shallow water flats of Raritan Bay, reducing storm impacts and filtering water. Looking back reminds us that dramatic change in place, environment, and ecosystem is part of understanding current urban ecology, and critical in projecting forward newly modified cohabitats and communities. Living Breakwaters builds on this legacy and is developed for the Rebuild by Design initiative in response to the damage caused by Hurricane Sandy. The project develops a protective necklace of breakwaters designed for risk reduction and habitat regeneration along the South Shore of Staten Island and Raritan Bay in New York, planned to start construction in 2019.

While extreme events shape the dialogue around climate resilience in coastal regions, many large-scale infrastructures designed to protect against these events neglect the experience of the everyday and sever a community's relationships with water. Public Sediment, a project designed to help the San Francisco Bay area adapt to rising sea levels, plans for community stewardship and ecosystem function within a larger watershed, today, to adapt to threats at the water's edge. Public Sediment for Alameda creek is a proposal to design with mud, the building block of resilience in the San Francisco Bay area. The baylands require sediment to keep pace with sea level rise, yet sediment is trapped upstream in dams and flood control channels. To bring sediment to the baylands, the project proposes to unlock and redesign Alameda Creek upstream, as the creek is the largest local tributary that feeds the Bay. Public Sediment strategically redesigns this waterbody to create functional systems that sustainably transport sediment, engage people, and provide habitat for anadromous fish. Upstream work boosts sediment flows downstream, and connects the creek to the marsh, creating a resilience and healthy bayland that can better adapt to sea level rise.

Both of these projects represent a paradigm shift in how we plan for climate change – rather than hardening the edge and ignoring the long-term consequences, this work propose to recalibrate our relationship with sediment and water resources and invest today in living systems that grow over time and adapt to a changing climate. While the projects are site and place-specific, the concepts are broadly applicable across multiple scales and geographies.

DAY 1 TIME: 14:40 – 15:00

Designing Resilience In Asia. Designing The Unpredictable, planning with uncertainty.

Professor Oscar Carracedo García-Villalba

Director Designing Resilience in Asia Research Programme
Director Master of Urban Design
National University of Singapore

Synopsis:

In the last decade and beyond, we have witnessed in greater frequency extreme weather events and natural disasters due to the effects of global environmental and climate change. Events such as the 2015 earthquake in Nepal, the 2013 typhoon Haiyan or the 2011 flooding in Thailand evidence how relevant is building resilient Asian cities and communities, specially with the exponential urbanization and population growth.

The Designing Resilience in Asia (DRiA) International Research Programme, hosted by the School of Design and Environment of the National University of Singapore, was initiated in August 2014 with the objective to promote and foster a substantive research and discussion about innovative ideas and propositions towards the resiliency and sustainability of Asian cities in light of the effects of climate change.

In the DRiA, we understand Urban Resilience as a model for anticipating, preventing and preparing for the effects of climate change and global warming that we are experiencing before us such as sea level rise, flooding, coastal erosion, storm surges, typhoons, earthquakes, etc. The programme assumes an active responsibility to return to our cities and urban environments the original environmental qualities. With the objective of promoting this environmental recovery, practical actions and specific solutions are designed and planned to adapt to the impacts of climate change, as well as to mitigate the causes of global warming, protecting cities and communities and reducing their vulnerability.

The DRiA programme aims to fill the gap between research and practical implementation promoting innovative responses to climate change through design. With this objective, the programme integrates research, education and capacity building efforts and translates research into practice in industries, local authorities and their cities globally.

An interdisciplinary network organization of researchers, designers, architects and planners from 14 prominent universities from Asia, Australia, Europe and North America, work on the investigation and proposal of architectural design, building technologies, urban planning and urban design solutions adapted to different contexts in order to prevent, anticipate, prepare for and respond to the environmental effects while simultaneously improve the quality of life of cities.

Last but not least, as a research programme within the National University of Singapore, the DRiA aims to create awareness and inspire students to re-think the role and social responsibilities of architects, urban designers and planners, and stoke the flames of passion within them. Through several projects done in China, the Philippines, Indonesia and Thailand, the lecture will explain how the DRiA understands urban resilience and the method applied to face the challenges that climate change poses to our cities.

[Eco]Logical Urban Placemaking: Connectivity and Climate Change Resilience by Design

Judith Stilgenbauer

University of Hawaii at Manoa School of Architecture, 2410 Campus Road, Honolulu, HI 96822, USA

Abstract

Comprised entirely of islands and surrounded by ocean, the Hawaiian archipelago and its inhabitants are highly vulnerable to the inevitable effects of climate change. The waterfront in Honolulu's urban core is fragmented and lacks resilience, as well as social and ecological connectivity. Many of the city's most densely populated areas, and the drivers of the state's economic development—such as Waikiki—are located in very low-lying areas of the island of Oahu. Soon, these coastal parts of Honolulu will see increasing instances of multi-hazard flooding in near-shore developments through rising sea levels and the effects of storm surges, as well as ground water inundation. The city's various fast-moving redevelopment and transportation plans currently do not sufficiently acknowledge these coastal vulnerabilities.

This paper highlights the role of landscape architecture in the creation of resilient waterfronts. It advocates for the anticipation of climate-change-related challenges through innovative urban ecological design that embraces dynamic conditions and flooding rather than preventing them. By challenging conventional wisdom and pushing beyond the status quo, the design research presented here—with its focus on tropical Honolulu—further and broadens the contemporary global discourse on climate-change-resilient, adaptive urban coastal development.

The outcomes of multiple years of applied research and speculative ecological design studios on topics of coastal resilience and sea level rise adaptation strategies held at the University of Hawaii School of Architecture under the direction of the author have stimulated public awareness and significantly contributed to the local professional discourse on the topic. Forward-looking, conceptual planning and design proposals for parts of the South Shore of Honolulu advocate for resilient, amphibious waterfronts that respond to climate change, flooding and inundation, as well as issues related to the city's aging conventional infrastructure.

In times of changing climates, near-shore urban ecological design practice must anticipate variable built environment conditions and focus on adaptation strategies that decrease coastal vulnerabilities. Researchers and practitioners of landscape architecture are uniquely positioned to address the urban challenges of our time through water-sensitive ecological design

concepts. Carefully conceived retreat and abandonment strategies for areas with future amphibious ground conditions need to be combined with intense densification and resource-self-sufficiency in less vulnerable parts of waterfronts. Adaptive multi-purpose ecological infrastructure, hybrid-type public open space systems, and networks of ecological priority zones become essential drivers of urban form in the planning of climate-change-resilient Honolulu coastal areas. They act as soft defense mechanisms against sea level rise and inundation, allow for indeterminacy, increase biodiversity, provide ecosystem services, and, at the same time, create livable urban place amenities for all people.

Varied, locale-specific sea level rise adaptation design strategies for waterfront neighborhoods and their infrastructure have the potential to merge the seemingly conflicting goals of ecological performance and urban placemaking into mutually beneficial, resilient relationships.

Keywords: Climate Change Resilience; Urban Waterfronts; Ecological Design; Sea Level Rise Adaptation; Placemaking

Introduction

As a result of growing ecological and social design challenges, in recent decades the environmental design professions have focused increasingly on sustainable urban design practices that address variable built environment conditions. This paper explores the role of adaptive, ecological infrastructure as an essential driver of urban form in the planning of resilient Honolulu waterfronts. In the not-so-distant future, climate change, weather variability, sea level rise, and ground water inundation will profoundly affect densely populated high-value areas of this tropical-climate metropolis.

Practitioners of landscape architecture are uniquely positioned to address these urban challenges through forward-looking, water-sensitive ecological design concepts that have the potential to further and broaden the contemporary global discourse on resilient urban waterfront development.

The Reality of Our Cities

Heavily affected by ongoing urbanization, many metropolitan areas of the world are

characterized by a general lack of ecosystem services. Most central city environments suffer from insufficient vegetated areas and the consequences of the urban heat island effect. Cities' crumbling conventional gray infrastructural systems, engineered streams and copious amounts of impervious surfaces heavily impact the hydrological cycle and contaminate nearby bodies of water. Ongoing climate change will continue to amplify these and other urban ecological concerns and their resulting socio-economic and public health consequences.

The U.S. Global Change Research Program's recently updated 2017 *Climate Science Special Report* in its "high" scenario predicts a 2-meter sea level rise by 2100 relative to 2000 levels. The six scenarios presented in the research range from low to extreme. [1] Comprised entirely of islands and surrounded by ocean, the Hawaiian archipelago and its inhabitants are highly vulnerable to the unavoidable effects of global warming. Rising sea levels will inundate Honolulu's low-lying, densely developed waterfront in the foreseeable future. It is only recently that Hawaii

legislators, scientists, planners, and designers have begun to discuss and address the effects of climate change on the state's built environment.

Flooding Vulnerabilities and Responses

Regular instances of saltwater inundation in coastal Honolulu are among the obvious effects of more frequent extreme weather events. The same can be said for the continuing erosion of shorelines, beaches, and wetlands, as well as expected habitat shifts or losses in protective aquatic ecosystems and coastal agricultural areas. Salt intrusion and potable water contamination are of great concern in a densely populated island environment with limited resources. Additionally, due to the higher density of intruding seawater, rising sea levels will result in ground water inundation of low-lying inland urban areas that are already prone to drainage problems and nuisance flooding. Contaminated coastal sites are in danger of releasing their pollutants into the water. Public uses and access to shorelines will be affected, public health impacts are expected, and weak populations might be displaced or left behind.



Fig. 1. Multi-hazard inundation map illustrating Honolulu impacted by 1-meter sea level rise (blue) plus tsunami (orange) or hurricane surge (red); image: University of Hawaii Sea Grant College Program, 2014.

Vulnerability maps, such as Figure 1 above, clearly illustrate how much of Honolulu's critical urban infrastructure and existing building stock will be in harm's way in the event of a one-meter sea level rise plus storm or tsunami surges: dense urban residential areas and economic centers, wastewater treatment facilities and major sewer lines, energy facilities, as well as transportation systems, including Honolulu's newly planned rail and the international airport. In late 2017 the Hawaii Climate Change Mitigation and Adaptation Commission released its new *Hawaii Sea Level Rise Vulnerability Adaptability Report*, a statewide evaluation of the islands' susceptibility to sea level rise. Using models that predict a sea level rise increase of 1 meter by 2100 (an intermediate scenario by current standards), the report estimates that flooding due to coastal inundation will cause over \$19 billion in land and structure damage, displace around 20,000 people, and affect 26,000 acres of coastal land, 65,000 structures and 38 miles of major coastal roads. [2]

Rather than passively reacting and rebuilding after disasters, cities such as Honolulu that—to date—have been spared major climate-change-related flood events need to anticipate future changes and increased variability in built urban waterfront environments. The common goal must be to embed creative forward-looking solutions in today's urban design plans and regulatory frameworks that anticipate change and address future climate-change-related ecological and socio-economic vulnerabilities in order to enhance and

sustain the quality of life and health for generations to come.

Dynamic Processes Over Time

The landscape architecture profession throughout history has embraced the ephemeral and dynamic nature of its medium and thus the notions of temporal change and adaptation. In recent years, the importance of the temporal and indeterminate component in urban ecological design has been widely recognized and ecological processes are routinely integrated into the planning and design of urban sites.

Dynamic ecological placemaking that balances designing for uncertainty with a more traditional focus on carefully selected permanent urban armatures and people-centric places can lead to resilient solutions that decrease shoreline developments' climate-change-related vulnerabilities. Currently underutilized sites most vulnerable to inundation, as well as outdated structures and mono-functional infrastructural elements, must be reprogrammed into adaptive, multi-tasking public open space systems and dynamic green infrastructure. Innovative changes in policy and operational practices will allow for more spatial and programmatic flexibility and a greater degree of uncertainty in the built urban environment.

Design Strategies for Rising Sea Levels

By studying recent sea-level-rise-themed ideas competitions and precedent design and policy initiatives around the country that

address issues of coastal flooding and inundation, particularly in the Gulf of Mexico region following hurricane Katrina and the New York and New Jersey areas subsequent to superstorm Sandy, one can deduce a number of common defense and accommodation strategies.

Traditional hard defense systems against coastal flooding include engineered linear systems such as levees, seawalls, rip-rap, and other forms of barriers that armor existing shorelines. These systems have been known to fail over time, often resulting in catastrophic damage.

In contrast, networks of soft, green defense systems—including strategically placed living breakwaters, oyster or coral reefs, coastal wetlands, tidal marshes, other green shoreline buffers, and extensive systems of parks and green infrastructure in coastal urban areas—rely on ecosystem services to retain and absorb inundation, slow erosion, provide habitat, and increase the distance between water and vulnerable development (Figure 2).

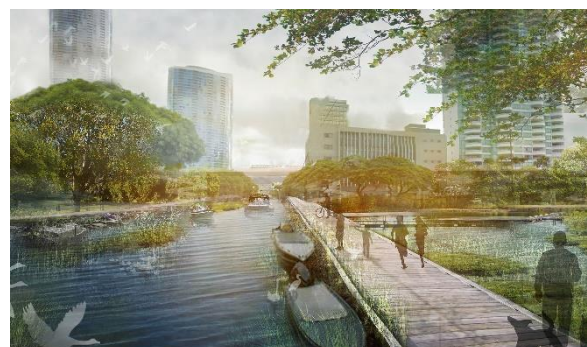


Fig. 2. Soft defense and strategic retreat vision for McCully Avenue in the Ala Moana area of Honolulu; image: Duangpon Hanseree, UHM SoA, Spring '15 ARCH 743, instructor: J. Stilgenbauer.

Commonly agreed-upon sea level rise accommodation design strategies include the elevation of coastal built structures and infrastructure, for example by raising the elevation of the ground or building on pilings that allow flood water to flow underneath; conceiving of floating buildings, transportation and infrastructural systems that respond to changing water levels; and developing floodable structures and open space systems designed to withstand inundation. Additionally, where feasible from a socio-economic perspective, withdrawal strategies might need to be applied strategically over time in the most vulnerable coastal areas of low-lying cities such as Honolulu. These strategies include designing for disassembly, managed abandonment, and retreat to higher ground or structures. Cities will need to apply locale-specific, complex combinations of the above mentioned and other innovative engineering and design strategies to achieve the goal of more resilient urban waterfronts.

Honolulu's South Shore

A tropical island state in the middle of the Pacific, Hawaii will be progressively more affected by the dramatic effects of global warming and sea level rise. Many of the most densely populated areas of Honolulu and the drivers of the state's economic development, such as Waikiki, are located in very low-lying areas of the south shore of Oahu, which makes them prone to numerous flooding and inundation vulnerabilities. Soon, these parts of Honolulu's waterfront will see increasing instances of multi-hazard flooding in near-shore developments through rising sea levels and the effects of

hurricane and tsunami surges, as well as storm and ground water inundation.

The city's various fast-moving, existing shoreline redevelopment and transportation plans for Honolulu's urban core currently do not sufficiently acknowledge these unavoidable coastal flooding vulnerabilities. The outcomes of multiple years of applied research and speculative, academic ecological urbanism studios on topics of sea level rise adaptation strategies held at the University of Hawaii School of Architecture under the direction of the author have stimulated public awareness and significantly contributed to the local professional discourse on the topic. These forward-looking, conceptual urban design proposals for the Waikiki, Ala Moana, and Kakaako neighborhoods of Honolulu advocate for resilient, amphibious waterfronts that respond to climate change, inescapable shoreline changes, flooding and inundation, as well as issues related to the city's aging conventional infrastructure.

Resilient Waterfront Design

In times of uncertain future urban conditions, it seems critically important that current urban design practice for near-shore developments focus on the implementation of hybrid-type performative public open space systems, adaptive green infrastructure, and networks of ecological priority areas that anticipate rising sea levels and amphibious ground conditions. Such an approach allows for the merging of the seemingly conflicting goals of ecological function and urban placemaking into a mutually beneficial, resilient relationship.

Hawaii's year-round warm, humid, and nutrient-rich conditions provide fertile ground for varied, layered public open space networks, green infrastructure, and responsive, adaptive coastal wetland systems. Our goal must be the creation of sustainable urban place solutions that are problem solving, multifunctional, and dynamic, yet livable, beautiful, and memorable. Innovative urban design needs to allow for indeterminacy and, at the same time, appeal to humans' desire for stability in their built environments.

Policy, regulation, development, and urban design decisions should be based on the spatial identification of vulnerable elements of coastal areas through mapping over time and careful risk assessment that, in addition to physical, ecological, cultural, and social factors, also takes into consideration questions of ownership and real estate value. Carefully conceived managed withdrawal strategies need to be combined with intense densification in higher areas. The design of these future dense, self-sustained and off-the-grid neighborhoods should apply varied sea level rise adaptation strategies through elevation of buildings and critical infrastructure, interspersed with floodable, performative open space-dominated public places. Locations most prone to damages from flooding and inundation should be set aside for programmatically indeterminate open spaces and ecological priority areas; more expensive, permanent development should occur in less vulnerable areas. Critical (infra)structural systems and new transportation elements, gradually elevated off the ground over time, facilitate access to areas designed for flooding and connect

future densely developed areas with decentralized systems of water, energy, food, and waste.

Recent design research conducted by the author with graduate students at the University of Hawaii School of Architecture has resulted in a number of additional findings and recurring themes. Urban ecological design proposals that anticipate and embrace change and flooding rather than attempting to prevent it seem more promising in addressing climate-change-related challenges. A carefully designed hierarchy of water-based and elevated, innovative transportation systems can serve as a resilient alternative to Honolulu's current automobile-centric circulation system. As water levels rise, walkways and critical infrastructural elements need to be elevated off the ground. Streets become canals; underutilized spaces that are prone to flooding are turned into productive or ecologically performative urban landscapes. Elevated public transit, bicycle networks, and covered walkways facilitate pedestrian and material flows and become conduits for future adaptable, resilient urban infrastructure (Figure 3).

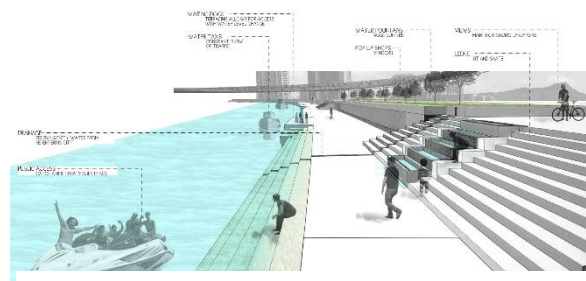


Fig. 3. New elevated urban infrastructural systems; image: Ronald Ribao, UHM SoA, Spring '14 ARCH 543, instructor: J. Stilgenbauer.

Conventional gray infrastructure is reprogrammed into green infrastructure and ecosystems. A system of canals, wetlands, public open spaces, and elevated walkways drives urban form. Hard edges are softened, begin to perform, and provide habitat and storm surge protection. Coastal highways become waterways and floodable pedestrian corridors. These multi-purpose public waterfront promenades reflect both sea level rise adaptation and urban placemaking strategies (Figure 4).

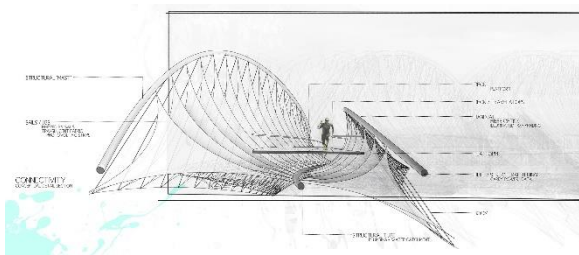


Fig. 4. New pedestrian-oriented waterfront promenades and coastal defense systems; image: Ronald Ribao, UHM SoA, Spring '14 ARCH 543, instructor: J. Stilgenbauer.

Self-sufficient, walkable eco blocks replace conventional city blocks and gray infrastructural systems. Areas that are subject to inundation undergo a scenario of managed retreat and possible future abandonment through elevation of critical infrastructure, retrofit of existing structures, and eventual disassembly. New ecological priority areas and biodiverse park-hybrid urban agricultural landscapes provide ecosystem services, create urban place amenities, and serve as soft defense mechanisms against sea level rise (Figure 5).



Fig. 5. Speculative design for retrofitted residential eco block in the Ala Moana area of Honolulu; image: Duangpon Hanseree, UHM SoA, Spring '15 ARCH 743, instructor: J. Stilgenbauer.

Such academic, speculative design work, by its nature, questions numerous current land management and ownership systems, regulatory frameworks, and ongoing development plans. However, as tragically demonstrated in places such as New York after superstorm Sandy, drastic changes in the way we regulate, plan and develop our waterfronts are necessary in order to prepare for the inevitable changes ahead. It is the role of the academy to challenge conventional wisdom and push beyond the status quo through furthering and broadening the contemporary discourse on resilient shoreline development and long-term planning and ecological urban placemaking for a sustainable urban Hawaii.

All urban waterfront planning and design work must anticipate uncertainty and focus on adaptation strategies that decrease shoreline vulnerabilities. We need to highlight the significance of green public corridors and other types of multi-purpose infrastructure that have the potential to adapt to changing environmental conditions and perform as soft shoreline defense systems

and, at the same time, open space amenities
and places for people.

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ReCrafting Urban Climate Change Resilience Understandings – Learning from Australian indigenous Cultures

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Abstract

Internationally a growing body of literature has interrogated the vulnerability, risk, resilience, and adaptation of Indigenous peoples to climate change. Key traits in this literature synthesis point to the impacts of climate change on sovereignty, culture, health, and economies that are currently being experienced by Indigenous (First Nations) communities globally. While knowledge and science of how climate change impacts are affecting Indigenous peoples can contribute to the formulation of policies, plans, designs and programs for climate change adaptation, settlement resilience planning and greenhouse gas emission reductions, little research has validated this knowledge as well as its potential. In Australia, climate change is expected to have social, economic and environmental impacts on urban Indigenous communities inhabiting coastal areas throughout south-eastern Australia. These impacts include a loss of community and environmental assets, cultural heritage sites, significant impacts on the quality of life of populations, and the establishment of favourable conditions for the spread of plant diseases, weeds and pests. Over most of south-eastern Australia, including southern Victoria and the Brisbane region, climate change is expected to lead to increased risk of heatwaves, longer drought periods, increased bushfire risk, increased risks of flood events and more frequent coastal inundation and associated impacts such as coastal erosion.

This paper defines and describes the key frameworks that inform Australian Aboriginal (and Torres Strait Islander) understandings of climate change impacts and pathways for adaptation and mitigation, including, sovereignty and self-determination, culture and cultural identity, and Aboriginals community health indicators, with an emphasis upon Geelong and Brisbane urban areas. It also provides a synthesis of climate knowledge, science, and strategies that Aboriginal communities are exploring, and their understanding of the gaps in research on these issues. A review of the literature examining the impacts of climate change on urban Aboriginal people found that there is limited research on the topic in Australia and globally. The review identified that lower socio-economic members of this group are more vulnerable to climate change compared to the general Australian population. Their adaptive capacity is low as a result of the same systemic issues confronting Aboriginal people that have led to disadvantage. As such, research on climate change adaptation positions climate change as one

of the many issues facing Aboriginal people and needs to be addressed collaboratively and not in isolation. Research from other more remote regions in Australia and abroad indicate collaborative community-based approaches are needed for effective climate change vulnerability assessments and the building of individual and collective adaptive capacity.

The evidence emerging from this research clearly demonstrates that Aboriginal people's consideration of the future, even with the overlay of climate change and the requirements for serious considerations of adaptation, are significantly influenced and dominated by economic aspirations which are seen as fundamental survival strategies for their communities.

Keywords: Australia; Indigenous knowledge systems; Aboriginal knowledge systems; First Nations; Climate change; *Wadawurrung*; *Quandamooka*; *Kaurna*; *Wathaurong*; *Boon Wurrung*; *Bunerong*; *Jagera*; Landscape architecture

temperature and declines in seasonal rainfalls [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11].

1. Cultural Acknowledgement

We wish to acknowledge the Elders, families and forebears of the *Kaurna* people of the Adelaide Plains region, the *Wadawurrung* and *Boon Wurrung* peoples of the *Kulin* Nation surrounding the Port Phillip Bay region, the *Jagera* people of the Ipswich and Brisbane region, and the *Quandamooka* people of Moreton Bay and North Stradbroke Island, past present and future, who were and are the custodians of the land and water for many centuries.

2. Introduction

For some of our Indigenous co-authors on this paper, they are not certain what all the relatively sudden interest in 'climate change' is all about.

Our *Wadawurrung* human ancestors have witnessed and orally recorded histories of sea level rises, loss of land bridges and the formation of new bays and barrier reef complexes, seen volcanoes exploding and their lava cover our favoured grasslands, and the vegetation of our *Country* change from a mixed wet sclerophyll to a dry sclerophyll open forest and expansive grassland in synergy with major increasing changes in

For the last 50 years we have witnessed academics and politicians debate, research, discuss and put forward arguments and thoughts about the last 200-500 years of human residency and impacts upon this planet.

The question we ask is,

Why are we not asking the Indigenous peoples of their regions who have generationally witnessed often 60,000 years of climate change transformation, and whom offer remarkable lessons in resilience and adaptation, what has been occurring and how have they managed this change and how to go forward?

We all know that the Earth is changing, is continually changing, has never stopped changing its environmental fabric and biological residents since Pangaea evolved in the late Paleozoic and early Mesozoic eras, and humans have certainly aided the pace and perceived impact of this change in the last 12,000 years since the Agricultural Revolution by their 'acts of progress' and the digital accessibility revolution that we are experiencing. It is more a question of time, shortness and longevity of time that

offers different insights as to this ‘climate change’ of which Western knowledge appears to be temporally short in its ‘reading’ of time, whereas Indigenous peoples interpret time in both temporal short and long but also future time dimensions.

Climate change is affecting the sovereignty, culture, health, economies, and life of Indigenous or First Nations peoples across the World [12, 13, 14, 15, 16, 17, 18, 19]. The level of recognition of impacts upon First Nations peoples and their *Country*’s or lands/waters however is very mixed according to political jurisdiction and that First Nations’ standing and political legitimacy within the boundaries of the present ‘nation’ in which they reside today. In particular in Australia [12], New Zealand, the United States and Canada [13, 14, 15, 20, 21], there are very different understandings and recognitions of First Nation sovereignty and scientific acceptance of their Knowledge Systems as holding valuable longitudinal environment.

Colonisation has resulted in dispossession and transference of residency and knowledge, but not the cultural obligation and will to care for *Country* and to take a larger custodial role within the ‘temporary’ Western rules/laws that have only often 200 years of existence [22, 17, 23, 24, 25]. Thus, for Aboriginal Australia, the passion and commitment to continue custodial obligations and relationships with *Country*, with each Aboriginal nation’s or community’s lands and waters [27], is still there despite social, economic, demographic and educative attempts to assimilate and colonize both people and land.

Country refers to Australian Aboriginal and Torres Strait Islander people’s traditional affiliation and responsibility for lands and waters which they collectively refer to as their *Country*, of which they are a systemic part of this *Country* [28, 29, 30, 31]. The analogy, is an ecological system whereby their culture positions humans both as an equal actor but also as an environmental quality performance monitor in anticipation of the return of their Ancestors whom vested these obligations and responsibilities upon them. Responsibility to look after or ‘care for country’ is a key part of these Aboriginal societies together with their family groups, clans and as individuals.

Anthropologist Rose (1996) has explained *Country* as:

People talk about country in the same way that they would talk about a person: they speak to country, sing to country, visit country, worry about country, feel sorry for country and long for country ... country knows, hears, smells, takes notice, takes care, is sorry or happy ... Because of this richness, country is home, and peace; nourishment for body, mind and spirit; heart’s ease [28].

In this paper, we use the terms ‘First Nation’ and ‘Aboriginal (and Torres Strait Islander)’ and ‘Indigenous’ interchangeably unless referencing a specific group or specific recognition status.

3. International obligations

The right to Indigenous self-governance and self-determination has been acknowledged by the majority of nations around the world as signatories to the United Nations' *Declaration on the Rights of Indigenous Peoples* [43]. Appendix A summarises the key Articles that need to be heeded.

In October 2016 UNESCO led a workshop on "Mainstreaming Traditional Knowledge to support Climate Change Adaptation Policies" focussed on the valuable role that Traditional Ecological Knowledge (TEK) plays in its 'adaption to climate change variations that concluded the need to contend with environmental changes, as recorded in points 1-5 in Appendix B, and that

These knowledge systems are transmitted and renewed by each succeeding generation, and ensure the well-being of people around the globe by providing food security from hunting, fishing, gathering, pastoralism or small-scale agriculture, as well as healthcare, clothing, shelter and strategies for coping with environmental fluctuations and external forces of change [13].

4. What the literature is starting to conclude

Increasingly academic literature has been examining the vulnerability, risk, resilience, and adaptive capacity of First Nations, Indigenous and Aboriginal peoples to climate change.

There is however little Aboriginal voice in this literature and to a lesser degree Aboriginal authorship of this 'research' and discussion.

This larger body of literature is increasingly pointing to climate change impacts upon Aboriginal sovereignty, culture, health, livelihoods, and economies that are currently being experienced by Aboriginal communities internationally. This literature is increasingly concluding that each and all Aboriginal communities are already experiencing the impacts of climate change [14, 32]. While such impacts differ accordingly to region [33, 34, 35, there are commonalities in how climate change is experienced by these communities and how they are perceiving it is affecting their lifestyle, *Country* or customary obligations, and culture in the shadow of colonisation, dispossession and questionable sovereignty legitimacy over their 'nation'.

Thus, coastal communities are witnessing erosion and sea-level rise threatening community infrastructure *Country* health further and are leading to forced displacement and relocation; some inland or freshwater communities are witnessing changes in streamflow and water temperature negatively affecting the succession and harvesting of fish, shellfish, eels and other culturally important species; for inland or saltwater communities rainfall frequency decline and increased propensity of prolonged drought is affecting soil quality and agricultural practices [36]. Such is evident affecting in reductions in access to culturally important habitats and species; such as making it more difficult for hunters

to access traditional hunting grounds, changes in animal migration patterns and plant flowering and fruiting patterns, changes in water temperature and flow increasing stresses upon fish and shellfish populations that are often vital to the economic, spiritual, and cultural health of communities; or, the increasingly influx or transmigration of noxious or exotic invasive animal and plant species mixed with prolonged drought disrupting agricultural and food harvesting practices. These changes threaten traditional knowledges, food security, water availability, the essence of *Country* and Aboriginal cultural obligations to *Country*, further undermine Aboriginal ways of life and the environmental quality and ‘health’ of lands and waters (*Country*) that have adapted for thousands of years.

The vulnerability of Aboriginal communities and their respective *Country* to climate change can be thematically observed through their cultural, social, and economic dependence on local species, habitats, and ecosystems, as well as legal, social, and political contexts of colonialism, institutionalized racism, and forced relocation [17, 23, 24, 25, 26]. Vulnerability is a product of systems of inequality and is not characteristic of a community Marino [24]. Communities and their respective *Country* differ in their vulnerability to climate change based on their distinct cultural practices and economies, and the vulnerability of Aboriginal socio-political, economic, and ecocultural systems may differ by geography and climate regime [37]. Climate-change ‘adaptation’ refers to preparing for, responding to, and coping

with the effects of (contemporary) climate change. While ‘adaptation’ is not new for Aboriginal peoples, climate change impacts for Aboriginal peoples are increasingly threatening that what Whyte [26] calls their “collective continuance” or a “community’s capacity to be adaptive in ways sufficient for the livelihoods of its members to flourish into the future.”

Aboriginal vulnerability and resilience to climate change cannot be separated from colonialism [23, 24, 26, 38]. The latter created the contemporary economic conditions for anthropogenic climate change and the legal and social constraints that limit Aboriginal resistance and resilience capacity to ‘normal’ development change to their *Country* as well as climate change itself.

Thus,

Climate change itself ... is thoroughly tied to colonial practices, both historically and in the present, insofar as greenhouse gas production over the last two centuries hinged on the dispossession of indigenous lands and resources [38].

As a result of colonialism, many of the traditional adaptation practices that allowed Aboriginal communities to endure environmental changes are no longer possible. Thus, climate-change adaptation is not only about responding to observable impacts of climate change, it is also about understanding the politically-informed context and the often Western process that structures the way Aboriginal communities are exposed to the impacts of climate change.

The Intergovernmental Panel on Climate Change (IPCC) defined resilience as “the ability of a social, ecological, or socio-ecological system and its components to anticipate, reduce, accommodate, or recover from the effects of a hazardous event or trend in a timely and efficient” [20, 21, 39].

Although Aboriginal resilience does not eliminate the consequences of colonialism or climate-change impacts, it does demonstrate the capacity of Indigenous populations to monitor impacts and to develop strategies for adapting to and mediating climate change in short to long term visions. This resilience is embedded in Traditional Ecological Knowledges, livelihood diversity, *Country*-specific cultural values, and new social and cross-Country networks towards sharing strategies and information about adaptive capacity [13, 40].

5. Indigenous Communities in Australia

To better understand these Aboriginal peoples’ strategies to climate change, a deep investigation was undertaken with key representatives from Aboriginal organisations in five coastal locations in three states of south-eastern Australia [13, 41, 42]. The research thematically unravelled social, economic and environmental impacts on these Aboriginal communities including a loss of community and environmental assets, such as cultural heritage sites, with significant impacts on their quality of life and the establishment of potential favourable conditions for the spread of plant diseases, weeds and pests.

The research also found that opportunities did not readily exist for engagement with climate change adaptation policy and initiatives and this was further exacerbated by acute shortages of qualified/experienced Aboriginal members that could represent their communities’ interests in climate change adaptation forums. The research conclusions clearly demonstrates that Aboriginal people’s consideration of the future, even with the overlay of climate change and the requirements for serious considerations of adaptation, are significantly influenced and dominated by economic aspirations which are seen as fundamental survival strategies for their communities.

A number of specific climate change induced issues to emerge from the research included: the potential for Aboriginal involvement in the ‘bush tucker’ industry utilising wild plant species will potentially suffer from changes in species availability; concern was expressed about changes associated with peri-urban and urban development which appears to be escalating micro-environmental changes; peri-urbanisation is a major environmental change which threatens cultural assets including Aboriginal sites; Aboriginal communities need representation in climate change adaptation forums and to be more directly involved in land and sea care projects. The chapter concludes with recommendations to better position Aboriginal engagement and knowledge systems in the wider climate change adaptation policy discourse.

Whilst conventional Australian climate change-related Aboriginal research has tended to focus on traditional Aboriginal communities of remote and central and northern Australia, these residential facts highlight the importance of understanding the majority of Aboriginal people, i.e. those residing in urban and peri-urban locations. Of note is a key difference between coastal urban and peri-urban Aboriginal people and those residing in semi-arid, arid and tropical communities in northern Western Australia (WA), Queensland (Qld) and the Northern Territory (NT). In essence, the former do not live in discrete Aboriginal communities and tend to be generally integrated into the wider urban and peri-urban community, i.e. the majority of urban and peri-urban Aboriginal people live ‘off-country’. This fact had important methodological implications for the research engagement with the case study organisations [12].

The participating Aboriginal organisations included:

- Kurna Nation Cultural Heritage Association Inc.–*Kurna Country*.
- Wathaurong Aboriginal Co-Operative Limited –. *Wadawurrung Country*.
- Boon Wurrung Foundation Limited – *Boon Wurrung Country*.
- Quandamooka Lands Council Aboriginal Corporation -- *Quandamooka Country*.
- Jagera Ganay-Magil Aboriginal Corporation -- *Jagera Ganay-Magil Country*.

The location of these communities are depicted on Figure 1. A summary of the generic characteristics of each of the five case studies and their respective

organisation is provided in Appendices B and C..

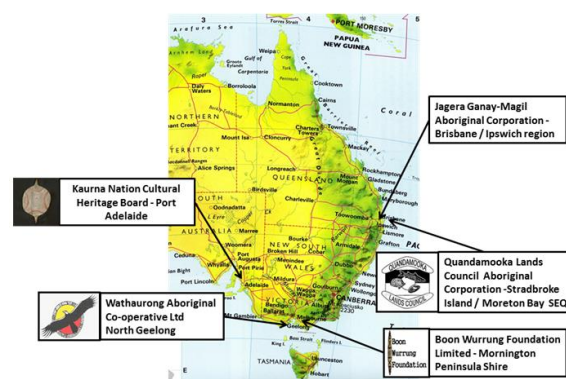


Figure 1: Location of participating Aboriginal organisations. Source: [12].

6. Key Issues

The research employed a mixed method methodological process reliant upon a series of workshops with each community group. This resulted in the emergence of a number of consistent themes, namely: (i) Aboriginal representation; (ii) housing; (iii) employment; (iv) environmental and cultural assets; and (v) wild food network together with Aboriginal communities’ perceptions as to climate change variable risk and impact [12, 41].

Aboriginal Representation (or sovereignty) refers to the opportunities for, and capacity of, Aboriginal people to represent their interests and concerns in climate change meetings, decision-making forums and policy documents that are largely controlled by various tiers of government. This also relates to the availability of individuals who are capable

of representing their community's interests in such forums and discussions.

Housing clearly was a key theme. It includes a category of issues related to the ability of Aboriginal people to either move or modify their existing housing to mitigate the effects of climate change. It also concerns the degree to which Aboriginal people can engage in energy and water saving schemes for climate change adaptation. All participants noted the large numbers of Aboriginal people from their communities who were reliant on public housing.

Employment concerns the negative aspects of job loss due to changing employment prospects through climate change and also included the positive aspects of job creation in industries involved in climate change adaptation and mitigation, such as carbon-trading and sequestering schemes and revegetation programs.

Environmental and Cultural Assets includes those connected to land managed by Aboriginal people as well as on-Country not directly accessible to Aboriginal people. It includes cultural sites containing burials and archaeological materials, as well as native title areas, Aboriginal-run farms, areas connected to fishing and hunting licences and national parks for which there are joint management agreements.

The Wild Food Network includes those concerned with the cultural and economic importance of Aboriginal people being engaged in the native bush food industry, particularly with wild harvesting, growing,

processing, value adding, catering and spin-off guiding/talking businesses.

The evidence emerging from this research clearly demonstrates that Aboriginal people's consideration of the future, even with the overlay of climate change and the requirements for serious considerations of adaptation, are significantly influenced and dominated by social and economic aspirations which are seen as fundamental survival strategies for their communities. This is largely because many other initiatives can be linked and/or run in parallel with climate change adaptation initiatives which can start to address some long standing issues of a socio-economic and human capacity nature.

Such strategies need to involve a high degree of inclusive participation and youth engagement to empower greater youth Aboriginal connection to Country, thus improving the chances of enhancing the climate change adaptive capacity of individual and collective Aboriginal peoples.

In summary, there was universal recognition that climate change was placing a disproportionate burden upon Aboriginal people. Circumstances contributing to this unsatisfactory situation included:

- the lack of specific climate change adaptation policy to support Aboriginal people and communities;
- a lack of awareness and understanding of climate change and adaptation options by Aboriginal urban and peri-urban people; and

- their dispossession and absence of direct access to their *Country*.

There was an overwhelming position that to adapt to climate change, access to land was important, change had to be seen, and there was a need to understand it.

7. Conclusions, Barriers and Limitations

Aboriginal peoples' values and perspectives are absent in most Australian (Commonwealth, state and local) government climate-change programs and initiatives. Aboriginal community involvement is also lacking on government climate-change committees, working groups, and initiatives, leaving *Country* - specific perspectives and values absent from this discourse. This disvalues the significance of Aboriginal peoples' knowledges in informing government climate-change research and policy towards the formulation of effective climate-change solutions.

The majority of Australian research relies upon peer-reviewed literature and does not take into account Aboriginal traditional knowledges and oral traditions. This further marginalises Aboriginal organisations, their voices and those of their communities and members whom are already delimited by limited access and vulnerability to political and economic contexts. Even with existing funding sources, communities often lack equitable access to financial, technical, and other resources needed to adapt and mitigate climate impacts and support renewable energy, energy efficiency, and green jobs programs.

While there is an increasing Australian government policy shift towards joint management of lands and waters particularly vested as 'national parks', the complexity of land and water 'ownership', native title, jurisdictional 'management' is resulting in unclear impacts upon native title and reserved lands, ancestral *Country*'s generally, as well as sacred sites and places therein.

Increasing Aboriginal participation and empowerment in climate-change initiatives is a key solution for increasing the resilience of Aboriginal communities in Australia.

There is a need to 'listen', 'listen', 'listen' and 'ask first' before writing conclusions, 'answers' and policies. Aboriginal perspectives and traditional knowledges must inform and guide climate-change assessment and adaptation to develop culturally appropriate strategies.

Because climate-change vulnerability is a product of historical and ongoing social inequality [24], it is important that Aboriginal communities facing relocation have access to lands of their choosing that allow them to continue traditional practices. The perspective and knowledges of Aboriginal communities serve as an invaluable source of knowledge for climate-change adaptation and mitigation strategies nationwide because of Aboriginal communities' demonstrated capacity for adaptation [13].

However, with the limited number and diversity of Aboriginal communities covered

and the limitation in chapter length, the report captured only a snapshot of the breadth of climate-change impacts and solutions.

The lack of published knowledge about climate-change impacts on Australian Aboriginal (and Torres Strait Islander) peoples disadvantages these communities. Thus, research is needed to address these knowledge gaps to comprehensively and sensitively describe *Country*-specific Aboriginal (and Torres Strait Islander) values and ‘histories’.

Finally, we can be inclusive and comprehensive through the:

- Inclusion and integration of Aboriginal values within climate change understandings, policies and initiatives;
- Creation of *Country*-specific chapters on Aboriginal (and Torres Strait Islander) values in all climate change understandings, policies and initiatives;
- Publication of special reports on Aboriginal (and Torres Strait Islander) issues.

These changes would provide opportunities for the inclusion of more Aboriginal perspectives and voices [12].

So, if the contemporary policy and decision makers really want to appreciate climate change adaptation, resilience strategies, and a long perspective of environmental change ‘Why are they not asking the Aboriginal (and Torres Strait Islander) peoples of their regions?’

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Appendix A

Extract from the United Nations' *Declaration on the Rights of Indigenous Peoples* (2007). Source: [43].

Article:	Article Text:
Article 3	“Indigenous people have the right to self-determination. By the virtue of that right, they freely determine their political status and freely pursue their economic, social, and cultural development” (UNDRIP 2007: 4) [43]
Article 4	“Indigenous people, in exercising their right to self-determination, have the right to autonomy or self-government in matters relating to their internal and local affairs, as well as ways and means for financing their autonomous functions” (UNDRIP 2007: 7) [43]
Article 24.1	1. “Indigenous peoples have the right to their traditional medicines and to maintain their health practices, including the conservation of their vital medicinal plants, animals and minerals. Indigenous individuals also have the right to access, without any discrimination, all social and health services” (UNDRIP 2007: 9) [43]
Article 25	“Indigenous peoples have the right to maintain and strengthen their distinctive spiritual relationship with their traditionally owned or otherwise occupied and used lands, territories, waters and coastal seas and other resources and to uphold their responsibilities to future generations in this regard” (UNDRIP 2007: 10) [43]
Article 29	“Indigenous peoples have the right to the conservation and protection of the environment and the productive capacity of their lands or territories and resources. States shall establish and implement assistance programmes for indigenous peoples for such conservation and protection, without discrimination” (UNDRIP 2007: 11) [43]

Appendix B

Indigenous Knowledge as a Foundation for Decision-Making, key points. Source: [13].

#	Point Conclusion:
1	Indigenous peoples live in all regions of the world and own, occupy or use resources on some 22% of the global land area, which in turn harbours 80% of the world's biological diversity. While there is no single definition for indigenous peoples, a core set of criteria guide the identification of this highly diverse group.
2	Indigenous or traditional knowledge refers to the knowledge and know-how accumulated across generations, and renewed by each new generation, which guide human societies in their innumerable interactions with their surrounding environment.
3	Although nascent in climate science, indigenous knowledge has been widely recognized in fields such as agroforestry, traditional medicine, biodiversity conservation, customary resource management, applied anthropology, impact assessment and natural disaster preparedness and response.
4	Indigenous observations and interpretations of meteorological phenomena have guided seasonal and inter-annual activities of local communities for millennia. This knowledge contributes to climate science by offering observations and interpretations at a much finer spatial scale with considerable temporal depth, and by highlighting elements that may not be considered by climate scientists.
5	Indigenous knowledge focuses on elements of significance for local livelihoods, security and well-being, and as a result is essential for climate change adaptation.

Appendix C

Comparative summary of climate change variables for each case study region, updated from Low Choy et al 2013 [12].

Climate Change Variables	Case Study Regions				
	Kaurna National Cultural Heritage Association Inc (KNCHA)	Wathaurong Aboriginal Co-Operative Ltd (WACO)	Boon Wurrung Foundation Ltd (BWF)	Quandamooka Lands Council Aboriginal Corporation Inc (QLCAC)	Jagera Ganay-Magil Aboriginal Corporation Inc (JGMAC)
Vulnerability Rating [20]❖	Medium	Medium	Medium	Hot spot	Hot spot
Temperature Changes	Temperature increases of 0.5°C to 1.1°C by 2030 and by 2.6°C to 4°C by 2090 [35]	Temperature increases of 0.4°C to 1.1°C by 2030 and by 2.5°C to 4°C by 2090 (RCP8.5) [35]	Temperature increases of 0.4°C to 1.1°C by 2030 and by 2.5°C to 4°C by 2090 (RCP8.5) [35]	Temperature increases of 0.4°C to 1.3°C by 2030 and by 2.7°C to 4.7°C by 2090 (RCP8.5) [33]	Temperature increases of 0.4°C to 1.3°C by 2030 and by 2.7°C to 4.7°C by 2090 (RCP8.5) [33]
Rainfall Changes	Winter rainfall decrease by up to 15% by 2030 and 25% % by 2070 [35]	Generally less rainfall in winter and spring; winter decreases of up to 30% by 2090 [34]	Generally less rainfall in winter and spring; winter decreases of up to 30% by 2090 [34]	Little change or decrease in winter and spring [33]	Little change or decrease in winter and spring [33]
Rainfall and Drought Events	More extreme rainfall events and longer periods of drought [35]	More extreme rainfall events and longer periods of drought [34]	More extreme rainfall events and longer periods of drought [34]	More extreme rainfall events and longer periods of drought [33]	More extreme rainfall events and longer periods of drought [33]
Flooding & Wind Events ❖	Not available.	Potential increase in the frequency or magnitude of flood events or flood heights [45]	Potential increase in the frequency or magnitude of flood events or flood heights [45]	Moderate thunderstorm activity averaging between 20 to 40 days per year [44]	Moderate thunderstorm activity averaging between 20 to 40 days per year [44]
Sea-level rise	Sea-level rise of 0.07 to 0.18 m by 2030 and 0.28 to 0.65 m by 2090 [35]	Sea-level rise of 0.07 to 0.19 m by 2030 and 0.27 to 0.66 m by 2090 [34]	Sea-level rise of 0.07 to 0.19 m by 2030 and 0.27 to 0.66 m by 2090 [34]	Sea-level rise of 0.08 to 0.19 m by 2030 and 0.30 to 0.65 m by 2090 [33]	Sea-level rise of 0.08 to 0.19 m by 2030 and 0.30 to 0.65 m by 2090 [33]

Climate Change Variables	Case Study Regions				
	Kaurna National Cultural Heritage Association Inc (KNCHA)	Wathaurong Aboriginal Co-Operative Ltd (WACO)	Boon Wurrung Foundation Ltd (BWF)	Quandamooka Lands Council Aboriginal Corporation Inc (QLCAC)	Jagera Ganay-Magil Aboriginal Corporation Inc (JGMAC)
Evapotranspiration (CSIRO, 2007)	Increased potential evapotranspiration in all seasons; and reduction in relative humidity for winter and spring [35]	Increased potential evapotranspiration in all seasons; and reduction in relative humidity in the cool season [34]	Increased potential evapotranspiration in all seasons; and reduction in relative humidity in the cool season [34]	Increased potential evapotranspiration in all seasons; and little change in relative humidity [33]	Increased potential evapotranspiration in all seasons; and little change in relative humidity [33]
Bushfire Events	Harsher fire-weather [35]	Harsher fire-weather [34]	Harsher fire-weather [34]	Harsher fire-weather [33]	Harsher fire-weather [33]
Hot Days and Frost days	More hot days and warm spells; fewer frosts [35].	More hot days and warm spells; fewer frosts [34]	More hot days and warm spells; fewer frosts [34]	More hot days and warm spells, two to three times the average number of days above 35% by 2090; fewer frosts [33]	More hot days and warm spells, two to three times the average number of days above 35% by 2090; fewer frosts [33]

❖ Note: This Vulnerability rating was used in [20] by the IPCC, but in their later [21] report it was absent because existing vulnerability assessments are not providing confident results, and dynamic nature of vulnerability (especially regarding adaptive capacity).

⊛ Note: recent projections for these which could indicate inaccuracy in models.

Appendix D

Summary of Generic Characteristics of the case studies. Adapted from [12].

Case Study	1	2	3	4	5
Organisational Name	Kaurna National Cultural Heritage Association Inc	Wathaurong Aboriginal Co-Operative Ltd	Boon Wurrung Foundation Ltd	Quandamooka Lands Council Aboriginal Corporation Inc	Jagera Ganay-Magil Aboriginal Corporation Inc
Country: Geographical	Adelaide Plains	Geelong and Barwon	Lands stretching	Moreton Bay and North	Brisbane – Ipswich

Location & Scope		Region, south-west of Melbourne	from southern Melbourne to Wilsons Promontory including the Mornington Peninsula	Stradbroke Island region east of Brisbane	metropolitan areas
Corporate Status	Incorporated with an aim of cultural heritage custodianship and referral	Co-operative with an aim of employment, social and health provision for Indigenous residents	Limited company serving as a spokesperson for the Boon Wurrung	Incorporated with an aim of cultural heritage custodianship and referral	Incorporated with an aim of cultural heritage custodianship and referral
Legal Status	Advisory referral service	Advisory referral service; not a Registered Aboriginal Party (RAP) which is fulfilled by the Wathaurung Aboriginal Corporation	Advisory referral service; not a Registered Aboriginal Party (RAP) but has made application for status in conjunction with the <i>Boon Wurrung</i> community	Quasi-local government entity arising from a successful Native Title claim	Advisory referral service
Urban Characteristics	Urban and peri-urban Adelaide Plains metropolitan context	Urban and peri-urban Geelong metropolitan context	Urban and peri-urban southern Melbourne metropolitan context	Peri-urban Moreton Bay regional context	Urban and peri-urban Brisbane - Ipswich metropolitan context
Geographical Characteristics	Plains landscape adjunct to the Gulf St Vincent	Rolling plains landscape adjunct to Port Philip Bay and the Bellarine Peninsula	Mixed environment from coastal to swamps to farmlands to national parks	Coastal and riverine landscapes including major islands	Mixed environment from coastal to swamps to farmlands to riverine plains

The Landscape Carbon Calculator: A Tool to Understand and Improve our Carbon Footprint

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Abstract

Landscape architects are uniquely qualified to process and synthesize complex challenges that yield sustainable, world-changing solutions. We have a significant role to play in climate change – both in adapting landscapes from the effects of global warming and by mitigating, or designing against, the causes of global warming.

‘Landscape’ is what sets us apart from architecture and this distinction makes all the difference in what we are trying to accomplish. Landscapes are traditionally planted in one form or another so they possess the power to sequester carbon where architecture cannot. That said, landscape architects can do better than carbon neutral. We can strive beyond neutrality by providing Climate Positive solutions. In order to join this global initiative, we must measure the contribution of the profession.

To improve the impact of our projects on the planet, we must understand their Landscape Carbon Footprints. To enable this initiative, I have created a carbon calculator for landscape architecture that can track the carbon footprints of our projects and help set collective goals for the profession. This tool uses a 3-part structure that takes into account Sources, Sinks, and Costs – arriving at a Landscape Carbon Footprint.

After developing a beta version of this tool and running several CMG projects through it, directly applicable insights are observed. By making a few design or material changes, we can see drastic reductions in the overall carbon footprint of a project and the time needed to offset the carbon emitted during construction. On a park project, a few simple moves could have eliminated 200 metric tons of carbon from the atmosphere. And on a plaza site, by increasing the planting area from 5% to 10%, the time it takes to offset its emitted carbon is reduced by over 100 years.

This exercise confirmed that landscape architects impact the environment beyond the sensory experience. Through the development of this tool and ongoing carbon tracking through the life

of a project, we can greatly improve the carbon footprint of our projects. We can both decrease the amount of carbon emitted through our work and sequester additional greenhouse gases from the atmosphere, contributing to the reversal of global warming. It is through advancements like this that our profession has the chance to ensure future resilience of our planet.

Keywords: mitigate climate change

1. Introduction

As landscape architects, we are uniquely qualified to process and synthesize complex challenges that yield sustainable, world-changing solutions. We have a significant role to play in the fight against climate change – both in adaptation but also by mitigating the causes of global warming. But what is holding us back, and what are the tools that we need to step up to this challenge?

According to the Intergovernmental Panel on Climate Change (IPCC) we are on track to hit a two degree (Celsius) increase in global temperatures by the year 2050 [1] — at which point in time the scientific community tells us we “lock in the climate” to a constant state of change. Beyond this point, reversing global warming is no longer possible and we understand now that we have thirty years or less to prevent this catastrophic tipping point. Considering not all countries have signed the Paris Agreement, which targets preventing the two-degree increase, we need to take it upon ourselves as a profession to contribute to this goal.

The World Green Building Council reports that the built environment contributes to nearly half of the annual global greenhouse emissions [2]. Because landscape projects are typically grouped into the “built” environment with architecture and infrastructure, it is difficult to

distinguish the landscape architectural contributions to the global carbon dilemma.

To put the impact of profession of landscape architecture into the global carbon context, according to the International Federation of Landscape Architects (IFLA), there are approximately 75,000 landscape architects [3] in the world. Conservatively, if the average size of our projects is an acre and each team (of 2 landscape architects) builds a one acre project per year, with an average emission of 25 lbs of carbon per square foot, the carbon footprint as a profession is 20 million metric tons per year – equivalent to the volume of 7,000 Olympic size swimming pools. At that rate, by the year 2030 the emissions exceeds 70,000 swimming pools, and by 2050 – the year we are expected to reach the 2-degree tipping point – it reaches over 200,000 pools (appx. 500 million metric tons). Again, that is an extremely conservative estimation, but highlights the fact that our work does have a direct measurable impact to the environment.

The good news is there is something that we can do about it right now, without requiring global treaties or government mandates, or reducing the quality of our work – just the willingness to design for change.

Paul Hawken’s book, “Drawdown” describes eighty solutions that when implemented together over the next thirty years will reverse global warming. Fifteen

of the solutions are land-based. All of which can be implemented in the work of landscape architecture and add up to 20% of the total drawdown needed. They equal 200 out of 1,050 gigatons (GT) required to reach drawdown—the point at which atmospheric greenhouse gases begins to decline on an annual basis [4]. Those solutions cover a wide range from designing walkable cities to afforestation.

To address the positive contributions of site design specifically, as landscape projects contain trees and plants, they possess the power to sequester carbon. So, if each 2-person team of the 75,000 landscape architects builds a one-acre project per year for the next thirty years, we will sequester over 800 million metric tons of carbon (.84 GT) in our projects as typically designed with a 60% softscape to 40% hardscape ratio. After subtracting out our carbon footprints, the delta of our positive contribution is .28 GT of sequestration. If we can increase our contribution slightly through modifying our designs and increasing our sequestration above .32 GT, we will make it into the top 75 solutions for reversing global warming from “Drawdown”, achieving a greater impact than implementing ridesharing globally.

Landscape architects can do better than carbon neutral. We can instead strive beyond neutrality to be Climate Positive and contribute to the fight against global warming. To do this, we need the tools for change.

2. Objectives

2.1. *Measuring Landscape Carbon Footprints*

To improve the impact of our projects on the planet, we need a better understanding of Landscape Carbon Footprints. Carbon calculators exist for architecture, such as Athena or GaBi but none are publicly available for landscape architecture. Our work is distinct enough that we need a specific and custom carbon calculator for our profession in order to track carbon footprints and set collective goals. Without being able to measure the carbon footprint of a site, it is extremely difficult, if not impossible, to contribute to the 2030 Challenge [5] that the IFLA and the American Society of Landscape Architects (ASLA) have adopted, which targets that all projects be carbon neutral by 2030.

2.2. *Goal Setting for the Profession of Landscape Architecture*

We also need to understand Landscape Carbon Footprints to define terminology and appropriate goals specific to our profession.

The 2030 Architecture Challenge is an excellent and ambitious target for our colleagues, but is just that – an architecture challenge. “Carbon Neutral” being defined by Architecture 2030/The 2030 Challenge states that “All new buildings, developments, and major renovations shall be carbon-neutral by 2030”, and defines “Carbon Neutral” as “using no fossil fuel greenhouse gas (GHG)-emitting energy to operate” by the year 2030. Although the embodied carbon is understandably a fraction of the energy uses of a building over time, not targeting design elements that we

can easily change through the process is a missed opportunity.

More importantly for landscape architecture, because landscapes typically consume very little GHG-emitting energy to operate, as a profession, we should be more concerned about the GHG's emitted in the production/construction of our sites. Being "Carbon Neutral" for landscape architecture is better defined as the point at which the emitted carbon from the project is offset by the site itself. The most significant goal for landscapes should be to minimize the initial carbon footprint of the project, offset that footprint through sequestration as soon as possible, striving to reach the point where we pull additional carbon out of the atmosphere. It is an instead a more proactive goal of being "Climate Positive".

The thickening layer of greenhouse gases in the atmosphere is the cause of rising temperatures and the cause of climate change. Drawing it down is the most significant contribution that we can make as a profession to reverse global warming.

3. Methods

Without finding the tool needed to understand the carbon footprint of our projects at CMG, I created a simple carbon calculator. It uses a 3-part structure that takes into account Sources (embodied carbon of materials/construction – carbon emitted for the project), Sinks (such as trees, plants and wetlands – where the carbon is stored), and the Costs (carbon emitted through grading, ongoing maintenance, etc.). Then by adding the Sources and Costs together and subtracting the Sinks you arrive

at the Landscape Carbon Footprint of a project.

$$\begin{aligned} & Sources - Sinks + Costs \\ & = Landscape Carbon Footprint \end{aligned}$$

The Inventory of Carbon & Energy (ICE) Version 2.0 [6] from the University of Bath, funded by the Carbon Vision Buildings, the Carbon Trust and the UK Energy Research Council establishes the material embodied carbon quantities referenced in the calculator.

Similar to a typical project cost estimate format, the calculator lists building materials with their associated embodied carbon quantities. Separately the landscape Sink data includes annual sequestration rates (comparable to the US Forest Service tool called iTree [7]) which are subtracted from the total year one footprint. Similarly, the Costs, or additional emissions over the life of the project, are identified and added into the overall footprint.

A carbon footprint quantity represents the day one/year one impact, but in reality, that number changes over time. If the site has greater carbon Sinks than Costs, the initial carbon footprint is offset more quickly. The total emissions from the construction of the project are then tracked over time to identify the carbon neutral point and the transition into having a Climate Positive impact.

To gain a broad level understanding of Landscape Carbon Footprints, a wide range of projects were run through the calculator as originally designed – a garden, a park, a plaza, and a streetscape. Then modifications were made to the site without reducing the quality of the design to see if the overall footprint could be reduced.

In a separate exercise, the projects were scaled-up in size to better understand the emissions, sequestration opportunities, and offset time for larger scale projects.

4. Results

4.1. *Measuring Landscape Carbon Footprints*

By making a few design or material changes, we can see drastic reductions in the overall carbon footprint of a project and the time needed to offset the carbon emitted during construction.

The first case study was a half-acre garden project that was 60% pervious and included seventy trees. If our design replaced some lawn for shrubs, used a locally sourced wood versus tropical hardwood, and minimized the aggregate base, we could have reduced the footprint by 25 metric tons and lessened the carbon neutral milestone by five years.

The second case study is a six-acre park, also 60% permeable and with closer to one hundred trees. This project as currently designed has a conservative footprint estimate of 1,000 metric tons of carbon, which will take at least thirty years to offset. By changing some asphalt to stabilized crushed stone paving, minimizing paving quantity by consolidating the vehicular access areas, reducing the depth of aggregate base, adding in fifty trees and swapping some lawn for shrubs, we could have reduced the carbon footprint by 20%

and knocked ten years off the carbon neutral milestone.

Perhaps most significant is the half-acre plaza case study site, with only thirteen trees and 5% permeable surfaces. Just by increasing the planting area from 5% to 10%, we could have reduced the time it takes to offset its emitted carbon by over 100 years. Not only was sequestration increased, but also with the increase in planting area, hardscape was eliminated and less drainage infrastructure was required. The streetscape study found similar and comparable impacts and reduction strategies as the plaza.

One element that all case studies shared was the ability to decrease the time to get to carbon neutral by 50% without making significant design changes or quality reductions.

Another notable observation is that when scaling a project up in size, if the ratio of hardscape to softscape remains the same, the offset time remains similar to the small project. However, the overall carbon emissions of a large project significantly increases, so we should be mindful of trying to increase the softscape ratio on larger projects, ensuring to minimize the overall carbon emissions.

In addition to the case studies, through examination of the Inventory of Carbon & Energy and literature review, the following high-level strategies can be deduced:

1. High carbon outputs are from highly processed materials – plastics, steel, concrete

2. Natural elements have less embodied carbon – if wood, use reclaimed, or sustainably harvested
3. Use recycled materials where possible like steel or aluminum
4. Plant as many trees and plants as you can – incorporate forests at any scale, even tiny ones can have a great impact
5. Create other carbon sinks
 - 5.1. Coastal wetlands, such as mangroves, tidal marshes, and seagrasses can sequester up to five times the amount than tropical rain forests. [4]
6. Consider bamboo- because it is a grass, the plant can store carbon in the soil for thousands of years. [4]
7. Green roofs can sequester carbon and also reduce the energy needs in the floor below by 50% [4]
8. Use the maximum amount of cementitious substitutions (slag, flyash, silica fume) in concrete
9. Get creative to reduce materials in a attempt to “do more with less” – limit piping by using natural swales and permeable paving
10. Overgrading leads to an excessive release of CO₂. Keep your site’s carbon in the soil. More information is available through understanding regenerative farming practices.
11. On urban projects, “greening” is a challenge. Consider vertical vines/gardens or rooftops.
12. Product manufacturers need to provide the carbon footprint of their products so we can incorporate this into the overall project carbon footprint. The preferred standard is the Environmental Product Declaration (EPD), a standardized report that uses the technique of life-cycle assessment (LCA) to quantitatively measure the environmental impacts of materials or products.

4.2. Goal Setting for the Profession

With the information from the beta version of the Landscape Carbon Calculator, we know at a high level that we can make changes immediately to our projects without reducing the quality of our work. With the case study knowledge, we could set a goal as a profession to reduce the emissions offset time of our projects by 50%.

The case study examples also highlight that there is a significant importance in the ratio of hardscape vs. softscape. With that knowledge, we could target a 60% permeable to 40% hardscape ratio from the outset of our designs. By employing that ratio, we can set professional or practiced-based goals of, for example, “All projects have a targeted goal of offsetting their footprint within 10 years” so we can more quickly contribute to drawing down additional carbon from the atmosphere.

With a better understanding of the profession’s impact, we can further define our role in global solutions, and set goals for ourselves. None of which was possible or at least was not publicly available to date.

5. Conclusions

5.1. Measuring Landscape Carbon Footprints

This exercise made it clear that landscape architects impact the environment beyond the sensory experience. With a more refined tool and ongoing carbon tracking through the life of a project, just like a cost estimate, we can greatly reduce the carbon footprint of our projects. Not only can we decrease

the amount of carbon emitted through our work, but the sooner we offset their carbon footprints, the sooner our projects can begin sequestering additional greenhouse gases from the atmosphere and contribute to reversing global warming.

The Landscape Architecture Foundation (LAF) has selected the advancement of the Landscape Carbon Calculator as a 2018 Fellowship recipient. This national platform, combined with the support and testing through CMG, will allow the calculator to be publically available and distributed for use in 2019.

Refinements to the beta version of the Landscape Carbon Calculator are scheduled to be shared at the ASLA Annual Conference in Philadelphia, Pennsylvania, USA in October 2018.

Once complete, this tool can become a resource for existing sustainability rating systems such as LEED or SITES to adopt.

5.2. Goal Setting for the Profession

Because we are a global profession, we must set goals at the global level. To date there is no guidance or measure of success for improving our contribution to this environmental crisis. Now is the time for us to step up in support of the Paris Agreement.

With the knowledge gleaned from the Landscape Carbon Calculator, our leading organizations can establish Climate Action Goals. These goals can targets for our contribution to the 2030 Challenge specific to our profession.

Because global temperatures and seas are already rising, our profession has a significant role to play in adaptation and

designing for resiliency as well as mitigation. These goals should span all aspects of our professional contributions to climate change.

Climate Change is the most significant environmental challenge of the century and our contribution is now more important than ever. Through the development of the Landscape Carbon Calculator, which can inform a series of goals to support the 2030 Challenge and the Paris Agreement, landscape architects will join other leaders as Climate Positive advocates for the world.

6. Bibliography

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Please e-mail feedback or queries to:
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Vegetation succession planning and resilience: Digital visualization and modelling of the Adelaide Park Lands, Australia

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Abstract

Discourses about urban heat island effects has pointed to two positive conclusions that firstly inserting greenery into the city fabric will ameliorate the impacts and that secondly the existing fabric already is serving in some capacity in ameliorating the effects. Both are conclusions positioned in static temporality and do not respect the dynamic nature of landscapes and in particular tree species. In these discourses little attention has been given to nurturing existing vegetative resources, sustaining these resources and how best to holistically address temporal change or the senescence of these resources. This paper considers and case study's the internationally iconic town planning template of the 'City of Adelaide Plan', elevated to prominence by Ebenezer Howard in his garden city arguments, but focuses upon the Park Land ring that has historically characterised Adelaide as being unique and of international cultural significance.

Trees are not static elements like buildings. They grow, mature and die, and their mature-phase profuse oxygenation cools the city environment and psychologically enriches its terrestrial and aquatic residents' (human and animal alike) environmental behaviour. But tree loss is change. Loss does have a deterioration upon the urban heat island. It represents damage to the integrity of the urban forest, and is dynamic and multifaceted in its characteristics due to age, drought, species, longevity, clustering, water-draw, and density. The latter are exceedingly difficult variables and attributes to model especially when dealing with a plant palette of Indigenous, native and exotic species with a paucity of historical knowledge about their growth performance and health compounded by the short less than 200 year post-colonial invasion history of Australia's plant and landscape architecture knowledge.

This paper examines vegetation geodesign modelling for the Adelaide Park Lands landscape to consider the consequences of species growth and senescence upon its urban heat island.

The evidence emerging from this research clearly demonstrates that Aboriginal people's consideration of the future, even with the overlay of climate change and the requirements for serious considerations of adaptation, are significantly influenced and dominated by economic aspirations which are seen as fundamental survival strategies for their communities.

Keywords: Adelaide Park Lands; Tree succession planning; geoplaning modelling; Landscape architecture

1. Introduction

Contemporary academic and scientific discussions about urban heat island effects has pointed to two positive conclusions. The first is that by the insertion of greenery into a city's fabric amelioration of heat island and climate change impacts will occur. Secondly, the existing vegetative fabric of the city is already serving in some capacity in ameliorating the effects [1, 2, 3]. Both are conclusions reflect the static temporality of data pertaining to trees and vegetation in their calculations and modelling. Both conclusions do not respect the dynamic nature of landscapes and in particular tree species type and growth patterns. Additionally, these discussions have paid little attention to nurturing existing vegetative resources, sustaining these resources and how best to holistically address temporal change or the senescence of these resources [4, 5].

This paper investigates the internationally iconic town planning template of the 'City of Adelaide Plan' [6, 7, 8, 9, 10, 11], elevated to prominence by Ebenezer Howard [12, 13, 14] in his Garden City arguments. The core focus of the investigation is upon the Park Land 'ring' that has historically characterised and encircled Adelaide resulting in its design, urban planning and environmental uniqueness and of international cultural significance [15, 16, 17].

Trees are not static elements like buildings. They grow, mature and die, and their mature-phase profuse oxygenation cools the city environment and psychologically enriches its terrestrial and

aquatic residents' (human and animal alike) environmental behaviour. Tree loss, tree limb fall, tree foliage shedding, pests and disease can affect the tree, natural and human tree structure or root damage is or results in change to the individual tree species as well as the tree family in its immediate location, and possibly the species only across a wider landscape [18, 19].

Tree loss has a deteriorating impact upon the urban heat island. It constitutes damage to the integrity of the 'urban forest', whether a formal or informal forest, whether a set of vegetated corridors or roadscares, whether a sequence of exotic or indigenous grasslands, and thus this 'urban forest' is dynamic and multifaceted in its characteristics due to age, drought, species [18, 20], longevity, clustering, water-draw [17, 21], and density [19].

The latter factors are exceedingly difficult variables and attributes to model. Such modelling is especially more difficult when dealing with a mixed plant palette of Indigenous, native and exotic species with a paucity of historical knowledge about their growth performance and health compounded by the short less than 200 year post-colonial invasion history of Australia's plant and landscape architecture knowledge.

Thus, vegetation in a city is the green infrastructure that enlivens the spirit and character of the place, psychologically and physically enriches the well-being of humans and animals, and mediates many of the negative effects of a city.

This paper examines vegetation geodesign modelling for the Adelaide Park Lands landscape towards understanding the consequences of species growth and senescence upon its urban heat island [2, 3].

The evidence emerging from this research clearly demonstrates that Aboriginal people’s consideration of the future, even with the overlay of climate change and the requirements for serious considerations of adaptation, are significantly influenced and dominated by economic aspirations which are seen as fundamental survival strategies for their communities [22, 23, 24].



Figure 1: Location of Adelaide. Source: <https://www.worldatlas.com/oc/au/sa/where-is-adelaide.html> , accessed 1 March 2018.



Figure 2: The Adelaide Park Lands and Square. Source: <http://www.adelaide-parklands.asn.au/> , accessed 1 March 2018.

2. Urban Ecology

Urban ecology evolved internationally in the 20th century as being a potential solution for improving sustainability and liveability in cities [25]. Authors like Steiner [26] and Ndubisi [27] have asserted that ecologically motivated landscape architecture and site design, such as the Sustainable Sites Initiative [28], is good practice.

With an increasing urban population globally and the challenges of incremental depletion of the Earth’s resources and increasing pollution, more academic and policy attention is being given to investigating, analysing and proposing actions to improve the quality of our urban environments. The conservation and enhancement of nature and natural processes in cities is increasingly perceived and documented as one key solution to some of these global and local challenges. The two-way relationship between city and nature, or

the ecology of the city, is instrumental in this policy discussion, whether in Singapore, Melbourne or Adelaide.

Niemelä [29] has investigated the emergence and history of the discipline of urban ecology and studied different aspects of urban ecology science. His examination of the ecological patterns, processes and applications in urban environments and accompanying discussion about the ecology of urban settings and their relationship with urban land use planning, points to the immediacy of taking a solid appraisal of existing and proposed green infrastructure and the need to take a dynamic vision to manage this resource. What is also clear from contemporary research is that the bigger picture of ecological land use and smart growth planning and proposed strategies and criteria for planning and designing multi-functional green infrastructure need to scaffold and promote ecological services in the city.

We argue that urban ecological studies must include multi-functionality, connectivity, integration, communicative and social-inclusive processes, and a long-term strategy thinking, and recommend that these approaches be applied to improve our cities. But such investigations must be dynamic in their perspective, not be impeded by ‘now’ information, but toned to incorporate the modelling of vegetation growth and succession so to better manage the current and future urban heat island effects that are increasingly encircling our cities. In formulating this argument, we recognise that a major goal of urban ecology is to

understand the relationship between the spatiotemporal patterns of urbanisation and ecological processes. Such research needs to identify and discuss urban ecological patterns and processes in a dynamic not time static model, and in particular examine it having regard urban infrastructure planning and design.

Urban ecology principles have evolved since the 1970s, and there is increasing interest among scholars to investigate ‘urban ecology as science of cities’ [30]. Urban ecology principles currently embrace a wide range of variables, values and attributes in habitats, biodiversity, plants and vegetation, animals/wildlife, soil, chemicals, air, water and organisms, greenspaces, and residential, commercial and industrial areas in cities and rings around the city [31].

Pickett *et al.* [32] have recently concluded that ecology in, of and for the city are valid approaches to advancing the knowledge of urban ecology. In this research, ecology in the city focuses on natural features within cities, whereas ecology of the city involves entire urban mosaics as social-ecological systems of biological, social and built components. Ecology for the city helps urban sustainability goals and encourages ecologists to engage with other disciplines to shape sustainable urban environments. These perspectives—especially Pickett *et al.*’s [32]—are helpful in landscape ecological methods and their applications in the study of urban infrastructure as it relates to broader urban environments.

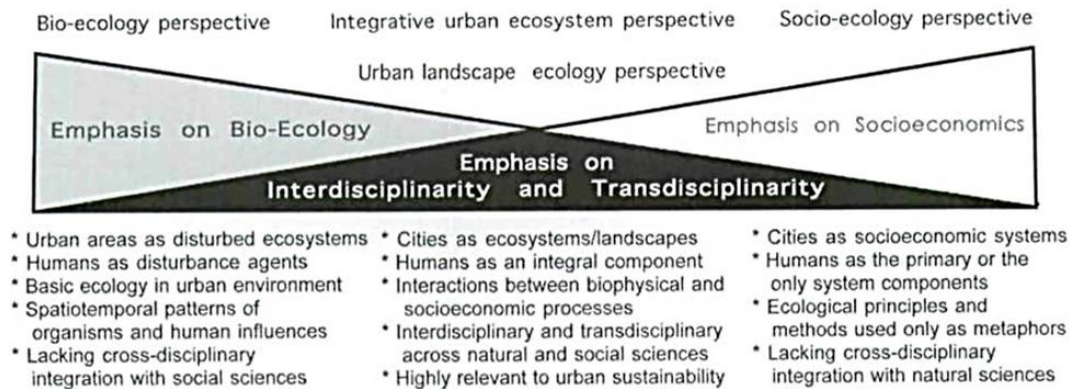


Figure 3: Different perspectives in urban ecology and their major characteristics in terms of assumptions, research emphases, and methodology. Source: [33].

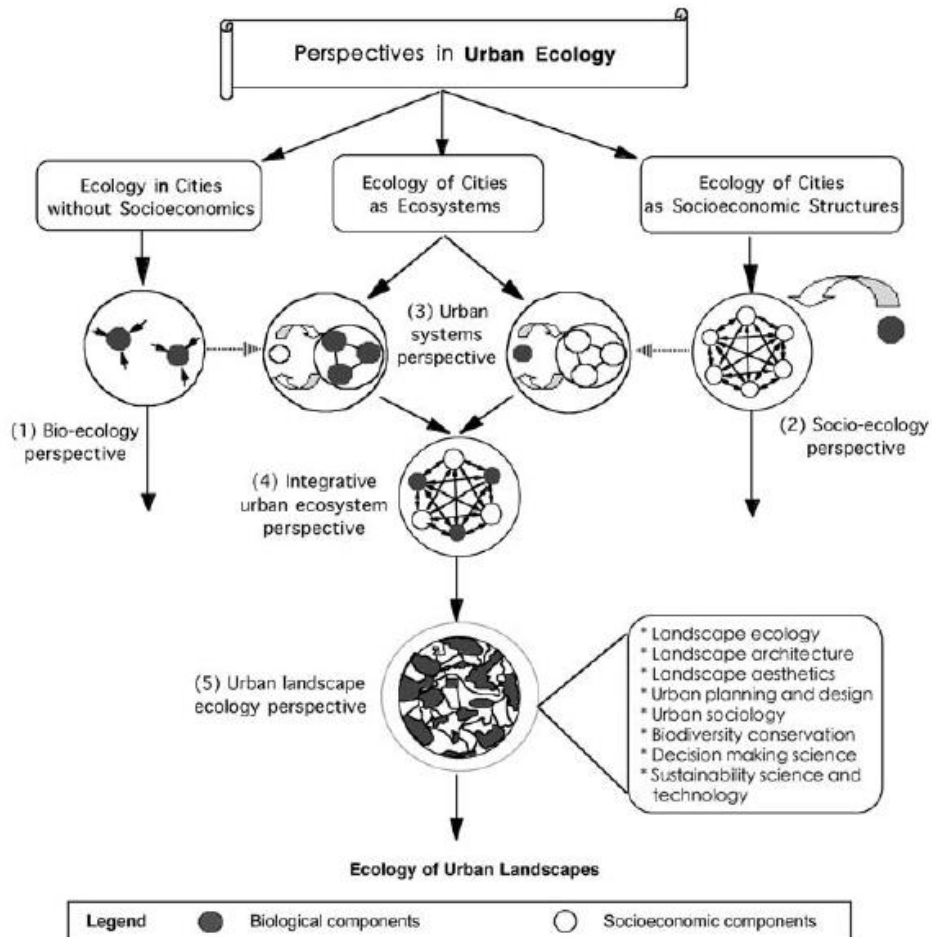


Figure 4: An illustration of the evolution of urban ecological perspectives from ecology in and of cities to ecology of urban landscapes as socioeconomic structures and urban ecosystems. Source: [33].

3. Adelaide Park Lands and National Heritage

On 7 November 2008, at the foot of a statue commemorating colonial surveyor Colonel William Light, The Honourable Peter Garrett MP, Australian Commonwealth Minister for the Environment, Heritage & the Arts, announced the National Heritage listing of the ‘Adelaide Park Lands and City Layout’ under the Commonwealth’s *Environment Protection and Biodiversity Conservation Act 1999* [34]. The actual citation text is provided in Appendix 2.

The ‘Adelaide Park Lands and City Layout’ was included in the National Heritage List as fulfilling criteria a, b, d, f, g, and h as quoted in Appendix 1.

Minister Garrett concluded that the place fulfilled 6 of the 9 values for Listing evaluation under section 324JJ of the *Environment Protection and Biodiversity Conservation Act 1999* [34], and that the ‘significance threshold’ was successfully fulfilled.



Figure 5: ‘Adelaide Park Lands and City Layout’ National Heritage Listed place, under sections 324JG and 324JH of the *Environment Protection and Biodiversity Conservation Act 1999*. Source <http://www.environment.gov.au/heritage/places/national/adelaide-parklands>, and <http://www.environment.gov.au/system/files/pages/77631837-15de-45b4-8ec4-30e82f33e688/files/10575802.pdf> , accessed 1 March 2018.

The Adelaide Park Lands is a ‘cultural landscape’ comprising approximately 900ha. It is a multi-layered tract of land possessing Indigenous and post-contact associations, meanings and physical expressions both tangible and intangible [35, 36].

Cultural landscapes falls within the definitions of cultural heritage used by the former *Australian Heritage Commission Act 1975* [37], the present *Australian Heritage Council Act 2003* [38], the ‘Burra Charter’ as authored by Australia ICOMOS [39, 40], and the meaning under the *Operational Guidelines for the Implementation of the World Heritage Convention* [41, 42]. The latter definition is provided in Appendix C.

As a definition, and given the nature of the recent National Heritage listing, the listing is for the ‘Adelaide Park Lands and City Layout’. Thus, the listing includes the ‘park lands’ but also the squares within the ‘layout’ as well as all roadways and several tracts of state government administered land including the Adelaide Botanic Garden. It is important to note that most published literature separates the ‘park lands’ from the ‘squares’ in their narratives and definitions, but that under the Listing both tracts of land are included and that this spatial definition is used in this article. Further, most published literature also interchangeable uses ‘park lands’ or ‘parklands’ as a descriptor for the tract.

The place was deemed as possessing ‘outstanding heritage value to the nation’ in influencing the ‘course [and] ... pattern’ of the nation’s ‘cultural history’, as per criterion (a) [9, 10, 15, 43, 44, 45, 46, 47].

In particular, it contained a physical expression of the Plan draped over the Adelaide Plain and continued to maintain high integrity in its authenticity and had suffered minimal compromise in

amendments and changes to the overall configuration and road circulation system.

Second, the Plan was concluded a being a precedent of settlement planning in the Australian colonies, that embodies an aesthetically embellished ‘city plan’ possessing wide boulevards, generous open spaces reminiscent of London’s town squares.

Third, the overall ‘Plan’ had been and continues to be guided by a single co-ordinated management regime and this longevity of curatorial role, deemed valuable as part of the criteria applicability, was equally matched by a citizen or community-based action group – the Adelaide Parklands Preservation Association.

Fourth, it was concluded that the Plan exists as an international town planning precedent possessing the essential characteristics of the influential Garden City planning philosophy and movement, and continues to hold an international precedent role today in planning and landscape architecture literature.



Figure 6: Areas of intensive turf landscape in the Adelaide Park Lands. Source: REM (2006), *Environmental assessment of potential reuse of treated wastewater from the Glenelg WWTP within the Adelaide Parklands*, Figure 4.1.

4. Tree Longevity

Trees are both the longest-lived and largest organisms on Earth. These are distinguishing factors within the plant kingdom. Trees have been described by Shigo [48, 49] as being ‘A perennial, woody, compartmented, shedding plant; may be short or very tall, single or many-stemmed, sometimes massive, and long-lived’. Cobham [50], due to tree longevity, has observed that these plants can ‘provide long-

term structure’ to the landscape. Additionally Fakes [51] has observed that in order for a tree to provide this structure and therefore make this significant contribution to the landscape, it must ‘live long enough’. If they do live long enough however, old trees may become ‘important points of reference’ in the landscape, and may assist to ‘determine the character of an area’, according to Russell et al [52].

As ‘integral parts of cities around the world’, and within a planning context, trees in urban landscapes have been considered to be features almost as important as buildings themselves, noted Russell et al. [52], and ‘have a higher priority in our towns and cities now than at any time previously’. The importance of trees in the landscape has resulted in a need for appropriate levels of understanding of these living organisms.

Definitions of both ‘senescence’ and ‘aging’ within the plant kingdom were examined in studies by Leopold [53], and Noodén [54, 55]. Leopold [53] has defined senescence as ‘the deteriorative processes that are natural causes of death’, and aging as the ‘processes of accruing maturity with the passage of time’.

Thus, aging was perceived as incorporating ‘... a much wider span of physiological changes, some of which may lead to the weakening of the organism while others may be quite neutral with respect to the capability of the biological organism to survive’. Examples of aging provided by Leopold [53] include the ‘physiological changes in a plant’, such as those causing ‘its conversion from a seedling to a juvenile

plant, from a juvenile plant to a mature plant' or in the 'gradual decline' in vigorous growth as age increases. Salisbury and Ross [56] defined senescence as 'The processes of deterioration that accompany aging and that lead to the death of an organ or organism'. Leopold [53] characterises senescence changes as including changes leading to the colouring and eventual death of leaves on deciduous trees in autumn, and the death of annual and biennial plant species following their fruiting period.

Noodén's [54] definition mirrors Leopold's, with senescence described as 'a decline in physiological functions leading to death', with the following concise explanation:

During the course of their lives, all multicellular organisms and their organs or tissues reach a peak in terms of their physiological function, and then they decline until they die. This process of decline leading to death has been termed senescence, and a distinction has been made between degenerative changes that lead to death (senescence), and those that do not necessarily cause death even though they accumulate with age (aging) [55].

An important aspect of a study into tree longevity is an examination of the various factors that influence the lifespan of trees. The purpose of this is to identify the factors that cause tree death, and therefore potential limitations to tree life spans. The misconception within the wider community of trees being bestowed with 'eternal' life and not requiring replacement due to senescence was observed by Pescott [56] as having a

detrimental effect in landscapes, as authorities can be influenced by these community-based attitudes.¹⁴

Patrick [57] established 'that amenity tree plantings have a finite life' and will eventually succumb to senescence. Shigo [49] also observed that 'Trees, like all living things, grow old and die'. Hannah and Yau [58] stated that 'Trees have a finite lifespan'. Building upon this Hannah and Yau [58] reasoned that beyond their optimal age, trees 'will start to decline, reach senescence and ultimately die'. Crucially within this context of the inevitable nature of tree death, Clark and Matheny [59] observed that at some point in the lifespan of the tree, the amount of energy produced cannot meet the demands for continued 'growth and survival', resulting in tree decline and death. Shigo [49] had also noted this through the observation that 'No living system can grow beyond the limits of energy available to operate the system', and that 'no matter what you do, all living things will eventually die'. If tree senescence exists and tree death can be substantiated, there must also exist upper limits to tree longevity.

5. Methodology

In this research, the development of models predicting possible future tree senescence patterns required a review of various fields of research in order to establish appropriate models for use, and to assign confidence levels based upon the knowledge of tree growth, longevity, and senescence in predicted landscapes. Various tree growth parameters were collected from the field and combined with assigned tree ages to create matrix models that represented expected tree

growth trends. Through the incorporation of curves fitted to these matrix models, tree ages could be assigned to tree specimens of unknown age, to determine dates of establishment based upon key growth parameters [60].

Tree longevity figures for each taxon were sourced from an expert horticulturally-qualified and applied practice experienced peer reference group survey conducted specifically for this purpose.

Through the combination of calculated tree age and predicted tree longevity, senescence patterns for a region of the Adelaide Park Lands were modelled. Interactive structured query-based GIS software was incorporated to display these senescence patterns visually, and to provide interpretations of future landscape scenarios.

Results obtained from the peer reference group survey provided a range of valuable figures representing expected tree longevities for 131 taxa from within the Adelaide Park Lands environment. An extract of the detailed results is set out in Appendix D.

These longevity figures, combined with matrix models and GIS simulations, were test trialled in Tuttangga/Park 17 of the Adelaide Parklands in 2009 [19], and revealed that considerable populations of established trees within Tuttangga/Park 17 in the Adelaide Park Lands are at a high risk of reaching senescence within the near future.

The data was then in 2018 applied against the whole of the Adelaide Parkland tree vegetation inventory, and similar concerning

results and patterns as to tree senescence were realised.

The geospatial modelling part of the methodology employed to produce the various maps consisted of utilising a series of spatial overlays. Each overlay consisted of an aerial base map image of the City of Adelaide which was then over layered with GIS spatial data [60].

The City of Adelaide Tree file [60] represented the street trees in the CBD and North Adelaide region and are illustrated as red dots in Figure 7.

The Public Service Mapping Authority [61] Adelaide tree imagery file was used to illustrate the trees located in the Adelaide parklands area which surrounds the Adelaide CBD.

The PSMA raster file was converted from raster image to ESRI polygon shape file. The conversion process allowed the file to be thematically represented highlighting the number and type of tree.

A key finding from this modelling is the ‘scary’ end results of both the volume and spatial locations of tree senescence that will occurring in the next 20 years across the Parklands and city landscape.

Contextually, this is ‘scary’ because:

- the City is ill-prepared for this volume of tree senescence,
- the City does not have an adequate tree succession plan in place nor mature replacement trees going in plant nurseries ready to be used,

- the City lacks a policy understanding as to how this will affect the city's built environment character and fabric, and
- least of all the major urban heat island impact that will dramatically increase the city's surface and reflection temperatures in the absence of this volume of species senescence as well as the locations where this senescence will occur



Figure 7: Tree data assessment inventory locations of trees in the City of Adelaide.



Figure 8: Tree data assessment inventory locations of trees in the City of Adelaide, identifying patterns of projected tree senescence.

5. Directions

Tree longevity and senescence modelling is little used internationally as a tool to better understand the environmental changes faced by a city and its governance entity in dealing with climate change impacts, the implications of the urban heat island effect, and specifically tree succession planning.

In this research, it is;

- very clear that the City of Adelaide is ill-prepared for this volume of tree senescence;
- that the City of Adelaide does not have a robust tree succession plan in place nor mature replacement trees going in plant nurseries ready to be used, as used to occur under previous horticultural administrations of the Council in the 1860s-1940s period when extensive tree plantings occurred, and a very conscious tree-species specific tree planting program and vision were employed;
- that the City of Adelaide lacks a policy understanding as to how this will affect the city's built environment character and fabric, and that such will dramatically affect the quality and intent of the National heritage Listing citation of the place as well as the Council's adopted urban forest,

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greening, city strategy, and sustainability policies; and

- least of all the City of Adelaide council has little appreciated the role of extant vegetation and prospective tree senescence in managing existing and prospective the major urban heat island impact that will dramatically increase the city's surface and reflection temperatures in the absence of this volume of species senescence as well as the locations where this senescence will occur

Such findings, and conclusions, we venture, could easily be realised across the world.

In cities across the world, we need to be mindful of these findings because of the way that traditional tree succession planning has and is occurring being informed by static information lacking a dynamic context and the construction of an expert-informed reference group that has first experience in tree longevity and senescence pertaining to a specific piece of landscape.

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The authors wish to acknowledge the GIS resources of the City of Adelaide Council in undertaking this investigation.

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Appendix A: Australian National Heritage Criteria. Source:

<http://www.environment.gov.au/heritage/about/national/criteria.html>; accessed 1 March 2018.

The National Heritage criteria against which the heritage values of a place are assessed are:

- a. the place has outstanding heritage value to the nation because of the place's importance in the course, or pattern, of Australia's natural or cultural history
- b. the place has outstanding heritage value to the nation because of the place's possession of uncommon, rare or endangered aspects of Australia's natural or cultural history
- d. the place has outstanding heritage value to the nation because of the place's importance in demonstrating the principal characteristics of:
 - i. a class of Australia's natural or cultural places; or
 - ii. a class of Australia's natural or cultural environments;
- f. the place has outstanding heritage value to the nation because of the place's importance in demonstrating a high degree of creative or technical achievement at a particular period
- g. the place has outstanding heritage value to the nation because of the place's strong or special association with a particular community or cultural group for social, cultural or spiritual reasons
- h. the place has outstanding heritage value to the nation because of the place's special association with the life or works of a person, or group of persons, of importance in Australia's natural or cultural history

Appendix B

Adelaide Park Lands and City Layout' under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999*. Source: http://www.environment.gov.au/cgi-bin/ahdb/search.pl?mode=place_detail;place_id=105758; accessed 7th October 2011).

The national significance of the Adelaide Park Lands and City Layout lies in its design excellence. The Adelaide Plan is regarded as a masterwork of urban design, a grand example of colonial urban planning. The city grid and defining park lands were laid over the shallow river valley with its gentle undulations, described by Light as the Adelaide Plains. The city layout is designed to take full advantage of the topography, an important innovation for the time. The streets were sited and planned to maximise views and vistas through the city and Park Lands and from some locations to the Adelaide Hills. A hierarchy of road widths with a wide dimension to principal routes and terraces and alternating narrow and wide streets in the east-west direction were featured on the historic plan. Features within the Park Lands area included a hospital, Government House, a school, barracks, a store house, a market and a botanic garden and roads

Appendix C

World Heritage Convention definitions for cultural landscapes. Source: (WHC 2012, sections 37-42, accessed 7th October 2011).

37. *The term 'cultural landscape' embraces a diversity of manifestations of the interaction between humankind and its natural environment.*
38. *Cultural landscapes often reflect specific techniques of sustainable land-use, considering the characteristics and limits of the natural environment that are established in, and a specific spiritual relation to nature. Protection of cultural landscapes can contribute to modern techniques of sustainable land-use and can maintain or enhances natural values in the landscape. The continued existence of traditional forms of land-use supports biological diversity in many regions of the world. The protection of traditional cultural landscapes is therefore helpful in maintaining biological diversity.*
39. *Cultural landscapes fall into three main categories, namely:*
- (i) *The most easily identifiable is the clearly defined landscape designed and created intentionally by man. This embraces garden and parkland landscapes constructed for aesthetic reasons which are often (but not always) associated with religious or other monumental buildings and ensembles. ...*
 - (iii) *The final category is the associative cultural landscape. The inclusion of such landscapes on the World Heritage List is justifiable by virtue of the powerful religious, artistic or cultural associations of the natural element rather than material cultural evidence, which may be insignificant or even absent*

Appendix 4

Extract of tree succession findings for the Adelaide Park Lands. Source: [19].

Taxa	Common Name	Total Sum of Figures from Respondents	Number of Responses Per Taxa	Mean Tree Longevity Figures from Respondents (Years)	Standard Deviation from Mean (Years)	Response Rate Per Taxa (Percentage)
<i>Acacia iteaphylla</i>	Flinders Range Wattle	157	1 3	12	2.6	81.3
<i>Acacia pycnantha</i>	Golden Wattle	149	1 2	12	2.7	75.0
<i>Acacia</i> spp.	Wattle	155	3	52	21.4	18.8
<i>Acer negundo</i> *	Box Elder	872.5	9	97	35.0	56.3
<i>Allocasuarina luehmannii</i>	Bull Oak	1135	9	126	41.5	56.3
<i>Allocasuarina verticillata</i>	Drooping She-Oak	1430	1 1	130	60.5	68.8
<i>Angophora costata</i> subsp. <i>costata</i>	Sydney Red Gum	1170	9	130	26.5	56.3
<i>Araucaria cunninghamii</i>	Hoop Pine	1740	1 2	145	26.9	75.0
<i>Araucaria heterophylla</i> *	Norfolk Island	1520	1	138	42.8	68.8

	Pine		1			
<i>Arbutus unedo</i> *	Strawberry Tree	1010	1 0	101	21.8	62.5
<i>Brachychiton acerifolius</i> *	Illawarra Flame Tree	1275	1 2	106	36.4	75.0
<i>Brachychiton populneus</i>	Kurrajong	1510	1 2	126	32.7	75.0
<i>Callistemon rigidus</i> *	Stiff Bottlebrush	540	1 0	54	14.9	62.5
<i>Callistemon salignus</i> *	Willow Bottlebrush	555	1 0	56	17.5	62.5
<i>Callistemon viminalis</i>	Weeping Bottlebrush	662.5	1 0	66	26.8	62.5
<i>Callitris columellaris</i> *	Cypress Pine	1070	1 0	107	30.0	62.5
<i>Callitris gracilis</i>	Southern Cypress Pine	947.5	1 1	86	38.1	68.8
<i>Callitris preissii</i> *	Black Cypress Pine	1030	1 0	103	32.7	62.5
<i>Casuarina cunninghamiana</i>	River She-oak	1592.5	1 1	145	37.5	68.8
<i>Casuarina obesa</i>	Swamp Oak	1020	7	146	39.2	43.8
<i>Celtis australis</i>	Southern Nettle Tree	1185	1 0	119	31.8	62.5
<i>Celtis occidentalis</i>	North American Hackberry	1290	1 1	117	27.8	68.8
<i>Celtis sinensis</i> *	Chinese Nettle Tree	720	6	120	12.3	37.5
<i>Ceratonia siliqua</i>	Carob Tree	1710	1 2	143	59.2	75.0
<i>Cercis siliquastrum</i> *	Judas Tree	885	1 0	89	13.7	62.5
<i>Coprosma repens</i>	Mirror Plant	475	1 0	48	7.5	62.5
<i>Corymbia citriodora subsp. citriodora</i>	Lemon-scented Gum	1665	1 1	151	48.1	68.8
<i>Corymbia citriodora subsp. variegata</i> *		1160	8	145	28.1	50.0
<i>Corymbia ficifolia</i>	Red-flowering Gum	945	1 0	95	46.6	62.5
<i>Corymbia maculata</i>	Spotted Gum	1600	1 0	160	44.9	62.5
<i>Cotoneaster serotinus</i> *	Cotoneaster	300	7	43	8.8	43.8
<i>Cotoneaster spp.</i>	Cotoneaster	350	8	44	9.0	50.0
<i>Cupressus conybearii</i> *	Conybeare's Cypress	760	9	84	10.3	56.3

Hybrid City

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Abstract

In 2011 Thailand was hit by flood catastrophe which cost 14 trillion baht in damage. It was the wakeup call for Thai people to relook of what cause and what shall we develop our territory in the future.

For many decades we have developed our solid territory impose on the fluid territory. Fluid territory where we are living in is the Chaophaya River Floodplain which people in the past learnt how to adapt their way of life with flood phenomena. Since modern time we have applied the idea of man overcoming nature by building the solid territory. This solid territory is blocking the water way, replacing permeable surface, contaminating fertilized soil. We also applied modern agricultural method in order to be able to cultivate rice for 3 – 4 times per year which leave no rooms for flood water to contain. We also built the flood wall along the river bank to prevent city area from flooding .This flood wall has worsen the flood situation by escalating the water level in the river to be higher. This flood wall also damage ecology along the river at the same time. Solid city has applied solid solution to tackle the water by separating water from people and natural way of life. Solid territory has no rooms for water.

The flood situation will be worsen in the future due to the climate change which cause more rain fall and sea water rise while we still continue to build our solid territory to accommodate growing population. We shall relook at how the future territory should be developed in order to live with ongoing water challenges.

Hybrid city is the idea of how can we learn from the local wisdom in living with water in order to transform the solid territory to be more resilience with water and transform city to be more livable for all at the same time. Landscape can be a tool as green infrastructure in transforming the city toward hybrid city where solid and fluid territory can be coexist sustainably.

The strategy is to create more rooms for water within the solid territory by

1. Transforming agricultural land into water detention network
2. Safeguarding the existing permeable surface.

3. Reclaiming more permeable surface from the solid territory
4. Creating more water detention area and permeable surface with the new development.
5. Re-connecting all the water detention area of both private and public to work as one system
6. Forming a guideline to ensure the continuation of the water resilience strategy.
7. Empowering people to be part of the process

This strategy can be applied both in private and public development, new and existing development, as well as unutilized city infrastructure and abandon land . These developments include condominium, Community Park, street scape and district revitalization.

With this strategy it will help city and citizen to relook in adapting our solid city to be more resilience with water challenge in the near future.

1. Introduction

With the growing of urbanization which create much problems to the environment especially at the flood prone city in the Asian metropolis where it is located in the river floodplain .The more we built or expand the city the more flood and environmental problems will occur due to city blocks the water way and it remove the permeable area for water .As the United Nation has predicted that by 2050 ,70%of world population will live in the urban area. We have to transform the existing city not only to take care the growing population but also finding the way to resilience with water and environmental challenges at the same time.

This study looks into how the territory in the floodplain area has developed and evolved from the past until today by looking at Bangkok city as the case study. This study has led us to understand what cause the problems and importantly what are solutions from the local wisdom in living with water .This study also have led us to apply those wisdom into some of our ongoing landscape intervention projects which help transforming city to be more resilience with water which we can then

conclude into strategies that can be applied to other flood probe area. We called the “Hybrid solution” which focusing on how we can make the existing city to be more resilience with water and environmental challenges while maintaining the city growth and lifestyle of the people at the same time.

2. Agenda

2.1 River as sources of life : Fluid Territory
Bangkok situated in the Chaopraya River floodplain .This floodplain was formed 6000 years ago by formation of the natural silt that Chaopraya River brought. Floodplain is where rivers meet and where the land is form .During the rainy season, water from the mountains in the north together with water from its own zone rainfall flow into the river and overflow into the flood plain area .With its property of floodplain which almost flat, it makes the water not to drain properly .In consequence, the area is flooded in the rainy season with an average height of 0.5 -1 meter. The water stays for a certain period of time around 3-4 months before slowly flow into gulf of Thailand. This natural phenomena brings natural silt which

contain a lot of natural fertilizer that help to shape the land.



Fig 1. Chao Phraya River Floodplain

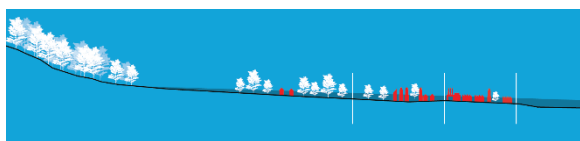


Fig 2 Section of Chao Phraya River Floodplain

People who lives around Chaophraya river floodplain do aware of this water phenomena and natural asset that the river brings, people utilize this asset by settle their villages and cities near the river and within floodplain area so that they can benefit from this natural asset of water and fertilize soil. People then cultivated rice and orchard .People also use river for accommodating their daily life.

River becomes sources of life and culture in many ways. Thai people learn how to live with water not against it. It is the “fluid perception” in people mind that lead people to form” fluid territory” in adapting their

way and space of living with water phenomena.

We still can see some evident of “fluid territory” in people settlements along the river and within Chao Phraya River floodplain. Some of settlements along the river people adapted their boats to be their living area or constructed their house on floating pontoon. Some communities constructed their house on the tall stilt where living quarter located above flood level on second floor, while on the ground floor is used for storage. In some case people tide their house with the pole and let it float when the flood came during rainy season.



Fig3 Settlement of People in Chao Phraya River Floodplain

For agricultural activity, most of the floodplain area was used for cultivating rice. People creates the ditch and dike system around their farm lands to detain water which benefit of growing rice. People also do aware that rice is the planting species which consume a lot of water .One of the native rice specie that people in the past used can even tolerate with high water level up to 3 meters . In some areas along the

Chaopraya River, people strengthen the existing canal system to bring water from the river into their orchard plantation which formed by ditch and dike system.

For city planning along the river, canal system is the main intervention tool in helping city manage flood .Bangkok is one of the example, city has benefited from the orchard area and rice field around the city which acted as the sponge in absorbing water during rainy season .The city core itself also strengthened the canal system to serve as defensive barrier as well as the water way to channelling water from the north to the sea quickly.

Those adaptability concept in architecture, agriculture, city planning and way of living with water has progressively been changed when Thailand entered to the modern era.

2.2 Modern Era: Fluid Territory VS Solid Territory

During the modern era, Bangkok city area has expanded to respond with the growing population. However the way we develop the city in the modern day is no longer has “fluid perception “in living with water in mind like what people in the past had. We adopt the western way of urbanization in using technology and engineering approach to overcome natural phenomena. In consequence, we imposed the “solid territory” into the existing “fluid territory” which full of dynamic ecosystem of people and nature.

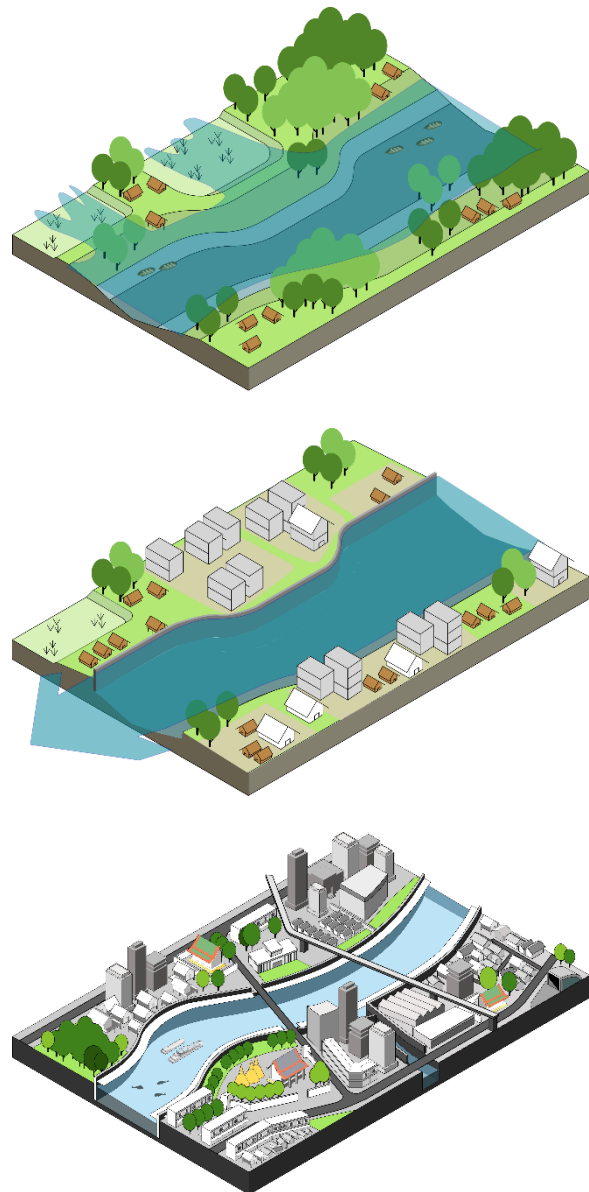


Fig 4 Evolution of the Settlement along Chaopraya River from Fluid to Solid Territory, Past to Present

The “solid territory “that we built has replaced orchard , rice field as well as natural area with concrete city and industrial estate .This solid territory is completely removed these productive

landscape area which also acts as water detention area for the city. Canal system in Bangkok city were also destroyed by replacing many of canals with roads. We used to have almost 2000 canals in the city in compare to 1600 canals at the moment. Bangkok city nowadays has lost its ability in dealing with flood.

Bangkok city and also other cities in Chaopraya River floodplain has grown in the way that blocked the water way .The agricultural land also been modernized ,Nowadays we cultivate rice for export which focus more on the productivity which require irrigation infrastructure , technology and fertilizer . Native rice species was modified, rice field can no longer hold amount of flood water during rainy season since farmers require space to cultivate rice throughout the year.



Fig 5 Settlement Block the Waterway in Chaopraya River Floodplain

It becomes clear that the way we developed our city by imposing the “solid territory” into the “fluid territory” without carefully taking water phenomena into the consideration has led to the flood

catastrophe in 2012 which cost 1.4 Trillion bath in economic damage and lost many life.

2.3 Solid Territory and its consequence.

Bangkok city is one of the city that illustrate how the city has evolved from” fluid territory “where people can live with water in harmony to the “solid Territory” where water become a threat .Nowadays almost 50%of the Bangkok city has already been transformed into concrete surface .The city surface has only 2% of green space while the 18% of agricultural and 8 % of abandon area around and within city are undertreated due to urban sprawl. Many canals has already been replaced with road while Chapraya River also been narrowed down due to the encroaching settlements along the river which left only 24% of the city surface in channelling water.

As the result city is becoming more solid and losing its own capacity in absorbing water and ability in channelling water during the rainy season. Bangkok city has applied engineering approach in solving flood problem by constructing floodwall along the river and around the city .We are now living inside the floodwall .This flood wall has been constructed after flood catastrophe in 2012 in order to protect city from flooding. Flood gate and mechanical pump has been applied at all canals and river throughout the city to manage the water during rainy season.



Fig 6 Floodwall along Chaopraya River

The floodwall is as tall as 2.85 m from mean sea level which at some location it is high as one story building. It was built in the river just in front of the riparian area. This wall blocked the water flow which is essential to the survival of riparian ecology. Those riparian ecology slowly died and soon was replaced with land reclamation. There are some evident show that by replacing those riparian area, it caused in reducing number of fresh water fish in the Chaopraya River.

The floodwall also built just in front of the river community which suffer the way of life of the people living along the river since they cannot connect to the river like what they used to be. The wall also prevent the rain water to flow to the river naturally, city need to apply mechanical pump to pump the water out to the river.



Fig 7 Construction of Floodwall along Chaopraya River

Floodwall not only replaced the riparian ecology along the river but also replaced the relationship between people and the river which is the unique way of life of people living along the Chaopraya River. River is becoming the drainage channel since there is no natural and people life

2.4 Territory's Future Challenges

By the year 2050, Bangkok population will be increased by 11 million people which will cause city to be expanded. If we continue to develop the city by continuing in replacing the "fluid territory" with "solid territory" we may face more natural catastrophe in the future. Fluid territory is play an important role in keeping the urban ecology in balance.

We need to increase city ability in dealing with flood by increase water detention area rather than removing them. At the moment Bangkok has water detention area which has the capacity of 13 million cubic meters, however city still require at least another 6

million cubic meters to be able to cope with the ongoing and future water challenges. These engineering approach in managing water with floodwall and mechanical pump does not seem to be the sustainable solution since it depends on mechanical and it effects natural system and people way of life. With the increasing impact of climate change, BKK is going to be effected by higher rainfall and seawater rise at 3 mm a year .It's going to pose the big challenge to the city which subsided at 5 cm a year .There is a prediction that by 2030 Bangkok city will be permanently flood.

2.5 Adaptability Approach.

It becomes clear that we cannot continue in fighting with water or continue in developing the territory in the direction that against the natural phenomena .We also realized that we cannot give up our territory to the challenges we are facing since territory has already been well developed for many generations .The best approach is to adapt our territory and also our way of life to the ongoing environmental challenges .Adaptability is the fundamental concept in which people in the past and even today learn how to live with water in harmony. Here are some examples;

Architecture ; people built their house on the tall stilt to locate their living area above the flood level and some people still live in the boat or floating pontoon until today .



Fig 8 Floating House and Agricultural Farm

Agriculture ; farmers applied ditch and dike system to manage water to benefit their rice and orchard plantation .In some case they reinvent floating pontoon which made of bamboo or plastic material to do farming .These floating pontoons allow farmers to continue their agricultural activity during the flood season.



Fig 9 Floating Rice Field

Adaptive Way of life ; People who live in Sena community which located on Chaopraya Rive bank in Ayudhaya province has to modify the entire district to respond with the rising water during the flood season every year. They installed the temporary

platform made of timber planks in the street and also in their house and shops above flood level. These temporary timber platform enable people to continue their daily life during the flood season for 3 months.



Fig 10 Elevated Platform during flood at Sena Community in Aydhaya Province

Transportation ; this case study shows how people innovate their everyday elements to live with flood. They combined two different things together which are motorcycle and boat in order to create the “amphibious vehicle” that enable them to navigate to anywhere during flood.



Fig 11 Amphibious Vehicle during flood

Those examples in adaptation with flood have shown the common characteristic as follow;

1. Territory need to be adapted for the survival of people.
2. We must look at flood or water as the natural resources that can benefit our way of live and can also increase economic value.
3. We must adapt our lifestyle to live with water instead of changing the environment to fit ours

2.6 Hybrid City

Since we cannot change our city to be completely “fluid “since it might not be relevant to today people behaviour. We also cannot continue in developing the city to be more” solid” since it will create more problems. “Hybrid city” is the idea in transforming “solid territory” to be more resilience with water by applying the ideas of” fluid territory “which people in the past use to adapt their territory to live with water in harmony.

The strategy is to increase city capacity in dealing with flood by making rooms for water out of the solid territory .Creating more water permeable areas and water detention areas in the city will help city absorb and detain more water during rainy season. This would help not to put so much pressure in term of water volume into the river and canal systems. The river and canal system then be able to channel water from the north and other part of the city to the sea quickly.

We also need to revitalize river, canal system and linear park to connect all the

water detention areas in the city as part of green infrastructure.

The objective is not only to make city be able to survive out of the water challenges but also to use this opportunity to revitalize the city for a better living condition for the people and create economic value at the same time. Importantly, it must include people to be part of the transformation process in order to create the city where everyone is belong.

2.7 Transforming Grey to blue and green network for resilience Bangkok

Even Bangkok has already been developed for solid environment for 48% of the city surface, there are still remaining resources in term of canal network, parks, abandon areas and agricultural area that can be revitalized to create the water resilience city.

There are 7 Intervention tools to be applied

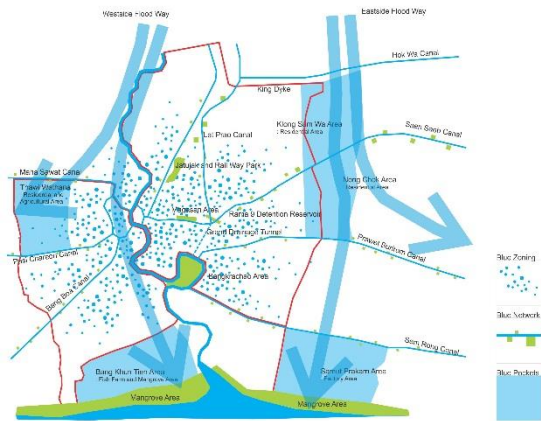


Fig 11 Proposed Water Detention Network in Bangkok

2.7.1. Transforming Agricultural Area as Water Detention Network.

Bangkok situated in the Chaopraya River floodplain. It is surrounded by agricultural land .However during the past decades these agricultural land was replaced by industrial and urban area due to urban sprawl .As the result it also replaced the water detention area which help to absorb flood water before overflowing into Bangkok city. We shall look into the possibility in safeguarding the remaining agricultural land around the city and redeveloping them for water detention purpose by improving ditch and dike system around the agricultural land to increase water detention capacity, improving canal and irrigation system to better channelling the flood water to and from these agricultural areas in order to work as the water detention network. We also need to promote water agriculture activity during this 3 month of detention period so that farmers can get economically benefit from the water at the same time.

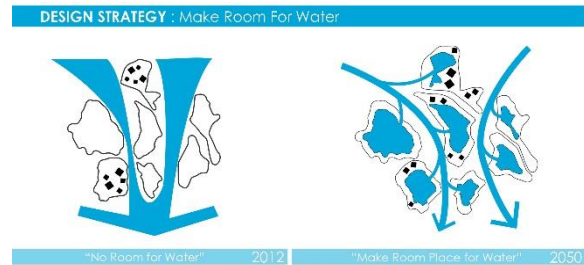


Fig 12 Make Rooms for Water Strategy



Fig 13 Rice Field as Water Detention Network ; Vision for 2050

2.7.2 Safeguarding existing natural area in the city

There are remaining untouched area in the city center and around city peripheral area owned by government and private for 8%. The government should find the policy in purchasing or renting those land from private or creating tax incentive policy to encourage land owner to safeguard them from urbanization. There is a possibility in developing them to be an ecological park for people to recreate and learn about natural ecology .Importantly it can combined with the water detention facilities within the park to help city mitigating with flood water.

2.7.3 Reclaiming water permeable surface and water detention area from built Environment

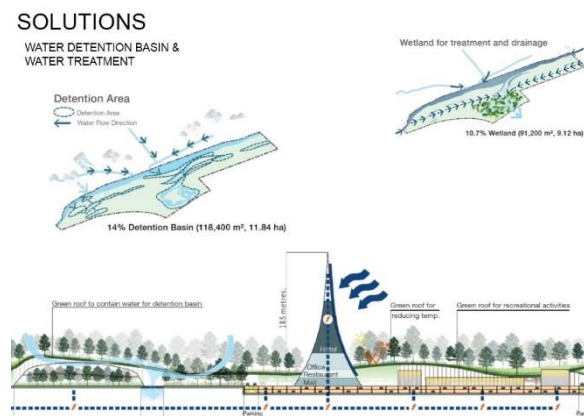


Fig 14 Development that Integrated water detention and Permeable surface

With the ongoing urbanization, some of the land used in the city centre are becoming less relevant to the current and future used of the city. Those land used are industrial land, government work place, military area and cargo port. We should find the way in revitalizing those area for the benefit of

economy, people life and also environment. The development shall provide sufficient amount of permeable area and water detention facilities which can be integrated with public space and commercial area.

2.7.4 Creating new permeable surface and water detention area with the new developments.

With the current approach in creating the new development, we tend to replace the existing green which is the natural water permeable **area** as well as water detention area with the solid **surface**. We should find the way in **maintain** the same water capacity of the land in **absorbing** and **detaining** water while allow the developments to take place to respond with the **growing** population and urbanization. The new development should look into the possibility in make building to become green provider and water collecting element by applying green roof and vertical green .The ground floor should provide sufficient amount of permeable surface and on ground or underground water detention area.

2.7.5 Reconnecting all the water detention area.



Fig 15 Green Network in the city can also act as water network

In order to manage the water volume efficiently, we need a network in connecting those existing and new scattered green areas to work as one system. We shall look into the possibility in revitalizing the existing canals network and also abandon liner space in the city like footpath, space underneath the expressway to work as Liner Park in collecting and channelling water runoff in the city. In additional, this linear space can help in cleansing this water runoff though a combination of planting and mechanical filtration.

2.7.6 Empowering people to be part of the process

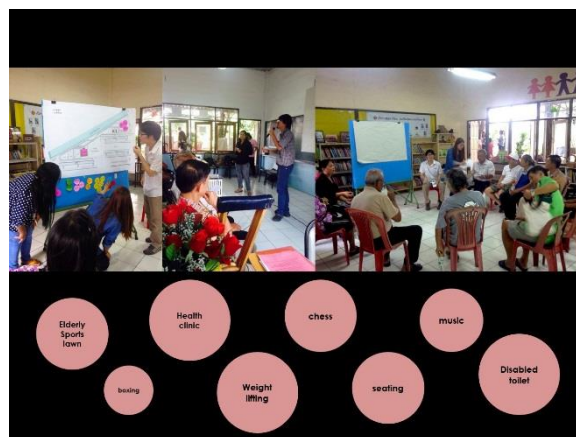


Fig 16 People Participatory Process in Creating Territory

For many decades we have been developing the city for the purpose of accommodating growing population and generating economic growth without understanding what are the purpose of the city. City is for people life .Without understanding the people behavior, we will continue to develop the city that no one use and belong to .We must change the process in developing the city from top down to co-create where people is part of the process from the beginning. With this co –creation process, it is not only creating the specific outcome that respond well to the ongoing and emerging people behaviour but it is also empowering citizenship of the people to create the city that everyone is belong .We should use this opportunity in transforming the city to be more resilient with water and also resilience with people need and behaviour as well.

2.7.7 Forming policies and guidelines

To ensure the transformation of city from solid to hybrid city where it resilience with water will take place in the future, we need the appropriate incentive policies and guidelines. There are possible policies such as providing tax reduction for those who safeguarding the land for water detention, providing subsidized fund for private development to improve water detention capability, providing FAR bonus for private development who provide extra water permeable surface and water detention area. We also need to come out with the framework in guiding the process and physical space in transforming the city. This framework include the principle in city planning to provide sufficient amount of green space as part of green infrastructure to help city mitigating with water and others environmental challenge. It also include how the building and open space should be formed in order not to block the water way and creating the water resilience environment.

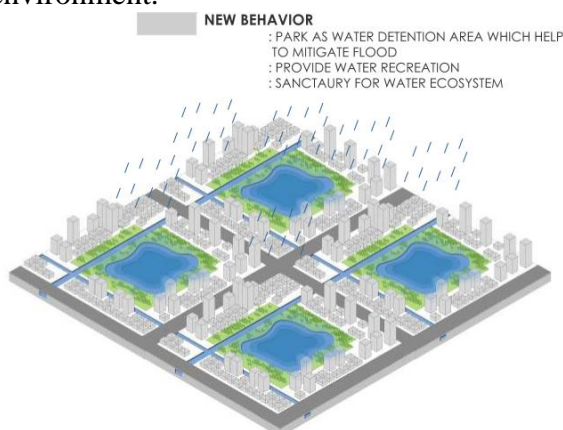
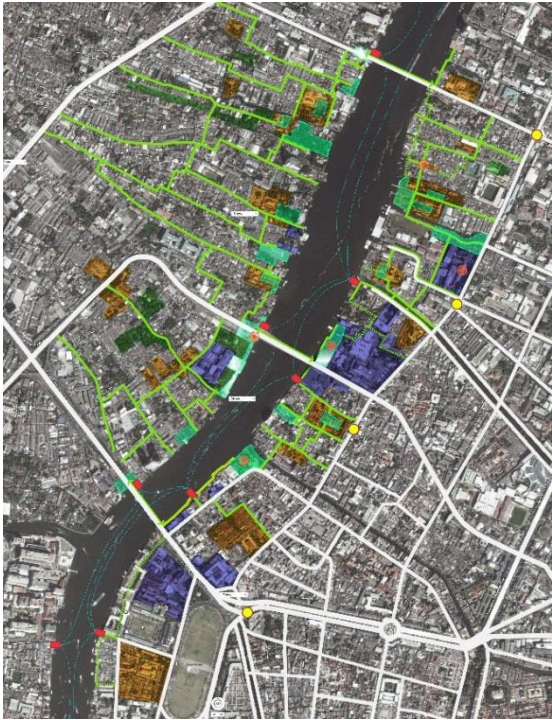


Fig 17 Design Guideline in integrating water detention area and network into the development

2.8 Conclusion

Landscape architecture will play an important role in helping solid city to transform into “hybrid city” where territory is more resilience with water. However each territory has its own context and evolution which we must learn from so that we can choose the suitable tool to be applied appropriately. These tools include planning of the agricultural land to increase capability in detain water. It also include the planning at the city area in finding more rooms for water from safeguarding the existing natural and abandon area ,reclaiming more permeable and water detention area from the solid territory , integrating water detention and permeable surface with the new development and forming the incentive policies and guideline to stimulate the transformation and ensure the proper result. Lastly as the city is for people life, we need to make sure that people will play a central role in co-creating the Hybrid City.



communities and providing pocket green as water detention area.

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Fig 18 Vision plan in revitalise the area along Chaopraya River by Revitalise

Green open space and the impact of tsunami-induced damage in Banda Aceh City

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Abstract

On 26 December 2004 the coast of Aceh, Indonesia had experienced 9,1 RS earthquake followed by tsunami wave about 30 m. One of the worst affected cities is Banda Aceh. This disaster causes hundreds of thousands of victims lost their lives, destruction of public facilities and infrastructures, and the paralysis of economy and community activities for several months. This disaster also made some disturbance and remnant patches that can be used as data to calculate the extent of damage. Some areas that have green open space on the coastal areas are allegedly able to minimize the damage caused by the tsunami. The distribution of green open space in Banda Aceh City before the tsunami was in an uneven condition, especially in the coastal ecosystem areas. According to tsunami researchers from Amalgamated Solutions and Research (ASR), the region of Aceh still has the potential of another tsunami even though they already facing tsunami before. But during this development they not really concern to that threat. After 13 years post tsunami, there's no mitigation program from the viewpoint of landscape architecture. The mitigation program is more directed at rescue activities during and after the disaster but does not think about saving the physical environment from a region. This study aims to examine the relationship between the number of green open space in Banda Aceh City before the tsunami with the damage caused after the tsunami. The method used was multiple linear regression. The results obtained from this study indicate a linkage of the number of green open space to the magnitude of damage caused by the tsunami. So that development of the city in the coastal area should concern the existence of the green open space area.

Keywords: Coastal; disturbance patch; landscape architecture; mitigation; remnant patch.

1. Introduction

Indonesia is an archipelagic country with a coastline of about 81,000 km. Indonesia has a diverse coastal region. Based on the seismotectonic map, the coastal area of

Indonesia has a high disaster threat, namely tsunami waves. Tsunami is a series of wave of ocean waves in large size due to the shift in the seabed due to earthquakes.

One of the coastal areas of Indonesia that had experienced a tsunami that is quite

severe is the coastal region of Aceh. On December 26, 2004 Aceh Province was hit by a tectonic earthquake of 9.1 RS followed by a tsunami wave as high as 30 m. Many impacts caused by this disaster among other damage to public facilities, and infrastructure, until the economic paralysis and community activities. Information obtained from some government agencies (*Bakornas, PBP, Depkes, Depsos, and Media Center National Institute*), the highest number of casualties in Aceh Province with numbers reaching 400,000 people (died and displaced). Based on the data also shows that the largest area affected by this disaster is the coastal area of Banda Aceh [1].

After more than a decade after the tsunami, the government and people began to rebuild the city of Banda Aceh. This activity deserves appreciation of its speed, but its reconstruction does not fundamentally change the community's perspective to build a more resilient city to face the possibility of a similar disaster. The rapid decision to complete spatial planning entirely restores the description of the city of Banda Aceh prior to the tsunami. Yet according to tsunami researchers from Amalgamated Solutions and Research (ASR), Aceh is still a potential tsunami even though the tsunami was hit by a big tsunami [2].

Recognizing this, the United Nations governments began to think about the disaster aspects and to think about how the city should be designed to deal with various types of disasters independently. One is the concept of resilient city. This concept focuses on the city's development system in

order to adapt to the coming of the disaster so that when a disaster occurs a city will not experience too much damage and have the ability to return to its original condition when faced with challenges or in a downturned condition.

The presence of green open space will also affect how much impact caused by tsunami waves. To realize Banda Aceh City that is resistant to future disasters it will be calculated impact through regression analysis comparing the amount of vegetation to the impact caused by tsunami waves, after the analysis results obtained then will be done coastal environmental engineering strategy with the concept of coastal layered coastal system (defensive structure), this environmental engineering can be either artificial structures or natural structures.

2. Methods

This research was conducted in Kota Banda Aceh, Aceh Province. The study was conducted for 4 months starting from September to December 2017.

The study was conducted by calculating the amount of vegetation before the tsunami and the magnitude of the damage caused after the tsunami through the image map obtained in Google Earth Pro, then processed through the application AutoCAD2007 and Microsoft Excel. Map of number of vegetation taken is map on 23 June 2004 and map after tsunami on 28 January 2005 as many as 16 images with same size. Locations are randomly selected and dominant in areas with the greatest damage.

After calculating the amount of vegetation and the damage caused, then the data is processed for multiple linear regression analysis to see the relationship between the parameters that yield the equation $y = a + bx$ and the correlation value (R).

To strength the analysis, the interview was conducted with an expert of landscape planning that have focused in tsunami case, especially in Indonesia. After the results obtained it will be made a design recommendation in the form of environmental engineering done to realize the city of Banda Aceh as a resilience city. This mitigation effort is obtained from expert interviews and literature studies.

3. Results and Discussions

Of the 16 images of the downloaded image map, calculating the amount of vegetation before the tsunami and the magnitude of damage caused after the tsunami, the results are obtained:

- a. Total vegetation (2014) is 844,740 m²
- b. Total damage (2015) is 1,240,726 m²
- c. Total of lost land (2015) is 241,879 m²



Fig 1. Image condition of Banda Aceh City before the tsunami (top), condition of Banda Aceh city after tsunami (down).

Correlation test using multiple linear regression analysis shows the relationship between the proportion of green open space to the impact of damage caused by tsunami waves in Banda Aceh City. With X variable 1 which is the total damage, and X variable 2 which is the missing plain. The result is that every 1% of the vegetation will reduce 0.08 m² of damage and 0.59 m² of land lost due to tsunami waves.

Based on interview with Qodarian Pramukanto on coastal spatial planning, the concept of a layered defense system (defensive structure) should be applied. Starting from the front liner structure to the back of the structure is important to consider in the preparation of environmental engineering guidelines and construction of coastal areas. Environmental engineering in coastal defense systems against splashing can be either artificial structures or natural structures.

In the coastal environment built, can be built artificial structure in the form of breakwater (offshore breakwater). The construction of wave breakwater walls along these coastal areas is built on the face of the waters of the bay or port. The coastal defense line is reinforced with a protective wall structure on the shoreline combined with evacuation paths on the rear. Material for the manufacture of retaining walls can be made of stone or concrete. In planning

should be studied in more detail in the form of structure must be strong and economical. However, the application of artificial coastal protection structures built in coastal waters or on shorelines should be through careful planning, otherwise there will be considerable impacts such as disruption of current patterns.

Another model is to plant along the coastline to the rear as far as 100 meters as the tsunami control forest (tsunamic control forest). Furthermore, this protective green line is combined with a protective structure built in the rear layer, and it's equipped with an evacuation path.

Vegetation has an important role in reducing the speed and strength of the waves. With layered and multi strata compositions, vegetation can damp the waves that come in several altitudes. In addition, the vegetation plays a role as a run-off filter before it is dragged back to the sea, holding on to the mass of vegetation so that it will be easy to carry out evacuation actions. The effectiveness of muffling the waves of the coastal green line depends on the composition of the vegetation and the thickness of the green line. The type of empowered coastline vegetation is highly dependent on local ecological characteristics.

Coastal forests are planned to be 500-1000 m wide adapted to the existing shapes and conditions of the coast [3]. The coastal forest as a barrier has a vegetation density between 40-60 trees per 100 m² depend on the shape and character of the planted tree. The location of this coastal environmental

engineering planning recommendation is one of them located at Ulee Lheue Beach, Meuraksa Sub-district, Banda Aceh City. It is the most heavily affected area of the tsunami waves, as it is a land facing the Malacca Strait. This location became an early fortress for the city of Banda Aceh in the south.

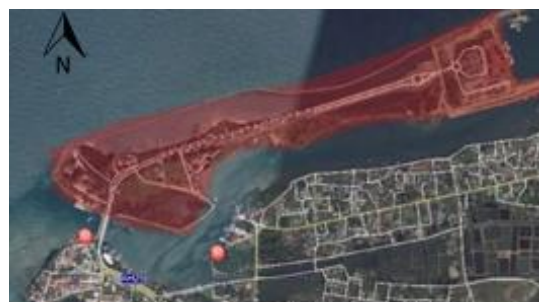


Fig 2. Ulee Lheue beach, Banda Aceh.

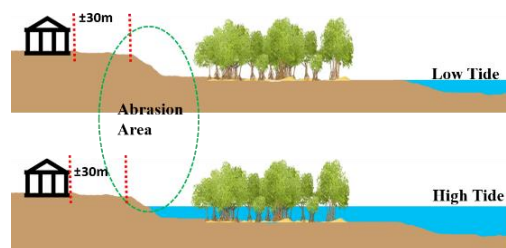


Fig 3. Existing condition of Ulee Lheue Beach

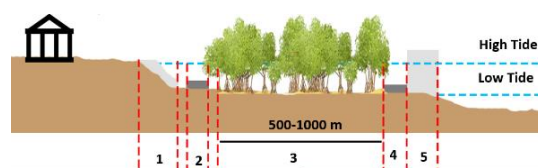


Fig 4. Planning recommendation

1. Erosion Retaining Structure
2. Evacuation Path
3. Tsunami Control Forest (tsunamic control forest).
4. Evacuation Path
5. Breakwaters (offshore breakwater)

Vegetation is a blend of various types of plants that grow in a particular area. Differences in the environment in which plants live will give different vegetation patterns [4]. The beaches of Banda Aceh are dominated by sandy beaches. The presence of the dominant sand in the coastal area causes the plant species that can live are plants that resist drought, high temperatures, strong winds, full sun and high salt levels [5]. These plants can survive, especially in the dry season with minimal moisture or dew at night. In choosing the type of coastal vegetation should be very careful to achieve the function of the plant that can reduce the impact of tsunami waves, abrasion dampers, reducing wind and animal habitats. Generally, coastal forest in Indonesia consists of various ecosystems with barringtonia formation dominated by tree species, pes-caprae formation is dominated by vines, while mangrove forest formation is dominated by mangrove species [6].

Physically mangrove forest is an ecosystem that serves as a wave dismantler absorbers. The root system can act as a breakwater and sediment trap. This would be more effective if supported by mangrove forest formations whose condition is still natural. The density of mangrove forest that tends to decrease will result in its function as a wave damper will also tend to decrease [7]. As a coastal stability protection system, the preservation of mangrove forests should be maintained so that the coastline is not abrasion so that it will support the ecological process in it.

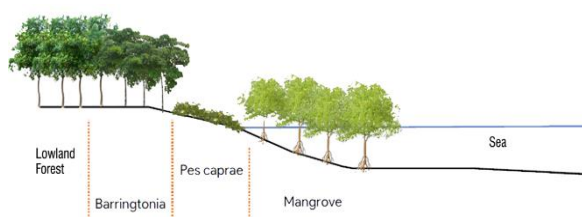


Fig 5. Coastal and mangrove forest formation.

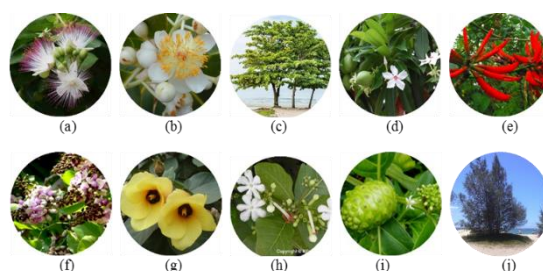


Fig 6. Barringtonia formation (a) *Barringtonia asiatica*; (b) *Callophyllum inophyllum*; (c) *Terminalia catappa*; (d) *Cerbera manghas*; (e) *Erythrina orientalis*; (f) *Pongamia pinnata*; (g) *Hibiscus tiliaceus*; (h) *Guettada speciosa*; (i) *Morinda citrifolia*; (j) *Casuarina equisetifolia*.

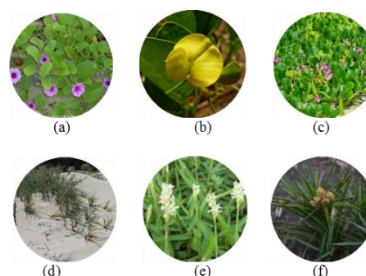


Fig 7. Pescaprae formation. (a) *Ipomoea pescaprae*; (b) *Vigna maritima*; (c) *Canavalia maritima*; (d) *Spinifex littoreus*; (e) *Ischeum muticum*; (f) *Cyperus maritima*

Based on the results of data acquisition, since the 1980s mangrove forests in Aceh have experienced the peak over the function of a pond. This happens because the outbreak of shrimp business in Indonesia at that time. After the tsunami, the extent of

mangrove forest here is declining. Mangrove forests before being affected by waves in 2004, generally grow naturally scattered along the coastline so it is still preserved ecosystem sustainability. After more than a decade, now the existence of mangrove forest in Banda Aceh city is still a focus for the government. The results showed that mangrove forest that grows naturally or intentionally planted (silvofishery).

No	Name of plants	Before tsunami	After tsunami
1.	<i>Acrostichum aureum</i>	-	✓
2.	<i>Acrostichum speciosum</i>	-	✓
3.	<i>Aegiceras floridum</i>	-	✓
4.	<i>Amyema anisomeres</i>	-	✓
5.	<i>Avicennia alba</i>	✓	✓
6.	<i>Avicennia lanata</i>	✓	✓
7.	<i>Avicennia marina</i>	✓	✓
8.	<i>Bruguiera parviflora</i>	-	✓
9.	<i>Ceriops decandra</i>	-	✓
10.	<i>Excoecaria agallocha</i>	-	✓
11.	<i>Nypa fruticans</i>	✓	✓
12.	<i>Rhizophora apiculata</i>	✓	✓
13.	<i>Rhizophora mucronata</i>	✓	✓
14.	<i>Rhizophora stylosa</i>	-	✓
15.	<i>Sonneratia alba</i>	✓	✓
16.	<i>Sonneratia caseolaris</i>	-	✓
17.	<i>Sonneratia ovate</i>	-	✓
18.	<i>Xylocarpus granatum</i>	✓	✓

Table 1. The types of mangroves found in Banda Aceh before the 2004 tsunami and after the 2015 tsunami

From Table 1 above shows the distribution of mangrove contained in Banda Aceh City in 2004 there are 8 types of mangroves that grow naturally before the tsunami. Post-tsunami re-planting of mangrove vegetation while maintaining the existing species, so that in 2015 there are 18 mangrove species that have grown up in several coastal areas in the city of Banda Aceh.

4. Conclusion

The city of Banda Aceh that had been hit by the earthquake and tsunami waves almost more than 1 decade ago gives us the learning to be more responsive to the possibility of disasters that will come. The process of disaster mitigation not only takes place as a form of community action in its daily life, but also leads to the physical mitigation of an area. This is called a concept of resilient city, a city can adapt and recover quickly from future disaster attacks. The presence of green open space in Banda Aceh City has a substantial share in reducing the impact of the tsunami. Each 1% of the vegetation will reduce 0.08 m² of damage and 0.59 m² of land lost due to tsunami waves. The form of environmental engineering that can be done is by artificial structures in the form of breakwaters (offshore breakwater) and tsunami control forest (tsunami control forest) equipped with evacuation path at the back.

The selection of appropriate coastal vegetation is also important in reducing the impact of the tsunami disaster. The existence of coastal forest with the formation of the ecosystem of barringtonia, pes-caprae, and mangrove forest into a single unit that can reduce the occurrence of coastal erosion, erosion control, muffle the wave as well as a habitat for the flora and fauna. With this concept, Kota Banda Aceh is expected to adapt to the possibility of future disasters

Banda Aceh still has the potential to experience another tsunami. The City Government of Banda Aceh should be able

to analyze the physical condition of its area before undertaking post-tsunami reconstruction so that development can be sustainable in the future. Green open space planning is one of the mitigation way to improve the quality of resilient city.

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Reconstruction Processes and support activities since the Great East Japan Earthquake

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Abstract

The Great East Japan Earthquake, which occurred in March 2011, caused serious damage and was followed by a large tsunami and an accident at a nuclear power plant. In this report, I describe the reconstruction process and continuing support activities in Miyagi Prefecture, which is cooperating extensively with Hyogo Prefecture where I reside.

The number of dead and missing people for this whole disaster is totally about 24,600. Miyagi Prefecture had no nuclear power plants, so there was no direct damage from that, but it had about 18,000 dead and missing people, the highest number of any prefecture.

As of November 2017, about 70% of the roads and 100% of the railroads had been reconstructed. However, 9750 people were still residing in temporary housing that was built just after the disaster. This is a decrease of 8% from the peak. The number of residences is 4,658, which is a decrease of 10% from the peak. Municipal public housing project construction has also advanced, with 14,886 residences (92.5% progress rate) completed in 21 municipalities. The progress rate for rebuilding community development projects is 100%, with 229 districts having completed disaster relief group relocation promotion projects and land division adjustment projects. In addition, publicly-funded community facilities, such as new public halls and “Everyone’s House,” have been newly established in various places. The recovery process is going smoothly, but large numbers of people are still in temporary housing, have been left behind by reconstruction, or need mental care.

At the beginning of the process, we provided support from Hyogo Prefecture with environmental improvements in temporary housing, providing horticultural therapy programs as a form of mental care. In addition, we carried out various other support activities, such as making plans for parks for new town planning, proposing plans for resettlement locations at higher elevations, and proposing biotope districts utilizing new natural resources.

We offered projects for the elementary school site where 74 children and teachers were taken by the tsunami, providing revegetation support efforts around the school and a horticulture

therapy program for the families of the children. Recently, we supported planting around an “Everyone’s House,” which had been built as a new community facility. We also continued planting support activities at welfare facilities and the planning of a biotope district in cooperation with the Agency for Cultural Affairs.

While doing various support activities like this, we have also been focusing on holding forums and networking aimed at collaboration and exchange with groups that are engaged in green community development activities in Miyagi Prefecture. From disaster restoration and reconstruction, a network for community-building that utilizes new greenery is starting to spread.

Key Words: Great East Japan Earthquake, reconstruction processes, support activities

1. Introduction

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2. Method

Below we examine our activities and their results both chronologically and by field of activity. Our activities can be roughly categorized as follows. Later, I will elaborate on my ideas following these categories.

- ① Investigations at initial stage
- ② Support for temporary housing
- ③ Proposals for community design
- ④ Support activities for reconstructed housing and permanent facilities
- ⑤ Networking

Table 1 Basic information about each city and town in Miyagi Prefecture

	Area Km ²	Flooded area Km ²	Population (Thousand)	Dead/Missing person	Number of evacuees	Main Industry
Matsushima Town	54	2	15	15	159	Agriculture
Higashi-matsushima City	102	36	15	1,769	2,734	Agriculture, Fishing
Onagawa Town	66	3	10	1,031	1,683	Fishing
South Sanriku Town	164	7	18	1,173	5,461	Fishing



Figure 1 Inundation areas in Miyagi Prefecture

3. Results

3-1. Investigations at initial stage

Hyogo Prefecture, which is where I live, has broad regional collaboration with Miyagi Prefecture, so there is cooperation among administrative municipalities to carry out various activities. As a result, our activities also mainly focus on Miyagi Prefecture.

As an initial investigation, we surveyed the damage from the north of Miyagi Prefecture, mainly from the towns of Minami Sanriku, Onagawa, Higashi Matsushima and Matsushima (Emergency Research Report on Reconstruction Support of the Japanese Landscape Architecture Academic Society). Based on the results of the investigation, we sought “soft reconstruction.” This is not to deny the influence of the terrain and the large tsunami that also changed the soil, but, as related to livelihoods and the reconstruction of homes, we considered community planning that takes natural activity into account. At the same time, we also sought cooperation with government

agencies, experts, local residents, NPOs and others.

Now that 7 years have passed, what was and was not accomplished should be verifiable at present as a passing marker in time.

3-2. Support for temporary housing

3-2-1 Horticulture Therapy Program

For temporary housing, we have been consistently providing horticulture therapy programs and support for vegetation planting since the beginning of the initial period. The main places include large-scale and small-scale temporary residences in Minami-Sanriku Town, temporary residences in Miyatojima (including Tsukihama, Ohama, Murohama, and Satohama), Higashi-Matsushima City, around Okawa Elementary school in Ishinomaki City, Ogatsu, Nagatsuraura, Miyagi University in Sendai City, and citizen centers.

Horticulture therapy programs frequently used “flower bento boxes,” “terra cotta pot planting,” “hanging baskets” and the like.

In the initial stage, “flower bento boxes” were easy to use because they can be provided inexpensively and easily. The method used is as follows.

- ① Prepare a hundred-yen plastic bento box, planting base, flower materials, scissors, etc.
- ② While showing a sample, cut the flower stems short and insert them into the planting base.
- ③ Have participants put names on their completed boxes, such as “Bento full of love” and “Spring bento,” and show them to each other.



Fig. 2,3 Flower bento making horticultural therapy program



Fig.4 Flower terra cotta pot making horticultural therapy program



Fig. 5 Flower terra cotta pot showing each other



Fig.6 Support for vegetation-planting activity using planters (Minami Sanriku Town, 2011)



Fig. 7 Showing the planters by the refugees

④ Afterwards, have herb tea and snacks, and relax with hand baths in warm water with floating herbs.

⑤ Inform participants that flower and plant activities stimulate the mind and promote positive brain activity and recommend continuing hands-on interactions with vegetation.

To some extent, after time, we began to use terra cotta pots and hanging baskets in which flowers can actually grow rather than bento boxes. An overview of these efforts follows. We made a pamphlet called, “Let’s participate in activities using flowers and plants!” We made a container garden for residents of temporary housing. Even after over five years since the Great East Japan Earthquake, there were still many residents living in temporary homes, and programs utilizing flowers and plants were effective. In Higashi Matsushima City and Ishinomaki City, for example, we have been conducting a continuous horticulture therapy program. In addition, we held tea times with herb tea and other refreshments so that these flower and plant activities also play a role in building spiritual stability in rebuilding the lives of the participants.

Flower arrangement programs have been found to not only provide healing and refreshment to refugees, but also to help activate the brain. Therefore, we tried to provide the refugees with this knowledge as well. We call this "dropping anchors." We tried "dropping anchors" and encouraged them to continue this activity so that the effect of the program would not end with just one experience.



Fig. 8 Support for planting vegetation over about 400 square meters (Higashi Matsushima City)



Fig9 Making vegetable kits (Minami Sanriku Town, March 2012)



Fig.10 Making flower beds (Nagatsuraura Ishinomaki 2015)

3-2-2. Support for vegetation planting

The summary of vegetation planting support activities is as follows.

In September 2011, we made planters for the residents of temporary houses newly built in Minami-Sanriku Town. We also advised the launch of a "Flower Association," and suggested creating a community group with flowers and plants for the 240 residents. In addition, we provided planter support even for small-scale temporary houses.

On Miyatojima in Higashi-Matsushima-City, in addition to making planters, we also made flowerbeds, including small-scale ones and a large-scale one of about 400 square meters. These functioned as temporary vegetation flower beds and encouraged local community interaction. We also provided similar vegetation planting support for temporary housing in the city such as at the Hibiki Industrial Park.

In order to encourage the participation of men, we also produced a large wooden kit for vegetable growing and provided a program for this. Men participated less often in flower programs, but it was easier for them to participate in vegetable cultivation, and this induced their activity in the temporary housing.

In the Ogatsu district, around the Okawa Elementary School area and in the Nagatsuraura district of Ishinomaki City, we supported the creation of a large-scale botanical garden in collaboration with local residents and the "3.11 Miyagi Association for Supporting Reconstruction with Flowers and Plants" NPO. We also conducted the above-mentioned horticultural therapy program at the same place. The tsunami

destroyed nearly all of the Ogatsu district and took the original residents of this large-scale garden. The surviving daughter and her husband maintain the garden with local residents. In addition, this son-in-law, who was a teacher at an elementary school, is conducting "earthquake disaster education" at a temporary office. He shares information about the situation at the time of the



Fig.11 Workshops in Miyatojima (starting 2012)



Fig.12 The results of the opinions

earthquake and knowledge about future disasters. Many visitors come to the place now widely known as the "Ogatsu Rose

Garden." Support and cooperation never ceases from people all over the country. School children from around Okawa Elementary School were in a state of waiting inside the school. As a result, over 70 people were killed by the tsunami. Many survivors have lost children or grandchildren. As a vegetation planting support activity, we plant flowering trees around the elementary school. In addition, when doing vegetation planting activities, we also offer horticultural therapy programs.

The Nagatsuraura district is a fishing town with oyster farming. A local leader who lost his grandson built a new lodge for fishermen. The local community also manages restaurants and other businesses and is trying to rebuild it. Here we also continue to plant trees around the lodge and offer gardening therapy programs.

3-3 Proposals for community design

In the Miyatojima district of Higashi-Matsushima City, we made a town development proposal in response to the request of a citizen center for a disaster area that had been completely washed away. In that process, we held workshops with the citizens, professionals, government officials and others from May 2012 to confirm the wishes of local residents while making a proposal for a green space.

We asked the people in Tsukihama area of the Miyatojima district what kind of town they expected, what they wanted to have, and what they wanted to do, for example. After summarizing these expectations, we created a greenery plan.

While checking every proposal written on sticky notes with the participants, we put the plan together. In the Tsukiyama district, they wanted to keep the Isuzu Shrine that had originally been there, preserve the crossroads, which connects to the shrine, as an important place for the town, make a temporary garden with flower beds and continue the custom of utilizing a rock cave “bora” formed from sandstone as storage. They also wished to maintain a walking path, preserve *Rhaphiolepis indica* var. *umbellata*, which is at its northern limit here, plant palm trees along the coast, restore a safe seashore, and emphasize the view from the observation deck. We submitted a plan that included these ideas.

In addition, among community planning proposals for Ohama in the Miyatojima district of Higashi-Matsushima City, there was one to conserve as wetland a valley area where rice paddies could no longer be used as agricultural land because of sea water infiltration. Ultimately, as a region of special scenic value designated by the Agency for Cultural Affairs, the city purchased it from the private sector, and provided support to conserve these wetlands.

3-4. Support activities for reconstructed housing and permanent facilities

Even though seven years have passed since the earthquake, about 73,000 refugees are still living in temporary housing. However, a lot of people have moved to higher elevations and are able to with donations. Planting trees to create green spaces around these facilities and in

areas swept away by the tsunami has also increased. In response to requests from such places, we have also been providing vegetation planting support activities throughout the region.

In September 2017 and March 2018, we carried out vegetation planting support activities together with a gardening therapy program at a "Connection house" in Shichigahama Town. We planted a lawn, trees and herbs with local residents, our



Fig. 13 Vegetation planting activities in Shichigahama (September 2017)



Fig.14 Community Garden in Nobiru district of Higashi Matsushima City (September 2017, March 2018)



Fig. 15 planting herbs in community garden students, horticultural therapists and volunteers. New community facilities were created, and the people doing vegetation planting activities seemed so alive, appearing to be full of hope beginning new lives there.

3-5. Networking

The population along the coast of Miyagi Prefecture is scattered. Various volunteer activities are performed, but there are few networks connecting the organizations. We visit Miyagi Prefecture for reconstruction aid from Hyogo Prefecture several times a year, and often we do it in collaboration with various organizations. We proposed creating a network to connect them and held a first gathering forum in 2014, inviting a woman who had formed a green “garden island” network in Hokkaido Prefecture.

In 2015, for a second forum, we organized workshops by grouping tables for each theme, including vegetation planting, horticultural therapy, open gardens, environmental education, networking, and village forest preservation. In 2016, we launched a network called the "Green

Exchange Forum" and linked it to social networking services. In 2018, we decided to collaborate with Tohoku Gakuin University's volunteer stations.

4. Discussion

As mentioned above, the Awaji Landscape Planning & Horticultural Academy (University of Hyogo) has conducted ongoing support activities, starting from field investigations and proposals made



Fig. 16 Keynote speaker for the forum to make networking



Fig.17 "Exchange forum on using greenery to invigorate the region" in 2014

immediately after the disaster (conducted as the Kansai Branch of the Japan Institute of Landscape Architecture).

In the early stage, we supported horticulture therapy programs with the goal of mental care at temporary residences, combining community building with vegetation planting. Those programs are continuing where temporary housing still exists.

After the earthquake, we began providing vegetation planting support at community welfare facilities that had been restored, and we have since carried out such activities in various areas. Starting with temporary green spaces, recently, there has also been permanent landscaping. In particular, vegetation planting activities at elevated relocation sites and rebuilt community facilities, combined with the enthusiastic motivation of local residents, creates a sense of achievement.

Miyagi Prefecture also has a long shoreline called the Sanriku Coast where the population is sparse and the role of women in community activities had been modest. Many women there are now participating as individuals in active organizations. Creating networks for them has been one of our goals. Currently, about 70 people have been able to connect through social networking services and participate in the forum. Furthermore, we plan to hold meetings in the fall of 2018 to coordinate with students.

Such activities can be continued because Hyogo Prefecture provides sources of funding, including various subsidies and funds for consulting activities. Students, NPOs, and university faculty members are

able to continue their activities because of these funds, and we would like to express our appreciation to Hyogo Prefecture.

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How to minimize the design of a place damaged by the disaster

Case study of Great East Japan Earthquake

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Abstract

In Japan, we met a serious disaster seven years ago. Currently, most of the reconstruction projects are coming to an end. However, the part where we are calling "low-lying area" is left behind from reconstruction. It is a place directly attacked by the tsunami, and it is also the place of home for the affected people. The area is designated as a disaster risk area, the construction of houses is prohibited, and the land use demand is extremely low. From such a situation, it is difficult to draw a future image for this area. In this paper, I proposed a new landscape design method for such kinds of damaged place based on the experience and knowledge that I have been making the garden with the residents in this place for 5 years.

Keywords: Great East Japan Earthquake, reconstruction, low-lying area, consensus building, minimum design

1. Introduction

For the Japanese, March 11, 2011 is a day that can't be forgotten. The magnitude 9.0 Great East Japan Earthquake was one of the most powerful earthquake in world history, and the huge tsunami that followed caused massive damage to coastal areas in the Tohoku region in particular. More than 15,000 people passed away, more than 400,000 homes were lost, 561 square kilometers of coastal area land was damaged by flooding. We have lost more than we imagined.

After the disaster, Japanese central government established Reconstruction Agency. The agency is ranked higher than other ministries and agencies and has overall control of the reconstruction budget.

The main reconstruction projects are, to construct new or higher tide embankment to prevent tsunami wave, to raise up the ground level in flooded areas and carry out land readjustment projects, and to move the residential areas from the flooded dangerous areas to the safe hill areas. Regeneration of the local industry like fishery and fisheries processing industry were also urgently carried out. Japanese central government

declared to the affected residents and to the world that we will finish the rehabilitation projects within 10 years from the disaster.

Approximately seven years have already passed from an earthquake disaster, and most of the reconstruction projects are in the final stage. However, many areas left from the reconstruction projects exist. Especially the area where were attacked by the tsunami directly which we called "low-lying areas" have few future plans and projects. Many lands affected by such disasters were isolated from the reconstruction project and abandoned.



Fig.2. flooded area map around Ogatsu Town (by GSIJ)

In this paper, I focused on the “low-lying area” which left behind from the reconstruction projects. Many of the areas are in small towns or fishing villages located at the downstream area of the river and most of the area where the tsunami attacked are hometowns of the affected residents. However, if the local community decide to move their residential area on the hill side, they can’t live there more. This is because Japanese Government compensates the place of residence transfer of community unit, and

they designate the former area for the disaster danger zone.

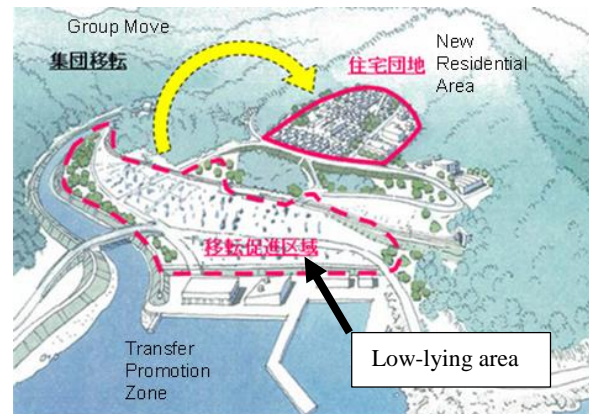


Fig.3. Group transfer promotion project to the highland (by MLIT)

For reconstruction projects, low-lying areas are dangerous and unusable land. As a result, the areas were abandoned and devastated. However, it is a place where the affected residents were engaged in their daily life before the disaster, and it is also unforgettable hometown for all. It was painful for them to see the areas were ignored, and the reconstruction project was progressing in new residential areas that are not familiar to them. I thought that planning future in this area is necessary because the revitalization of this area will be a power to promote the motivation for the reconstruction of local residents.

2. 2. A garden for mourning a mother

2.1. It started from planting a flower

Just after the earthquake, for the low-lying areas, there were no schedule of reconstruction projects and no budgets. So nobody was able to maintain it and only rubble was abandoned.

Under such circumstances, a very small personal activity began around the summer of 2011. A residents who lost her mother by the tsunami was tried to plant flowers to mourn her mother. Her mother's house was at a low-lying area.



Fig.4. Just draw grass and pick up rubbles in 2011

When she was planting flowers in the place where the mother house was, members of the university, including professor and students who came to support the temporary housing in the area, encountered her and helped plant the flowers. They belonged to the faculty of horticulture and the specialty field of the professor was land use and landscape. During in 2011, it was a time that many missing people were still not found, so they could only draw grass and pick up rubble. However,

in March 2012, one year after the earthquake, a change in feeling occurred to her. With the cooperation of family members, volunteers, local landscape company and the university members, she transformed the land where the mother's house was located into a large flower garden.



Fig.5. Large flower garden was born at the low-lying area

2.2. Changes in characteristics of the garden

Because the damage of the Great East Japan Earthquake was extremely large, even one year after the earthquake, most of low-lying were completely untouched. For this reason, affected people were pleased that a large garden was born. Around March 2012, there were few places where the flowers bloomed in affected areas. The garden was located along the main road, local residents, workers of the reconstruction project, many passers-by, enjoyed seeing the garden flowers.



Fig.6. The Garden in July 2012

As time passed, people gathered gradually in the garden. People who have been hurt their mind by the earthquake looked at the flowers and healed, and people who experienced similar painful experiences talked to each other at the place. At that time, new residential areas were under construction and low-lying areas were abandoned, so there was no place for people to gather and talk each other. Although it was not a place to construct for the reconstruction project with subsidies, it gradually changed to a public space for the people.

The garden also gradually developed, such as building a garden house and introducing a toilet, and changed it into a space where many people can welcome. All these work was done by handmade by residents and volunteers. A concert was also held in October 2013 when two and a half had passed since the earthquake disaster. This place healed and cheered the hurted people.



Fig.7. The Garden in October 2013

3. Reconstruction project and the garden

3.1. New road reconstruction project

This garden was located in Ogatsu Town, the peninsula part of Ishinomaki City, Miyagi prefecture. Ogatsu Town was merged into Ishinomaki City in 2005. The population of Ogatsu Town has drastically decreased from about 4,000 to 1,000 due to the earthquake disaster. The center of the town attacked directly by the tsunami, the whole area was designated as a disaster risk area, and to build of a house was prohibited. The population reduction rate in Ogatsu Town was the highest among the affected local communities.

Since the center of Ogatsu Town was designated as a disaster risk area, there are few residents who could remain there and it is difficult to form consensus among local residents. The plan of the reconstruction project of Ogatsu Town was delayed. Some residents went out of this place due to the fear of the tsunami. Some residents wanted to remain in the area, but the town which lost everything by the tsunami was inconvenient and difficult to continue living. There were few safe lands, and only a very few number of temporary houses could be built.

Under circumstances in which reconstruction projects are hardly decided, it became clear that the location of the garden was included in the new road constructed as a reconstruction project even though there were nothing in the surroundings. At that

time local governments did not consider the gardens made by the residents and their activities.

3.2. future plans for the entire center area

The garden was forced to relocate. At first, the members of the garden strongly opposed this reconstruction plan. However, because it was a garden that started with personal motives, new issues have arisen since diversified people began to visit the garden. For example, it was not enough to respond to elderly people and wheelchair users who are difficult to walk. So they finally decided to relocate the garden and create a universal space and true public place for all. We, the members of the university who helped her garden since 2011, also helped to make the relocate plan of the garden.

Toward the relocation of the garden, we held workshops many times by gathering local residents, stakeholders of the garden and local residents who had lived the center area of Ogatsu Town. In the process of repeated discussions, participants noticed that it is necessary to formulate future plans for the entire center area of Ogatsu Town to examine the functions required for the new garden. The garden was growing no longer the space for the landowners but the public space for the entire center of Ogatsu Town. Garden stakeholders wanted the garden to play a role to supplement what is necessary to reconstruct the center area of Ogatsu Town. They began thinking seriously about the future plan of the whole town and the division of roles that the garden should play.



Fig.8. Workshop with local residents



Fig.9. Discussion with residents using models

Through these process, we began to examine the landscape design of the entire area where damaged by the tsunami, that is low-lying area and disaster risk area in Ogatsu Town.

4. Changes in requirements on landscape design

4.1. The situation of the triple disadvantage

The center area of Ogatsu Town was very difficult to consider future land use. This area

was in a situation of having triple disadvantage.

First, the demand for the land use was extremely low. There is no public transportation. It is also far from the highway. Therefore, it is very difficult to access there. There used to be a residential area, so the site size is small. Basis of many houses remained, but since there are no plans for the future, expenditure of subsidies to remove this was not planned.

Second, because the whole center area of Ogatsu Town is designated as a disaster hazard zone, construction of residential buildings and houses are prohibited. Without local residents, it is also difficult to use land as a commercial. On the other hand, there is not enough space as an industrial site.

Third, human resources in the area were extremely limited. Because the whole center area of Ogatsu Town was designated as a disaster risk area, there are no residents. Only some elderly residents remain in the temporary houses, and the rest of the people lived outside the area to find a job because the town was completely destroyed. There were only dozens of reconstruction houses were planned to build in the center area where about a thousand people lived before the earthquake. Therefore, even if many people visit here, there are few people able to respond and there is no place for new people to live.

However, Ogatsu Town is a blessed place with abundant natural resources. Seafood such as scallops and salmon, stone mined from the mountain, river of beautiful water, starry sky, all were wonderful charms.

4.2. Consensus building and budget issue

In the Ogatsu Town, some local residents and local governments could not form consensus regarding reconstruction projects fully at that time. Several local key persons strongly opposed the reconstruction project. Reconstruction projects were delayed greatly, some residents raised distrust of local governments. Under such circumstances, it was impossible to draw landscape design with top-down style at the whole low-lying area. Moreover, the control type landscape design of the conventional expanding urban space did not fit in such a shrinking area. We had to create a new landscape design method in order to design this kinds of low-lying areas.

Initially local government have decided industrial land use for this area. However, local residents also understood the harsh reality that companies would not come here. On the other hand, even in the case of planning public facilities, the population of Japan has declined sharply, so for the place that visitors can't expect, the reconstruction agency did not allow budget expenditure. The era of people gathering as long as we create a nice and beautiful landscape design space is over. Even if it is a facility that the residents are requesting, due to lack of maintenance budget, local governments have abandoned construction of new facilities. Under such circumstances, how should we consider landscape design for low-lying areas?

5. Changes in requirements on landscape design

5.1. Examine a new landscape design method

We have examined a new landscape design method for places where land use demand is low and damaged by the disaster, based on knowledge and experience on the development and maintenance of the garden over the past five years.

It consists of the following four steps. 1) Based on the intention of residents' future land use activities in the area, 2) Formulation of land use plan by 2 step zoning based on consensus of local residents, 3) The future land use plan and landscape design should be connect past and present and to the future. This is a new bottom-up, resource-based landscape design method. I would like to explain the details below.

5.2. Based on the residents' intention

Even a place with rich attractive natural resources, it can't make use of resources unless there is a person who uses and manages it. In order to realize the future plan, people who are in charge of that are indispensable. So we focused on the capacity of residents who are interested in the area, intend to engage in the area, and decided to live in the area. At the same time, we have encouraged residents to draw out their potential capabilities of land use through opportunities such as workshops and hearings.

In areas with limited resources, the intention of future residents' activities are the most important factor to realize future plans. We tied the land use with the intention of

residents. Even if it is apparently a vacant lot, there are various potentials, and designing the future inconsistent with it will lower the motivation of the residents' activities.

It is very important to discover local potentials that are not visible at the moment, and to draw the future plan including them. It will also foster their possibilities.

5.3. 2 step zoning based on the consensus

Based on the consensus building of the residents, we have formulated a land use plan using two stage. It is impossible and undesirable to decide all the land use at once. Generally, in the case of reconstruction projects, the budget is not expended unless all the future plans are first formulated. However, in this area, it was impossible to do so because demand for land use is too low and regulation was too strong. So we roughly divided the entire low-lying area into 8 zones, and determined only the direction of each zone. It was difficult to obtain the consensus of residents of the detailed plan, but residents were able to agree on rough zoning based on previous land use. The point of rough zoning was to set up zones that are consistent with the resources of the remaining shrines and shops, etc. and previous land use. That is, we drew a plan for the future connecting the past and present points.



Fig.10. First step zoning for the center area of Ogatsu

5.4. Detailed design stage

Even if drawing a dreamlike future land use plan or beautiful landscape design, if there is no person who realizes or uses it, it will only become a rice cake drawn in a picture. So future land use plan should be drawn on the current extension line. It is also the plan that local residents could managed and understand. Of the eight zones, we have formulated a detailed future plan and landscape design only for the zone where garden activities are actually being conducted. It is not an irresponsible groundless desire, but it depicts the future based on activities in the area where each person can do. We minimized the design for the future. But landscape design is important for residents to imagine the future of the area and to share with all relations. Landscape design has the power to drive residents' motivation and make hope embrace the future. After that, our proposed landscape design was approved as an official plan of Ishinomaki City. This became the first comprehensive plan and landscape design for the low-lying area where attacked by the tsunami.

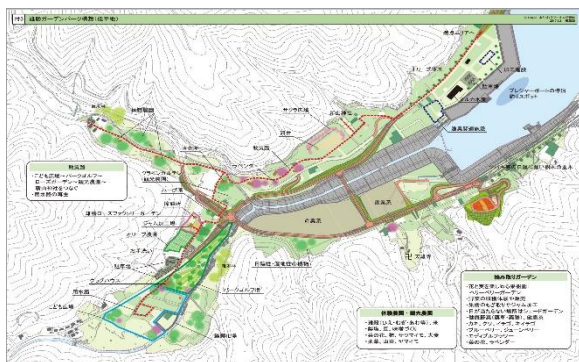


Fig.11. Detailed plan for the garden park zone

6. Conclusion

At first glance, there seems to be nothing in the land that was deeply hurt by the disaster. However, there is a potential existence of residents' intention to stand up from a sad experience. We should not ignore it. "Connect the time" is also an important role of designers in places where past and present were disconnected by the disaster. In such a place, the current state is very fragile, so if we design the landscape strongly, there is a danger of erasing the future as well. Drawing a beautiful landscape design that all people concerned share and hope for in the future with minimizing the design, encourages the resident activities and opens the way for revitalization.

Acknowledgments

I deeply appreciate everyone concerned with the garden, Ishinomaki city officials, and other concerned.

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Disaster Management Through The Use Of Animated Physical Model

Kenya Endo

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Abstract

4 dimensional model (4D model for short) is a representation method that combines physical model with an overlay of projected animation. It allows landscape architects to illustrate anticipated changes in the future, as well as to share his/her ideas with broader audience. This paper examines the usefulness of 4D model, specifically in the context of community engagement process for disaster and risk mitigation. Community workshop was conducted in Nagashizu as a case study, one of the heavily devastated communities along Tohoku Coastline from the unprecedented tsunami followed by Great East Japan Earthquake on March 11th, 2011.

Feedback during the workshop, regarding the usefulness of 4D model as a tool to help visualize, understand and imagine schemes for future resilience, was generally positive. For example, risk mitigation measures were discussed using the animation that explicitly illustrated the most catastrophic scenario born by the natural disaster in Nagashizu. It successfully allowed residents to realize the innate threat to their lives, which was not thoroughly recognized before the tsunami in 2011. Community-wide awareness could have mitigated the losses, by guiding all residents to take prompt evacuation actions. Participant's suggestion on incorporating tsunami wave speed, people's evacuation paces into the 4D model is one of the constructive solutions that will help refine the method for future application.

Likewise, compared to conventional community engagement procedure using 2 dimensional drawings, 4D model demonstrated its greater ability to showcase future outlook of Nagashizu both spatially and seasonally in detail. Series of rendered graphics have served to broaden participant's imagination in the course of brainstorming potential activities that can take place in Nagashizu, not only what, but also where and when. 4D model has smoothen the process in a way that both residents and non-residents have come together as one, and exchanged ideas that interrelate with Nagashizu's unique natural and cultural features.

In terms of future prospect, the workshop outcome has suggested that 4D model can be utilized in various purposes and phases in the process of disaster management, by customizing its content. In addition, resident's feedback has also reminded the significance of landscape architect's involvement in such process – as a narrative developer and a communicator. Unlike

engineering approach, landscape architects have the ability to synthesize indigenous natural and cultural resources into the argument of resilience planning. This Nagashizu 4D model workshop served as a first successful attempt of its kind, and demonstrated the potential for scaling-up the methodology into other sites in the world, or even in our daily practice.

Keywords: Disaster Management; Community Engagement; Representation Method; Four Dimensional Model

1. Introduction

In response to climate change and intensifying natural disasters, landscape and ecological systems have increasingly become a featured topic in the conversation of future resilience. Policy makers are slowly acknowledging the impossibility of shielding cities from nature's powerful forces, but instead to explore measures that are inspired by adaptability and inclusive planning [1][2]. In such context, landscape architects' role has grown ever so important due to our inherited ability to synthesize dynamic natural systems, and envision short-term, long-term narratives that are rooted to the site. Since disaster management is a highly inter-disciplinary process, our communication skills have become vital as well, to lead, agitate and settle conversations with a diverse group of expertise.

As a landscape architect, I have witnessed tsunami recovery process along Sanriku Coastline in Japan, from the earliest time when basic lifeline was still not in operation.

Through the personal experience, there were a couple of lessons come to light with regards to communication technique in situations specifically to community engagement - firstly, we, landscape architects, are not fully equipped with tools to represent changes and multi-spatial conditions. Particularly in disaster mitigation and planning process, spatial proposals must address, for instance, changes in water levels, various scenarios for evacuation measures, as well as dual functionality of spaces during normal times. Secondly, we must learn how to share our design proposals with broader audience. Planning for future resilience entails participation and understanding from the general public, who are not all planners nor engineers. The methodology of sharing ideas must be tangible and straightforward.

1.1. Concept of 4 Dimensional Model

The 4 dimensional model (4D model for short) is a representation method that combines physical model with an overlay of projected animation (Fig 1).



Fig. 1. Snapshot of 4D modeling concept using test models. People's movement, rain event and water level fluctuation were incorporated in the animation.

It can represent various spatial conditions over time, such as, water fluctuation, weather change, seasonal cycle, patina and people's movement. Strictly speaking, projecting digital graphics or simulation onto object(s) is not necessarily an innovative approach. A couple of successful applications are demonstrated in the field of research, participatory design and exhibition display [3][4][5]. However, there are little studies conducted, which couples digital display methodology with disaster management, despite its high visual communication capability [6]. Bearing that in mind, the objective of this paper is to clarify the usability of 4D model in the context of community engagement, specific to disaster and risk management. Identified potentials

and challenges were further digested to discuss ways in which enhance the role of landscape architects in the conversation of future resilience.

2. Site Context

2.1. Great East Japan Earthquake

On March 11th 2011, a magnitude of 9.0 earthquake hit the north-eastern coast of Japan, followed by an unprecedented tsunami exceeding 15m in height, recording 38m in wave run-up. Extensive areas along Tohoku coastline got heavily attacked by recurring tsunamis, washing away all sorts of standing objects - coast protection infrastructures, buildings, cars, forest, and killing over

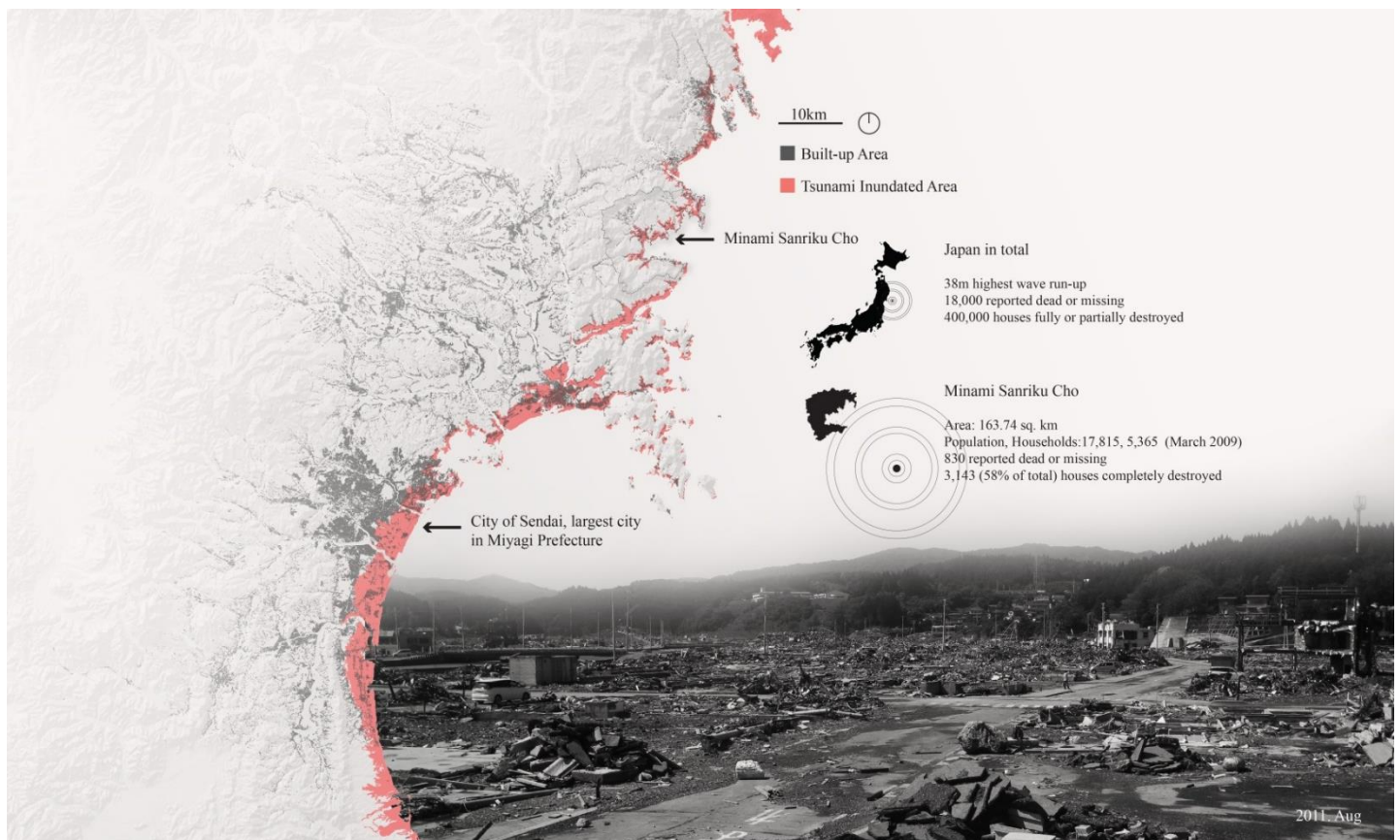


Fig. 2. Macro-scale site context of Tohoku Coastline, and the impact of tsunami followed by the Great East Japan Earthquake
 GIS data source: Geographical Survey Institute of Japan. Statistic data source: National Police Agency, Town of Minami Sanriku

15,000 people in total [7]. Also known as the Great East Japan Earthquake (3.11 for short), it was both one of the most powerful ever recorded as well as the most costly natural disasters in Japanese history (Fig 2).

2.2. Small Fishing Community: Nagashizu

Nagashizu, is a small fishing community along ria-shoreline, located at the southern tip of Minami Sanriku Cho (MSC for short), a coastal town located in Miyagi Prefecture (Fig 3). Before 3.11, there were 39 households, 172 residents dwelling at low-flatlands, nestled within a hilly topography. This terrain amplified the impact of tsunami by constricting the way and funneling the wave 800 meters into the valley, inundating 16.9Ha of land [8]. The epi-center was located 140km away, so tsunami waves



Fig. 4. Nagashizu River before reconstruction (Aug, 2015)



Fig. 5. Construction of Route398/seawall (Dec, 2017)

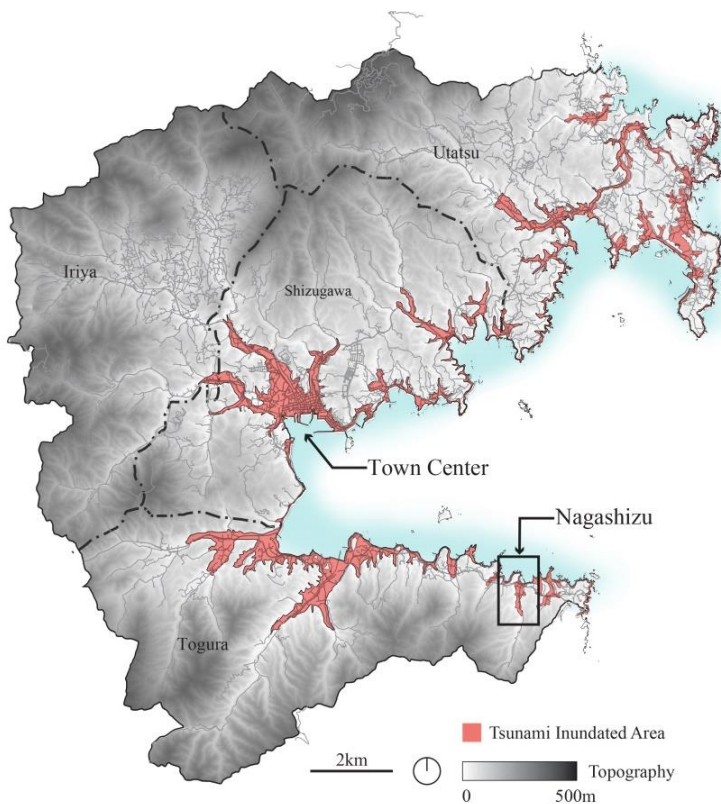


Fig. 3. Landform and tsunami inundated extent of MSC. GIS data source: Geographical Survey Institute of Japan.

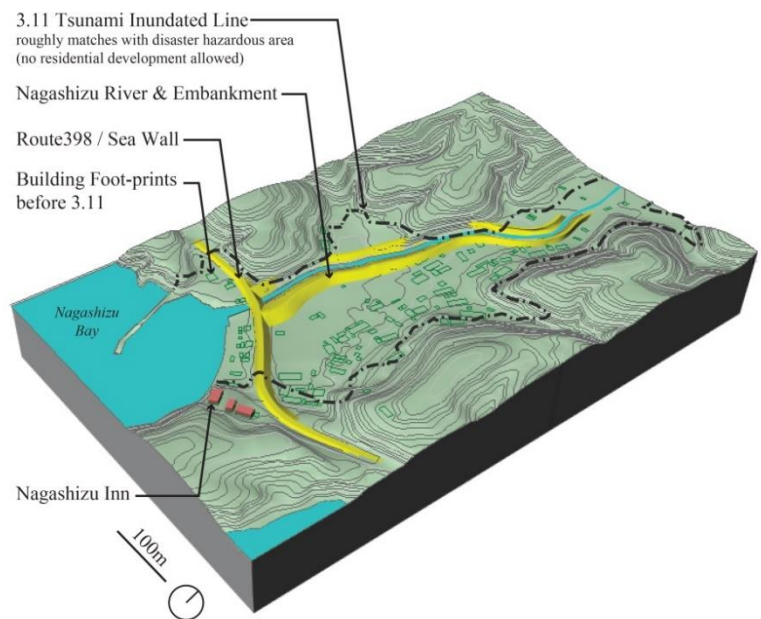


Fig. 6. Overview of Nagashizu in relation to landform, inundation and infrastructural works. Base data source: Miyagi Prefecture and Town of Minami Sanriku

arrived 30-40 minutes after the shake. As a typical coastal community, Nagashizu was well-equipped with sea protection infrastructures, such as wave-off blocks, sea-gates along shoreline. In addition, tsunami evacuation drills were conducted typically once a year and a number of sign boards for evacuation routes were provided by MSC.

7 years have passed. Currently, reconstruction works in Nagashizu are halfway through, including uplifting Route 398 – a 7.3m high elevated driveway above sea level, a structure that co-functions as sea wall. Similarly, 350m-long concrete embankment along Nagashizu river has been developed with more than 6m higher than water level (Fig 4-6). Most of the residents have migrated to higher grounds, approximately 600m away from the original settlement location. As many residents rely on fishing industry, ports and docking facilities are proposed for the open-spaces (disaster hazardous area) which are mostly left unplanned. Since most of the reconstruction works are going to be completed soon, Nagashizu stands at a milestone to plan for the future - how to revitalize the community once again with a resilient foundation.

2.3. Definition of Social and Community Resilience

The term “resilience” is a context-sensitive concept, and it entails both structural and non-structural interpretation in disaster risk management [9][10]. In this paper, emphasis is placed on the latter, and referring to Bruneau et al. (2003) [11], resilience is defined as “the ability of the community to mitigate hazards, contain the effects of disasters when they occur, and carry out

recovery activities in ways that minimize social disruption and mitigate the effects of future adversity”. Furthermore, the paper gives sub-category of social and community resilience, which key contributors differ as following; in Nagashizu, aspects that enhance social resilience are identified as communication, risk awareness, risk preparedness, and sharing of information. Likewise, community resilience is measured by long-term population wellness, quality of life, and post-disaster community functioning [12]. Particularly, community resilience is a critical concern for Nagashizu and other neighboring communities, where sustainable communal operation is in danger due to population decrease.

3. Methodology

In order to capture the sufficient extent of the coast and inundated area, an A0 size (840mm x 1194mm) physical model was created in 1:400 scale, with white foam board, cutting out every 1m contour lines. Base plans were collected through town and prefecture websites [13][14][15], and onsite survey and interview was conducted in December 2017 for clarifications. In addition to the physical model, total 4 minutes animation was created using Adobe AfterEffect, Rhinoceros 4.0 in conjunction with algorithmic modelling tool Grasshopper. Featured attributes in the animation were water level, micro-climate, movement of vehicles and fauna & flora.

These materials were used to evaluate and discuss the following 3 points:

1: Evaluation on its usefulness for infrastructural planning - In Nagashizu, infrastructural planning was led by MSC

town officials back in 2013. The intent was to understand the actual briefing procedure with Nagashizu residents, and compare the effectiveness of visual communication between conventional 2 dimensional plans versus 4D modeling.

2. Evaluation on its usefulness in planning for social resilience – The animation depicted the changes in water level and land conditions, in order to illustrate imminent threat of tsunami, flooding and land-slides. It is a translated version of the town’s hazard map with motion, supplemented by author’s slope analysis (color coding based on slope angle) and simple water flow simulation. The target was to rediscover resident’s pre-3.11 awareness level towards risks, and to collect ideas to upgrade social resilience for the future.

3. Evaluation on its usefulness in planning for community resilience – The animation illustrated an outlook of Nagashizu’s in the year 2030, and rendered various community

phenomena unique to Nagashizu within the animation (including spring folk festival, indigenous marine fog during summer time and rare migratory birds in Autumn), for the sake of addressing participant’s prospects on sustainable community redevelopment.

4. Results

4.1. Community Workshop in Nagashizu, MSC

The workshop was conducted on March 24th 2018, at Nagashizu-Inn. There were total of 19 participants : 4 local residents from Nagashizu, all in their mid-30s, 10 University students from Tokyo (2 students in landscape related field, 8 students in non-landscape related fields), and 3 facilitators including the author. The workshop was conducted in a relaxed setting, in order to address frank feedback from the local residents (Fig 7-9).



Fig. 7. Snapshot from the workshop: Author comparing 2 dimensional plans on the left and 4D model at the right.

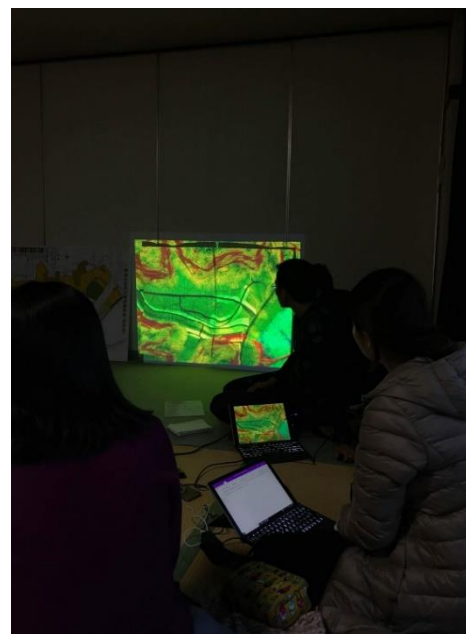


Fig. 8. Animation depicting the result of slope analysis. Subsequently, potential risk of landslide was projected and discussed.

4.2. Discussion Summary of Infrastructural Planning

It was clearly expressed by all participants that 4D model is absolutely superior to 2 dimensional plans in visualizing proposed infrastructural works. Unlike vector-based information with technical dimensions and annotations, 4D model successfully conveyed the perception of post-construction state – how they will be experienced from human eye-level. In fact, when construction works began to materialize in later years, residents were astonished by the massiveness of the 7.3m high seawall. It was often the case throughout MSC that residents expressing their concerns of being blind to the sea, which ironically amplified the un-secureness to tsunami disasters.

During the reconstruction planning phase in 2013, the frustration from the residents seemed to be borne in the long process of scrutinizing ideas. Resident’s proposals tended to travel a long one-way passageway, just to find out that they come to a dead-end

due to budgetary or legal reasons. Therefore, their collective suggestion was to embed a function within 4D model that allows immediate modification of the animation so as to speed up the process of idea development and refinement.

4.3. Discussion Summary of Planning for Social Resilience

“If this visual were shared before the 3.11 tsunami, we could’ve avoid such a big loss” – this is one of the most influential comments received from the residents, which also proves the effectiveness of 4D model as a tool to raise awareness of disaster risks. The appreciation was directed to the effort for enabling all participants to realize and discover the possible hazardous scenarios. In other words, the accuracy of tsunami inundation extent in the animation, for instance, seemed not necessarily important, but more on the realization of risk was point of their interest.

Residents expressed that, now they know



Fig. 9. Projection of rendered graphic of early summer time.

that climbing up the nearest high grounds makes sense, but it was not the case immediately after the earthquake. Some residents ran in the opposite direction from shoreline for security, which while it seemed logical, was actually not appropriate from a geographic viewpoint. Some residents remained at home watching TV, wishing to gain information, or drove close up to shoreline to observe the sea level. All residents could have made prompt actions for evacuation if only they were aware of the catastrophic scenario.

In addition, the information on vulnerable terrain and potential risk of landslide was accepted with surprise by residents. They mentioned that they were not familiar with town's hazard map, and especially elderly people will not have easy access to online information.

With regards to 4D model in the context of social resilience, core of the discussion was for the evacuation scheme. One of the most constructive feedbacks was to incorporate tsunami wave speed and people's walking speed into the animation. For example, elderly people will have slower walking pace, and it will be even slower at sloped terrain or unpaved pathways. In this way, 4D model can support community members in deciding best evacuation center location and its routes, as well as establish a community-wide consensus.

4.4. Discussion Summary of Planning for Community Resilience

It was agreed that a series of rendered graphics enhanced the imagination on potential activities that can take place in Nagashizu, not only what, but also where and when. From a non-planners point of view, it

seemed a challenge to imagine the full-picture after completion of all infrastructural works, let alone, tap ideas on top of it. Therefore, resident's remarks emphasized the importance of knowing the spatial organization in detail at earlier stage, which will allow them to prepare ideas to revitalize community as soon as possible.

However, it became clear in the end, that there was a strong need of specialists to help guide the spatial planning process, especially for public amenities. Residents explained that so called "public spaces" where children can play, for example, were spontaneous and ubiquitous in Nagashizu's surrounding forests, thus they did not require any planning efforts. Likewise, seasonal folk festivals used to be held at shrine owner's front yard. Considering these backgrounds, large area of disaster hazardous area requires external inputs to plan its full usage for community wellness.

Having said that, it was interesting to brain-storm ideas with non-local students as well, which helped outline the uniqueness of Nagashizu. Outdoor theater, Tarzan play (adventure zip-line made out of vines), and Instagram-perfect monuments with ocean view, were some of the ideas raised and discussed. 4D model successfully brought all participants to one table, and drew diverse ideas that interrelated to local resources. One of these ideas could become the seed to boost local tourism or eco-educational programs in the future.

5. Discussion

During the workshop, there were a number of profound insights for 4D model, as a tool to assist the process of disaster management.

Following remarks summarize other potential ways to further expand its usage.

5.1. For Other Areas in Japan or Beyond

There was a suggestion by participants that similar type of workshop should be conducted at other waterfront communities in Japan, or elsewhere in disaster prone countries in the world. Large number of communities that sit above Japan's Nankai Trough, for example, must be ready for a huge magnitude earthquake expected to occur within next 30 years in 70-80% percentile [16]. How will such communities foster a robust foundation for social and community resilience? Who will be able to facilitate discussion among community members, to properly plan for a resilient future?

4D model workshop in Nagashizu was the first attempt to answer these questions by offering a basic methodology for landscape architects to demonstrate not only the threats but also the potentials of any given site, and share the findings with broader audience. Hence, participant's aforementioned suggestion implied the scalability of the methodology, and at the same time, the latent significance of landscape architects in the process of resilience planning. This is because, it is only possible through the lens of landscape architects that to thoroughly comprehend local context in multi-scales and multi-moments. Creating an animation took a similar process as unfolding a number of dynamic layers (cultural, ecological and hydrological) that make up the physical landscape we see today, and reassembling them into a story. Nagahsizu in particular, there were a number of indigenous natural and cultural factors that were incorporated

into the narrative. Similar steps can be applied to other parts of the world - unlocking unique features of the site, reinterpreting, and finally incorporating them into the materials for community dialogue sessions.

5.2. For Our Daily Practice

There are also potentials for 4D model to be adapted in our daily landscape practice. Projects that deal with climate adaptation, and/or waterfront environments are some the territories for exploration. Natural systems and materials that landscape architects deal with are, needless to say, never in a static state. It is our challenge to anticipate changes over time, and to weave compelling design scenarios that maximize environmental and economical returns in the long run. In occasions of interfacing clients, 4D model will well-adapt to support practitioners to elaborate changing landscapes in their design proposals.

In order to examine its potential in our daily practice, the idea of 4D model was shared and discussed with 10 young professional landscape architects in Singapore. Feedbacks received were mostly positive and some ideas for improvement were:

- Add sound effects to enhance the overall ambience
- Projector should be placed right above the model so that participants can interact with the model freely
- Use diagrams and infographics to incorporate site's non-visible information
- Overlay results of various simulations (hydraulic, sunlight, wind modeling)

Pointed out difficulties were in the technical aspect, namely, in terms of software and time. To answer such concerns, animated

materials can be recycled through templates to shorten the production process. Similarly, depending on the focus, subject matter for animation can be selective and reduced to minimum.

As digital technologies rapidly make progress, so should our digital literacy. At the end of the day, digital representation shall diversify our design languages and strengthen our commitment to clients.

6. Conclusion and Prospects

4D model was well-appreciated by community members from Nagashizu in MSC, to help them visualize, understand and imagine schemes for future resilience. The workshop clarified that 4D model can be utilized in multi-purposes by customizing its content - for infrastructural planning, for social and community resilience planning. Simultaneously, 4D model revealed the limitations of conventional procedures of community engagement. Unlike engineering approach, landscape architects have the ability to synthesize indigenous natural and cultural resources into the argument. Nagashizu 4D model workshop served as a first successful attempt to seek opportunities to scale-up its methodology to other sites in the world, or even in our daily practice. However, a number of technical refinements were highlighted, in order to make the argument more effective and robust. Next 4D model workshop to be conducted in the world, should address the suggestions raised.

Lastly, Nagashizu residents stressed their hope of never to repeat the tragedy again. There were tremendous losses from 3.11, but lots to learn as well. Landscape architect's perspective and our design thinking are

essential to further worldwide discourse of disaster preparedness schemes.

Acknowledgments

I would like to express deep appreciation to the local residents who took the effort to participate the workshop in Nagashizu. Especially, the discussion went fruitful, thanks to Mr. Masanori Sato, Mr. Takeshi Endo, who shared their struggles and insights during their long journey of disaster recovery. In addition, special thanks to Mr. Taiga Fukushima, Ms. Hiromi Koyama, who helped address frank opinions from the participants, and crystalize the argument. My thanks go as well to colleagues from Ramboll Studio Dreiseitl Singapore for your kind suggestions. Thank you very much.

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[FEATURED SESSION SPEAKERS]

DAY 2 TIME: 10:30 – 10:50

Singapore's ABC Waters Programme: Integrating Blue-Green Designs in Urban Landscapes Setting the context

Tan Nguan Sen

Chief Sustainability Officer
Public Utilities Board
Singapore

Synopsis:

The ABC Waters Programme was launched in 2006. After over a decade since its inception, there are lessons learnt, obstacles surmounted and future challenges to overcome. Intensive development of our City-State has resulted in rapid urbanisation, with direct impact to our hydrological regime. 2/3 of mainland Singapore functions as catchment area that contributes to our water supply.

At its core, Blue-Green Integration has been the backbone of the ABC Waters Programme. Multidisciplinary in nature, the Programme has required the knowledge and expertise of Planners, Designers and Engineers; the trust and support of inter-agency collaboration and active participation and appreciation from the general public. Sustainability through the support of society and stewards of the Blue-Green movement are essential to the longevity of the Programme and the completed projects.

The presentation is framed upon the context of:

- 1. Urbanisation and its impact on the hydrological regime*
- 2. Blue-Green Integration: ABC Waters design features integrated with the Urban Landscape*
- 3. Sustainability through stakeholders, 3P Partnership and life of the project after conception*

Urbanisation and the impact on surface water & hydrology

Singapore's integrated water management strategy, with a closed loop system is one that relies upon effective harvesting of surface run-off to our reservoirs, the largest of which is Marina Reservoir with a highly urbanised catchment. Urbanisation's impact on the quantity and quality of stormwater runoff and increased peak flows in the public drainage system is a challenge that needs to be addressed. The ABC Waters management strategy differs from traditional stormwater management; it advocates a distributed system to detain and treat stormwater runoff, and to do this upstream, at source.

Blue-Green Integration: ABC Waters design features integrated with the Urban Landscape

3 Projects are selected to showcase a set of inherent challenges and integration at different scales. ABC Waters design features perform different functions such as conveyance, treatment and detention. These are expressed and integrated uniquely to each project.

1. Kallang River Bishan-Ang Mo Kio Park is the flagship project of the ABC Waters Programme. The project showcases integrated blue-green planning and government inter-agency collaboration at its best. At its core, this river restoration project is a well-loved regional park that is unique, for it is distinctly urban and adjacent to housing developments.

2. Downstream of Bishan Ang-Mo Kio Park, a subsidiary drain of Kallang River at Toa Payoh Lor 8, is an example of a retrofit blue-green project that solved a recurring flooding issue within the estate. A simple ABC Waters design feature - a rain garden, turning a liability into an asset.

3. Waterway Ridges – a collaboration with HDB and a pilot project to integrate ABC Waters Design Features with the landscape at a precinct level. Rain gardens are designed for the first time with active multi-functional spaces such as bioretention lawn basins, that can used as active open space during dry days. Rainwater is expressed in a water feature after being conveyed and cleansed – a celebration of the effectiveness of bioretention systems in a designed architectural feature.

Sustainability through stakeholders and 3P Partnership

With knowledge, and the understanding that education is key, initiatives like the ABC Waters Learning Trail are targeted at secondary school students, to educate about water related issues, encourage a conservation mind set, keep our waterways clean and adopt water safety habits. The Rain Gardens in Schools project built rain gardens in 8 schools, (primary to tertiary level) to reinforce these values and to enhance opportunities to learn about water, e.g. hands-on testing of water quality within the educational site and permeate application of ABC Waters design features within the water catchment.

Life of the project and its longevity is heavily dependent upon its care post-construction. Outreach via stakeholder consultation for the buy-in of the project pre-implementation is as important as the buy-in required by the stakeholders for the project's maintenance post-implementation. Sustainability of the ABC Waters Programme at its core is in its improvement of the urban landscape and its inherent added value to society. Continued support from stakeholders and the public can only strengthen the cause for well-designed and fully integrated Blue-Green Urban Landscapes.

DAY 2 TIME: 10:50 – 11:10

Biodiversity For Strengthening Resilience To Climate Change: The Singapore Experience

Dr. Lena Chan

Senior Director,
National Parks Board,
Singapore

Synopsis:

Many areas are facing the effects of climate change and coastal cities experience the consequences most severely. Solutions and preparations for climate change are most effectively if carried out in phases and ahead of time. While biodiversity will be affected by climate change, it can also contribute to the adaptation, mitigation and resilience.

Singapore by virtue of its physical location in the Malesian region is rich in flora and fauna, hence, Singapore's native biodiversity can form the cornerstone of nature-based solutions to climate change. Singapore already has a head start when it evolved from a Garden City to a green and blue biophilic City in A Garden.

The National Parks Board (NParks) of Singapore plays a major role in positive actions for climate change through several policies, strategies and action plans that form the thrusts of NParks' Nature Conservation Masterplan. These include the conservation of 4 Nature Reserves, increasing greater variety of plant species, ecologically connecting important natural ecosystems, promoting skyrise greenery, enhancing and enriching habitats in the Nature Reserves and parks, and carrying out species recovery programmes. The application of sound science and modern technology is crucial for the rational basis of these activities.

To ensure the sustainability of these actions, the participation has to be all-inclusive. This is only possible with the partnership of the public, private and public sectors working hand-in-hand. The young must be engaged from the earliest possible stage, hence education at all levels from pre-school to tertiary is essential. Public awareness and citizen science would further augment and drive people's efforts to meet the climate change challenges.

DAY 2 TIME: 10:50 – 11:10

Prepared Communities – participatory resilience planning in vulnerable communities

Lubaina Rangwala

Managing Associate

WRI India's Sustainable Cities Centre

India

Synopsis:

With climate change, cities are increasingly exposed to a range of hazards such as severe and prolonged droughts, intense rains, and increased temperatures. “The number of deaths attributed to natural disasters continues to rise, despite progress in implementing disaster risk reduction strategies. From 1990 to 2015, more than 1.6 million people died in internationally reported natural disasters” (SDG 13, Sustainable Development Knowledge Platform). The loss of livelihoods and the impact on social and economic assets, public health, and physical infrastructure that may continue to challenge the lives of vulnerable people, are seldom accounted for. As the world continues to urbanize, climate change is expected to increase the intensity and frequency of existing hazards, as well as usher in new climate risks.

Globally, experiences of the disaster management community suggest that there is a need to link top-down, institutionally driven disaster management approaches with community-based bottom-up approaches, to ensure that the city resilience strategy in fact enhances community resilience initiatives (IPCC 2012) rather than deepening infrastructure gaps. Moreover, since city resilience strategies largely focus on engineered or ecological solutions to manage risks (Vale 2014), they fail to focus on social assets – building back social networks and ensuring psychological recovery after an extreme climate event – systematically eroding a city’s social resilience capacity. In this context, planning and design play a critical role in shaping a city’s urban agenda towards climate sensitive and resilient pathways, while enhancing social cohesion.

Local communities are constantly shaping their built environment to improve their quality of life, reduce impending risks, and enhance their resilience capacities. To this end, the World Resources Institute has developed a participatory resilience planning process that helps cities and communities leverage their social assets in shaping resilient neighbourhoods and preparing for extreme events. This process involves collecting primary and secondary data in low-income communities living in at-risk areas in the city, assessing their resilience capacities, and co-developing resilience actions in gender and age segregated workshops. This process was conceived as a counter-approach to most top-down city resilience strategies and plans that tend to retain departmental silos, and largely focus on engineered solutions to reducing vulnerability in cities.

For this presentation, I will share findings from our projects in Surat (India) and Semarang (Indonesia), of working in low-income vulnerable communities, assessing their resilience needs and capacities, and co-developing resilience actions through a participatory planning process. Resilience actions ranged from climate risk management, improving urban infrastructure and services, and enhancing safety and social cohesion in low-income communities living in at-risk areas. Through these examples the presentation will address the following questions: How can cities assess, leverage and enhance the social assets available in vulnerable communities to design community-based resilient infrastructure that is locally relevant, gender sensitive, innovative and scalable? Moreover, how can this learning influence a city’s resilience plan, to enhance community initiatives and mainstream bottom-up planning processes?

DAY 2 TIME: 11:10 – 11:30

Building Urban Resilience in the Asia Pacific & beyond

Saurabh Gaidhani

Associate Director
100 Resilient Cities
Ethopia

Synopsis:

By 2030 60% of the world's population are living in cities, a proportion that will continue to rise as the 21st century unfolds. Cities will absorb—in less than 40 years—almost the entire increase in population in all recorded human history up to 1960. Cities are not just bricks and mortar. They are made to work not just by governments but also by the collective action of individuals, businesses, and institutions that collectively define it. From here on, when we refer to cities, we refer to everyone that plays a part in shaping their city. This is also the century where we will see globalization forces bringing rapid change to our cities. On one hand, there will considerable economic development opportunities; on the other hand, industries may also decline at a rapid pace.

Cities have always faced risks. Historically, many of the world's greatest cities have demonstrated their resilience in the face of resource shortages, natural hazards, or conflict. In the 21st century, the number of people living in cities and global pressures that play out at a city scale – such as climate change, disease pandemics, economic fluctuations, and terrorism – poses new challenges and uncertainty.

Our cities need better infrastructure and much of it will be conceived, designed, and built in the next 20 years. The annual cost of infrastructure that is resilient to climate change is around \$1.2 -1.5 trillion. The world cities will require estimated \$57 Trillion in global infrastructure investment in 21st Century. In ASEAN itself the major cities will require approx. 2.5 Trillion USD worth of infrastructure by 2030 & will house close to 350 Million Citizens. This is an unprecedented phenomenon of urbanization that needs a new outlook towards our cities & helping them in creating its required infrastructure & built environments.

100RC has recognized resilience as a critical urban agenda, and an opportunity for cities – particularly rapidly growing cities - to ensure that their development can enhance rather than undermine their resilience. Resilience doesn't just involve a better understanding of hazards, risk assessments and acting to reduce losses. It also includes tackling underlying vulnerability and strengthening the city's ability to withstand, recover from, and adapt to whatever shocks and stresses the future holds.

This is demonstrated by the decline of the US City of Detroit, Michigan, which was overly reliant on a single industry as its economic base. The city's failure to diversify its economic base meant that alternative options were not available to employers and employees when one industry began to decline. Like Detroit, many large cities such as Mumbai and Barcelona were once major centers of manufacturing. Both cities have evolved over time to absorb the decline of their manufacturing base with new industries such as tourism, culture, media, finance and information technology to continue to thrive today.

A city's wealth is not necessarily a defining factor of its resilience as relatively poor cities can also make choices that build resilience, create a thriving & liveable place for its citizens to live, adapt & grow.

DAY 2 TIME: 12:30 – 12:45

Biodiversity For Strengthening Resilience To Climate Change: The Singapore Experience

Dr. Lena Chan

Senior Director,
National Parks Board,
Singapore

Synopsis:

Many areas are facing the effects of climate change and coastal cities experience the consequences most severely. Solutions and preparations for climate change are most effectively if carried out in phases and ahead of time. While biodiversity will be affected by climate change, it can also contribute to the adaptation, mitigation and resilience.

Singapore by virtue of its physical location in the Malesian region is rich in flora and fauna, hence, Singapore's native biodiversity can form the cornerstone of nature-based solutions to climate change. Singapore already has a head start when it evolved from a Garden City to a green and blue biophilic City in A Garden.

The National Parks Board (NParks) of Singapore plays a major role in positive actions for climate change through several policies, strategies and action plans that form the thrusts of NParks' Nature Conservation Masterplan. These include the conservation of 4 Nature Reserves, increasing greater variety of plant species, ecologically connecting important natural ecosystems, promoting skyrise greenery, enhancing and enriching habitats in the Nature Reserves and parks, and carrying out species recovery programmes. The application of sound science and modern technology is crucial for the rational basis of these activities.

To ensure the sustainability of these actions, the participation has to be all-inclusive. This is only possible with the partnership of the public, private and public sectors working hand-in-hand. The young must be engaged from the earliest possible stage, hence education at all levels from pre-school to tertiary is essential. Public awareness and citizen science would further augment and drive people's efforts to meet the climate change challenges.

DAY 2 TIME: 14:00 – 14:20

Landscape approach, ecosystem services and future resilience

Himal Baral

Senior Scientist,
Center for International Forestry Research
Indonesia

Synopsis:

Rapidly increasing demand for food and agricultural non-food products to meet the demands of rising populations with new consumption patterns have worrying implications for sustainability of many ecosystems globally. Our aspirations towards global sustainable development and future resilience are dependent on how the world's ecosystems and their components are managed predominantly at the landscape level. Challenges of global food supply, welfare and livelihoods for billions of people, carbon sequestration, conservation of biodiversity and provisions of renewable energy, water and soil fertility all need to be addressed at the landscape level. Numerous studies indicate that sustainable use of many of our renewable resources is being exceeded on a global scale and that we should approach future use with great care. Production landscapes, if managed appropriately, yield a wide range of goods and services vital to humanity, including food, wood and other raw materials, as well as life support processes (e.g. climate regulation, water purification), life fulfilling conditions (e.g. educational, aesthetic and recreation opportunities) and conservation options (e.g. genetic diversity for future use).

However, the provision of ecosystem goods and services at landscape scale can vary considerably depending on land use and land cover, and management choices. For example, landscapes dedicated mostly to agricultural production have limited capacity to produce the range of ecosystem services required for human health and well-being, while landscapes with a mosaic of land uses can produce a wide range of services, although these are often subject to trade-offs between multiple ecosystem goods and services. This talk will briefly introduce the landscape research in CIFOR, ecosystem services under different landscape management scenarios and the potential for planning and reconfiguring landscapes toward achieving future resilience.

Keywords:

Landscape approach, ecosystem goods and services, landscape management scenarios, ecological resilience

DAY 2 TIME: 14:20 – 14:40

BETWEEN A ROCK AND HARD PLACE: Building Resilience in an Uncertain World

Jonathan Rigg

Director of the Asia Research Institute and Department of Geography
National University of Singapore
Singapore

Synopsis:

This presentation will seek to do four things. It will open by discussing the theme of 'resilience': what it means, how it is used, and its shortcomings. Second the paper will reflect on inherited vulnerabilities and how they have been addressed, or not, by processes of development-as-modernisation. Third, the paper will show, drawing on fieldwork in Nepal, Laos, Thailand and Vietnam, how increasing prosperity and declining vulnerability have also been accompanied, not infrequently, by rising 'precarity' – the precariousness of modern life. This will then illuminate the puzzle of how we see growing wealth and material prosperity across Asia on the one hand, accompanied by a growing precariousness of life on the other. This raises questions about the achievement of resilience through neoliberal policies of wealth and growth generation. Finally the presentation will return to high level debates and reflect on the 'reductionisms' inherent in much climate change science.

DAY 2 TIME: 14:40 – 15:00

Urban Wilds as a Resource of Resilient Cities

Yun Hye Hwang

Assistant Professor, Department of Architecture
National University of Singapore
Singapore

Synopsis:

The intensive and exponential growth of human activities in cities is a key driver of the significant loss of habitats. Given the competing land use for economic-driven human development, urban wilds could become a compelling natural resource to achieve ecological resilience in cities. Urban wilds are a bottom-up approach that starts with the simple act of reducing human interruption while allowing the spontaneous growth of landscapes. It is geared towards enhancing urban biodiversity and increasing the structural complexity and heterogeneity of urban landscapes, which, in turn, supports various local habitats that strengthen the ecosystem's capacity to deliver important ecological services. Inspired by Alberti's (2016) planning principles under uncertainty (maintaining the diversity of urban patterns, increasing adaptation capacity, actively reconfiguring policy actions, and expanding time scale of decision-making), the talk begins a discourse on the extent to which urban wilds can enable resilience in urban ecosystems by discussing three ongoing research projects.

1. Wild landscapes in a tidy city, Singapore: *Manicured urban greenery is the norm in Singapore, but this approach obstructs the accommodation of ecosystem dynamics and misses an opportunity to socio-ecological benefit from the region's tropicality. The two pilot projects have generated design and management strategies promote the use of spontaneous growth of urban greenery and suggest steps that can be taken at a policy level. A hybrid of natural growth and selective human management offers an approach to negotiating social demands in a compact city and provides a strong ecological incentive that works in harmony with the region's characteristics.*

2. More greenery for the poor, Mumbai and Jakarta: *Many studies on disparities in the distribution of urban green spaces (UGS) focus on accessibility of public green spaces. Yet when all types of UGS, including unmanaged greenery, are accounted for, claims of green space distributive injustice become more complicated. Using the case studies of Mumbai and Jakarta where the inequality issue has grown, this project questions the common assumption that the poor have less green space by analysing green space distribution patterns, vegetation densities, and patch sizes. The project's findings have practical consequences for policy and planning towards ecologically inclusive communities.*

3. Kabalikat Mangrove Project, Manila: *Situated in the mouth of the Pasig River, off Manila Bay, Baseco has been reclaimed. The coastlines were left bare and became a dumping site between two stone breakwaters extending out of the river and South Harbour, with a third of the settlement area marked as flood-prone. Spontaneous mangrove planting along the coastlines of Baseco to mitigate the impact of typhoons was started in 2012 by local NGOs in partnership with the resident group, Kabalikat; they used leftover funds from disaster relief donations to start a disaster risk reduction project. Despite numerous setbacks and a low mangrove survival rate, gradual improvement can be observed over three years, with constant improvisation by residents adding to the success.*

Infinitely adaptive socialized housing development for urban regeneration and resiliency

Jouykovi Ignaecia Cruel^a

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Abstract

Living in a fast-paced world requires one's ability to adapt. Rigid cities planned with minimal, or worse, no foresight and without room for any possible changes and for problem mitigation, expose people living in them to extreme vulnerability. With more than half of the world's population currently living in cities, urbanization continues to expand, and with it the increase in urban poor communities, social alienation, and environmental pollution intensifies, especially in developing countries like the Philippines. Every month, approximately five million people migrate to cities all over the world. In Metro Manila, eleven percent of its residents live in slum areas.

The urban poor faces multiple threats to their lives—pushed to places of least favorable circumstances and detached from various basic services. One of their weapons for survival is establishing informal settlements, though usually at areas in high risk areas (e.g. near waterways) —a product of survival and adaptation to the urban environment. Despite the living conditions of the urban poor, they have proven to have great capacity to improve and invest in their communities. These informal settlements should be seen as potential growth areas; these settlements are the answer to the incessant problem of growing slums.

The paper aims to strengthen the urban poor safety net by developing a design framework for self-sustainable, climate change-adaptive, and low-cost housing developments along waterways, where residents benefit from the surrounding areas to create an osmosis effect. Nearby linear parks serve as recreation area, flood-buffer zone, and bioretention basins with park bridges connecting them, for improved mobility and utilization of areas. Along with it is the implementation of an infinitely adaptive system that is not repetitive in nature, and, in turn, will help reduce the urban poor's vulnerability and will enable to cope up with the city's progress.

This design framework also aims to dispel the stigma and isolation of socialized housing from their surrounding developments by integrating and intermixing them with the community, thus, creating better access to basic services and giving the urban poor a sense of ownership and the sense of responsibility of taking care of their property and their surroundings as well.

In the Philippine setting, usual relocations sites are located at areas away from the town proper of nearby rural towns, with row houses haphazardly built. It is no news that many, some up to sixty percent, return to the city. Rather than uprooting and displacing established urban poor communities into disconnected pockets lying at the fringe of development, their current location along waterways is retained and is optimally utilized. From being areas of high risk and low value, the development becomes the city's first line of defense in mitigating the impacts of climate change, while, at the same time, provides better quality of life to the urban poor through sustainable landscape design and planning principles that promote urban regeneration and resiliency, among many others.

Keywords: Socialized Housing; Urban Regeneration; Urban Resiliency; Mitigate Impacts of Climate Change; Landscape Urbanism

1. Introduction

Urban populations have skyrocketed globally, where in more than half of the world's population live in cities. UN Habitat reports that current urban trends indicate that an additional three billion people will be living in urban areas by 2050, increasing the urban share of the world's population by two-thirds.^[1]

As urbanization continues to rapidly expand, the increase in urban poor communities, social alienation, and environmental pollution intensifies, especially in the developing world where current responses are having difficulty keeping up. Rigid cities planned with minimal, or worse, no foresight and room for changes and/or problem mitigation, expose people living in them to extreme vulnerability. But these did not stop the estimated five million people who migrated to cities every month last 2016^[2], and will not stop. Rather, it is projected to increase in the next coming years while rural population will decrease, with Asia and a number of its subregions on a more extreme level than that of the world as indicated in Table 1 ^[3].

	Urban population (%)				Average annual rate of change (%)			
	1950	1975	2000	2025	Urban		Rural	
					2000-2005	2025-2030	2000-2005	2025-2030
Asia	17.4	24.7	36.7	50.6	1.31	1.10	-0.80	-1.19
Eastern Asia	18.0	25.2	38.5	51.8	1.20	1.06	-0.79	-1.20
South Central Asia	16.6	22.2	30.6	44.7	1.36	1.37	-0.63	-1.18
South Eastern Asia	14.8	22.3	37.2	53.2	1.85	1.00	-1.18	-1.20
Western Asia	26.7	48.5	70.2	77.0	0.71	0.26	-1.77	-0.97
World total	29.7	37.9	47.0	58.0	0.83	0.77	-0.86	-1.12

Source: United Nations (2000) pp. 28-31, 72-73, 76-77

Table 1. Urban and rural population growth rates, 1950-2030

2. Urban Slum Formation and Slums of Hope

Aside from being a need and right, provision of 'decent shelter' is an essential precondition for social stability, as stressed upon Costa Rican President and Nobel Peace Prize recipient Oscar Arias. Global initiatives, such as City Alliance's *Cities Without Slums* and UN's *Millenium Development Agenda*, were started with the general goal of achieving significant improvement in the quality of life of people, especially of slum dwellers, including equal accessibility to basic needs and services, such as adequate and secure shelter.

But as governments of developing countries continue to focus on economic growth rather than providing linkage between expected

urban growth and housing provision, the quintessential problem on lack of ample and secure shelter, especially for the poor, will continue to plague the developing world^[3]. In the Philippines alone, the backlog on socialized housing was estimated to have reached 5.7 million units in 2016. An estimate of 2,600 housing units are needed to be built daily over the six-year period to resolve the said backlog^[4].

As government fail to effectively link economic growth to projected urban development and socialized housing provision, the competitive demand for land intensifies. As a result, the urban poor, usually large proportions are of rural migrants, are displaced into blighted informal settlements and are increasingly marginalized—pushed to settle at the fringes of development with the least favorable circumstances and are detached from various basic services. As the struggle of finding adequate and secure shelter persist and worsen, informal settlements in urban cities will remain in the same areas but intensely become denser. Asian cities such as Karachi, Dhaka Mumbai, Kabul and Metro Manila have some of the largest slums^[5], with Manila having eleven percent of its residents living in blighted communities^[6].

Establishing informal settlements, usually at areas of high risk (e.g. near waterways) that no one has interest in, serves as one of the weapons of the weak [Figure 1] to ensure survival and adapt to the urban environment. It is estimated that one out of seven persons in the world, or roughly one billion people, live in slums^[7].

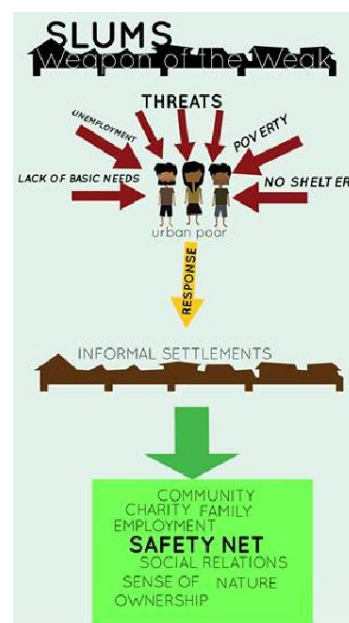


Figure 1. Informal settlement as answer and weapon of the poor against threats, reinforced by creation of a safety net.

“Slum” lack consistent terminology and is used interchangeably with “squatter settlement” and “informal settlement”. United Nation – Habitat^[8] construes slum household as any household lacking access to improved water, improved sanitation, sufficient living area, durable housing, and secure tenure. On top of concerns for their daily grind, slum dwellers are also threatened by environmental problems (air pollution, water pollution, flooding, and congestion) brought about by urbanization and economic development. These problems affect majority, if not all, of city inhabitants but “the levels of exposure and impact are highest in slums due to their location, limited infrastructure, and coping strategies.”^[9] (Ballesteros, 2011)

Despite the living conditions of the urban poor, they have proven to have great capacity to improve and invest in their communities. These informal settlements are starting to be seen as potential growth areas – as ‘slums of hope’ and the possible answer to the incessant problem of growing slums.

In the developing world, slums are in fact the dwelling places of much of the labor force and informal employees that drive the economy of cities. They are melting pots for different racial groups and culture, serving as breeding grounds for iconic political, and cultural movements. Through innovative solutions, the poor are able to improve their own living environments, and paved way to the “gradual consolidation of informal settlements.”^[10]

3. Strengthening the urban poor safety net through in-city and in-filling relocation

Close-knit communities of slum are one of the safety nets of the urban poor [Figure 1], as well as relying on nature, and employers. These are the few things they depend on during times of difficulty - nature for food and livelihood, their family and neighbors for financial and emotional support, and employers for income and loans. But through repressive policies such as forced evictions and resettlement, which sadly are still implemented in some cities, this safety net is weakened, if not entirely destroyed.

Off-city relocation model of resettlement often fail to support the social welfare of the urban poor. Usual relocation sites are

located at areas of great distance from livelihood sources, and with row houses haphazardly built by developers that limit participation of affected community/ies in the settlement development phase. It is no news that many return to the city. In the Philippines, up to sixty percent of relocatees return.^{[11][12]} (Galuzka, 2013 & Shahani, 2016)

Also, off-city relocation hasten depletion of land, a finite and scarce resource, and promote irresponsible sprawl. Instead of opening a ‘new land’, which may be utilized for a more critical and vital need such as forest conservation, in-filling and upgrading of blighted, underutilized, and vacant spaces in the city is a more sustainable option. In-city resettlement and in-situ upgrading maximize scarce available resources and consecutively reasonably lower socialized housing’s production and development cost so that beneficiaries may afford them.

This type of managed densification integrates and intermixes the community and secures their tenure, reinforcing their safety net and recognizing every individual’s right to the city. Some degree of harmony, order and discipline encompass the city and augment its resiliency and ability to regenerate.

4. Infinitely adaptive socialized housing development

However, on-site and in-city relocation proves to be a great challenge for the government of developing countries as space becomes premium and limited in the cities, amplified by rigid master plans that fail to respond to people’s need and

anticipate changing circumstances. Applying the concept of infinite flexibility/adaptability to in-situ socialized housing development may then be a great response to improve urban resiliency and urban regeneration. The concept views a city to be system of flexibility, made up of modular core and parts governed by the occupants; a matrix of incomplete objects and forms, wherein occupants complete what the designer started.

Main roads, high-end commercial areas, affordable commercial areas, waterways, green spaces, and transit stations are to be used as indicators on where to place the development and how they are to be formed. Close proximity to low-end commercial areas and transit hubs and access to main roads were factors prioritized to augment their linkage to the city, promote soft modes of mobility within, to and fro the development, and create an osmosis effect where in residents have access to affordable basic services and can benefit from surrounding areas.

4.1. Cyclical Housing Towers

The housing itself shall comprise of a structural frame and utility core that includes the stairs, elevators, mechanical-electrical lines, and plumbing lines, much like a skeletal frame. Modular, prefabricated units can be purchased or rented, adding more as the need for expansion arises. Affordability, then, is certain without compromising ample living space as cyclical housing [Figure 2] is accommodated – from living alone, to having a partner and children until the children build their own family and the cycle continues.

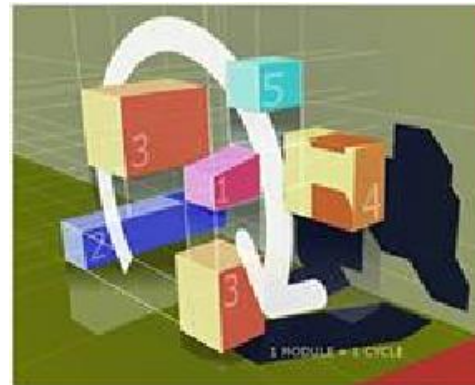


Figure 2. Cyclical Housing (1 – Single; 2- Newly Married; 3 – Married with Young Children; 4 – Married with Adult Children; 5 – Retired/Senior Citizen)

By providing the frame and basic utilities, the occupants themselves finish what was given – an infinitely adaptable system yet not repetitive in nature. As change of rate in slum and depressed are the highest in the city, the housing tower/structure is perfect in containing the constant changing of the residents’ homes. Mixing pockets of green communal spaces, such as vertical edible gardens, and commercial units into the housing structure will help induce more growth into the development and eventually to the city. [Figure 3]

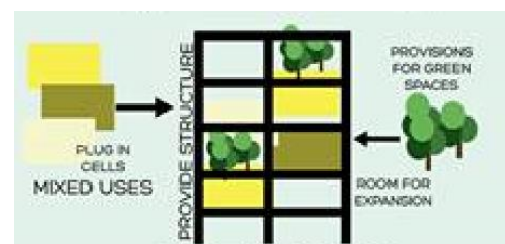


Figure 3. Infinitely Adaptive Housing Structures Concept

4.2. Public space for social, economic, and ecological development

Aside from preventing sprawl, redevelopment of informal settlements along waterways and vertical expansion of the housing structure also frees up the space on the ground level for other uses [Figure 4]. It can then address the issue of poor and scarce public space and provide democratic access to the river. Well-designed public space should not be seen as a luxury amenity but as vital to the well-being of the poor and the development of their community. They boost their social and economic quality of life. Depending on the needs of the community, they may be parks for recreation, public gathering, or marketplace – better yet a harmony of all.

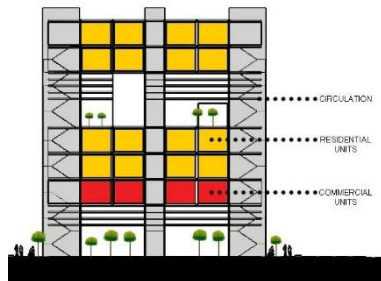


Figure 4. Vertical expansion for ground level public space allocation

Space is also optimized to mitigate effects of climate change and undesirable ecological impact like flooding, water pollution, and air pollution. Parks will also serve as transitory flooding parks and bioretention basins. Proper easement along waterways should be strictly implemented to provide for planting strips of rain gardens, sidewalks, and

bikelanes. [Figure 5] Creeksides and riverbanks are rehabilitated in order to fortify the development's defense against flooding brought about by torrential rains. Various sustainable bio-engineering solutions may be applied depending on the situation and budget like vegetated geogrids for bank stabilization and proliferation of site-appropriate aquatic plants for rain water filtration and slowing down of river current. Developing pedestrian park bridges help reinforce connection between the development and the city.



Figure 5. Developing easement for democratic access to waterways

The optimal aim of the development, aside from ample housing provision, is to give the urban poor something worth taking ownership of to restore their self-respect. By providing them something that they can be proud of and can call their own will awaken their innate concern to protect it. Hand-in-hand with ecologically sound habitable place-making, from being areas of high risk and low value, the development then becomes the city's first line of defense in mitigating the impacts of climate change, while, at the same time, provides better quality of life to the urban poor through sustainable landscape design and planning

principles that promote urban regeneration and resiliency, among many others.

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Re-enrooting Food and People to the Place and Re-exploring Landscape Locality for Future Resilience: A Case Study for the New Approaches Used in a Landscape Project in Yilan, Taiwan

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Abstract

Present day societies are highly connected to, and driven by, the global flows of resources and subject to influences from far beyond their geographic locations. Efficient and productive functioning requires the division of labor, production, and land uses, etc. to be strongly emphasized and implemented. As the development and functioning of places become more and more connected to the global and interregional contexts, and their physical existence mainly supported by professionally-provided services and production, the substantial socioeconomic networks for the functioning of a place, such as food, people, and communities, are, therefore, divided from each other at the local level and disconnected from the local contexts. The seemingly prosperous, globally attached but locally dis-embedded modern societies are often dependent upon the efficiency of division and accurately functioning systems beyond their location. While detached from the integration of a strong socioeconomic infrastructure and the local contexts, they can be vulnerable to environmental changes and poor prospects for future resilience.

Motivated by concerns that a new tourist center will open shortly providing, on the one hand, new sources of local development; but on the other hand, making significant changes to the local landscape due to tourism development and capital investment, a landscape project in Yilan County, Taiwan, in 2017 has responded to these challenges by using “food” as a medium of landscape intervention. The study examined this project which aimed to be a pilot project of using “food of the local table” to guide the local development and landscape changes into an inclusive, sustainable, and resilient future scenario. It explored and presented the multiple aspects of the value and characteristics of the local landscape; introduced the idea of embedment through the food on the local table at mealtimes; and demonstrated a new eating experience which could highlight the added value of the local landscape for the promoting of sustainable, inclusive local development grounded on local resources.

“Enjoying food of the local table, savoring the character of the local landscape” was the slogan of the project. The local table project created a local network of farmers, chefs, small business owners, and residents, and using “food” as a medium to initiate new actions and relations in order to revitalize the local socioeconomic chains. By re-enrooting food, its production, and the people involved to the place, the integration of landscape contexts aims to

strengthen the viable local socioeconomic infrastructure and to re-explore landscape locality as a valuable asset for the sustainable development and future resilience of the local communities.

The project shows new possibilities for the role of landscape architecture and new approaches for intervention within the landscape. The new strategies for the resilient future development could also focus on the re-exploring of landscape locality and the re-enrooting of food, people, and communities to the places while, at the same time, enjoying the diverse opportunities offered by global collaborations and exchanges.

Keywords: Embedment, Food, Landscape locality, Inclusive development, Socioeconomic infrastructure

1. Introduction

The food system, according to Malassis (1994), is the manner in which mankind organizes itself in time and space to obtain and consume its food and has been passed on through history and societies. In the early stages there was a unity of the location of production and consumption, commodity chains were relatively short, and food was not only for feeding but also the basis of creating strong bonds of human development and social cohesion in a locality.

The growing emphasis on the global and interregional division of production, especially since the first half of the twentieth century, lead to the delocalization of site-specific activities whereas the food-induced local social, cultural, and economic chains were broken down and replaced by the agro-industrial model characterized by specialization and intensification which has found a good match with the notions of globalization and urbanization familiar to contemporary society.

The present-day societies are becoming highly connected to, and driven by, the global flows of resources and subject to influences from far beyond their geographic locations. To secure efficient and productive functioning requires the division of labor, production, and land uses, etc. to be strongly emphasized and implemented. As the

development and functioning of places become more and more connected to the global and interregional contexts, and their physical existence mainly supported by professionally-provided services and production, the substantial socioeconomic networks for the functioning of a place, such as food, people, and communities, are, therefore, divided from each other at the local level and disconnected from the local contexts.

The seemingly prosperous, globally attached, but locally dis-embedded, modern societies are often dependent upon the efficiency of divided and accurately functioning systems beyond their locations. While detached from the integration of a strong socioeconomic infrastructure and the local context, such societies can be vulnerable to environmental changes and poor prospects for future resilience.

In rural areas for example, rather than embedded in the local environmental and socioeconomic conditions, agriculture is now characterized by socio-technical regimes shaped by schemes of prescription, control and sanctioning by state and private agents (Van der Ploeg, 2006). This has led to homogenization of agriculture and landscape in which national and international pressures such as speculative price-setting and subsidized technological investments have caused a “dis-embedding” of the agricultural landscape from its local and regional social,

environmental, and economic context. Through the ongoing process of regionally embedded regimes being replaced by the new ‘socio-technical regimes’, it is the logic of ‘un-embedded’ finance capital that influences rural landscape and development, rather than the aspects of embeddedness (Lyson, 2006).

The declining capacity of the agriculture landscape to contribute to the local economy could be understood as a consequence of large scale, intensive agriculture failing to bring economic benefits to the immediate local economy because of its dependence on long supply chains and economies of scale (Gallent et al. 2015). This situation does not offer attractive employment opportunities or invest its value added to the local economy when it depends on, and connects mainly to, exogenous systems instead of local socio-economic networks and resources.

An alternative local development model, stressed by Slee (1994), could come from endogenous factors whose value is determined by the variables within the regional system. Moreover, the benefits of development based on such factors tend to be retained in the local economy and local values are respected. In a modern context, how can food and eating be a bridge to re-connect to development that is embedded in the locality? How can an area employing endogenous factors grounded on local resources become a driving force for sustainable local development and landscape?

The study examined a landscape project in Yilan County, Taiwan, in 2017 which has responded to these questions by using “food” as a medium of landscape intervention. The project demonstrated that local landscape characteristics can be well represented in a “local table” (a locally embedded meal),

thereby creating added value to the eating experience. It showed that territorial resources can be important assets to the local communities for an inclusive, sustainable, and resilient future landscape scenario.

Based upon interviews with the project organizers, participants, guests, and the analysis of documents, the study examined the notion and representation of landscape, the locally embedded creation of food and the eating experience, the meaning of locality for future development, and the new approaches of landscape intervention.

2. The “local table” project

2.1. *The project and the area*

The local table project was held in Juangwei Township, Yilan County, Taiwan between February and June 2017. The project area is located on the coastal region of Yilan County facing east to the Pacific Ocean. The geographic features of the landscape consist of a low, fertile, alluvial plain, the coast and sand dunes, and small communities aligned north-south fitted into the edge of the sand dunes and the plain. Like many present-day rural areas, agriculture used to be the major driving force of the local landscape but now it cannot sufficiently support the local economy and jobs.

Motivated by concerns that a new tourist center will open in the area in 2018, on the one hand, tourism could provide new sources of local development; but on the other hand, the local landscape is expected to face significant changes due to tourism development and capital investment. The project aimed as a pilot project for using “the food of the local table” to guide the local

development and landscape changes. “Enjoying food of the local table, savoring the character of the local landscape” was the slogan of the project. It explored and presented the multiple aspects of the value and characteristics of the local landscape; introduced the idea of embedment through the food of the local table meal; and demonstrated a new eating experience which could highlight the added value of the local landscape for the promotion of sustainable, inclusive, local development grounded on local resources.

2.2. *The participants*

- a. Two teachers as project organizers from the landscape architecture department of Chung Yuan Christian University (CYCU).
- b. Seven master students in the CYCU landscape architecture department who helped to produce field records and to create the “meal of the local table”.
- c. Two local young people who ran a bed and breakfast and provided a venue for the project with the kitchen and dining space for the local table meal. They were also the major local contacts working closely with the organizers and helping to gain access to local chefs, farmers, artisans, and residents.
- d. A film director who helped the students to produce field record films.
- e. A local photographer doing photo records of the project.
- f. A Chef and two assistants from the local area who helped to create the recipes, menus and who lead the cooking of the “meal of the local table”.
- g. Three young local farmers who practised environmentally friendly farming and provided food ingredients and materials for the meal.

- h. A young artisan who helped to create tableware items.
- i. Three local residents who helped to provide food materials.

2.3. *The main activities*

- a. Creating one meal for a dinner as a demonstration of the embedded idea of food, people, and locality. The process for creating the meal included:
 - a). Field studies of the project areas to find local resources related to the creation of the meal and a good eating experience.
 - b). Discussion of the major ingredients and materials that are most representative of the local landscape.
 - c). Discussion of the menu (Table 1) and eating as a holistic experience.
 - d). Discussion of each course in the menu regarding the concept, name, expression, ingredients, and presentation.
 - e). Creating a local network of people regarding the produce used for the meal.
 - f). Several rounds of test cooking.
- b. Invited guests from public and private sectors of tourism, commerce, agriculture, culture, and the design and planning department to come to the dinner and share ideas for follow-up actions.
- c. Field recording of the landscape, seasons, people, and the production. The field records were made into short films, photographs and drawings, and presented in an exhibition combined with the meal, thus providing a multi-sensorial eating experience.

3. **Landscape on the table: The characteristic of the local landscape**

manifested through food and the eating experience

The idea of landscape has multiple dimensions combining physical, symbolic, and relational aspects. According to Wang (2015), landscape does not exist merely as objective facts, but also a creation out of human perception and imagination. While the physical and symbolic notions stress the visual and the already-made representations of landscape; nonetheless, the relational aspects emphasize landscape not so much as an entity in itself but as the assembled outcome of networks and embodied functioning relations (Wang and Chou, 2016).

Landscape is, therefore, not the still, scenic images and physical existence as commonly understood, but as something dynamic and having multiple aspects. Taking such notions, the project demonstrated that the multi-aspects of the local landscape could be expressed through food and the eating experience; and such embedment could highlight the eating experience that created added values and turned local resources into place-specific assets for sustainable local development.

3.1. The representation of local landscape through the menu and food ingredients

The food ingredients for creating the menu and the meal were the first question addressed in the project. Through the discussions among the chef, the local farmers, the CYCU teachers and students, the bed & breakfast owners, and some local residents, different ingredients were nominated. Discussions then proceeded through debates and communications which resulted in a list of

categories and ingredients as most representative for the local landscape including six categories and a total of sixteen ingredients.

The categories and the ingredients showed the local people's awareness of the geographic traits of the area. They also showed that the collective memories and local living played an important part in interpreting the local landscape. The creation of the meal and recipes were based on the list in Table 2.

According to one participant:

“I've never thought about this before, that the ingredients of food could represent our landscape. I'm impressed to realize that this landscape supported us with a complete meal on the table from seafood to pork, rice and vegetables.”

The meal did not only deliver the characteristics of the local landscape, but it also highlighted the diverse capacity of the landscape to produce food. In many places within contemporary society, the agri-industrial model of global and interregional division has deprived areas of the capacity to support a full meal on their local tables.

3.2. The eating experience connected to local materials and landscape images

The second question was the local materials (Table 3) and environmental characteristics that can be used in the meal and through the eating experience (Figure 1). The field study has recorded the local environmental contexts related to the creation of the meal and expressed through drawings, film, and photography in an exhibition at the venue as an accompaniment to the serving and eating of the meal. The landscape

contexts (the land, seasons, people, sunrise-sunsets, rainy-sunny, insects, birds...) of the locality were therefore connected to the people having the meal, highlighted the eating experience, and increased the added value of food and the locality (Figure 2, 3).

The design of the meal and eating experience were incorporated in the project through using representative local ingredients, the name of dishes, the exhibition of field records, and the presentation, tableware and decoration with local materials. The eating and enjoyment of food were highlighted as multi-sensorial activities combining gustatory, olfactory, visual, tactile, audio, and perceptual contacts. In the model of global division, the eating of food can be independent from any indication of specific locations, but, as stressed in the project, it can also have close connections to a location. According to interviews with the guests, the multi-sensorial eating experience highlighted the value and appreciation of the local landscape and has a good potential as an asset for local development.

3.3. The local reciprocal social network induced by the creation of the meal

The creation of the meal has not only created a chain of local ingredients and materials, but also created a social network of people (Table 4). In this case, the global and interregional division model shifted to the endogenous reciprocal network grounded on local resources and engaging local collaborators. The connections of the social networks could help to build up the social capital of the local communities in which reciprocity arises from such connections (Putnam, 2000). According to the chef:

“Using mainly local resources to create a full meal, I felt restricted at the beginning but then I found it challenging and rewarding as new resources and links to people started to emerge. It gave me new inspiration and meaning for cooking.”

4. Conclusion

The ‘place-less’ discourse of division and globalization are significant forces for change in the present-day landscape. In this case, the development of a location was strongly subject to the exogenous factors that are externally determined by variables outside the causal system of the local region. In the discourse of global and interregional division, the exogenous factors can be transplanted into local regions or localities, and the benefits of local development can be exported despite local values and identities tending to be trampled (Slee, 1994). As the development of a location is subject mainly to the exogenous factors, it could lead to vulnerability in future resilience and also cause an identity problem for a location.

In response to this problem, as Marsden (2017) stressed, the place-specific assets and place-based approaches should be developed for sustainable territorial development which embodies the construction of locational identities, brands, and images around new and redefined goods and services embedded in the locality. The effective social management of environmental resources should combine natural, social, economic, and territorial capital as ways to enhance the local and regional specific assets rather than disrupting and disregarding them. The viable social and economic activities that utilize the varied and differentiated forms of

environmental resources in sustainable ways could provide net benefits and add value to the local environment and community (Kitchen and Marsden, 2009).

The project showed new approaches for intervention within the landscape and stressed a shift from the place-less discourse of division to the emphasis of place-specific assets for locally-embedded territorial development. The strategies for the resilient future development could come from the creation of added value through re-exploring the local landscape and re-rooting food, people, and communities to the places while, at the same time, enjoying the diverse opportunities offered by global collaborations and exchanges.

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Appendix :

Table 1: The menu of the meal

Type	Name	Description	Concept
Beverage	Honey	Cold honey drink with lemon. Honey was a by product from a local farmer who keeps bees to pollinate pumpkins. The pumpkins were also ingredients of the meal.	A drink to start the story and the theme of agriculture and local landscape.
Appetizer	Local memories	Assorted local snacks rearranged.	Reflection of traditional local food with new arrangements. and presentation
Appetizer	Meeting the ocean horizon	Marinated fish presented on top of the small gravel stones from the coast on a plate made from drift wood from the local beach. The fish came from the local fishing practices.	Reflection of the land meets the ocean.
Appetizer	The gold of the earth.	Pumpkin cake.	Reflection of the fertile plain.
Soup	The dancing of the coast.	Soup with local seafood and ground sweet corn.	Reflection of the ocean products.
Salad	Happy country life.	Home grown tomato and melon with house-made sauces.	Reflection of the vegetable garden of the country.
Main course	Thankfulness.	Local pork and rice.	Reflection of a “thankful meal” of the local custom, offers to the neighbors and villagers who came to help with the harvest. Normally it’s a good meal served when the harvest work is complete.
Desert	Frozen.	Ice cream of peanut and taro.	Reflection of the memory of the local desert with new interpretation and presentation.
Beverage	House specialty.	Homemade fruit vinegar drinks.	Reflection of the homemade custom common to local households.

Table 2: The representative local ingredients

Category	Ingredient	Remarks
Sand dune products	White radish, Peanut Melon, and Water Melon.	The three representative products of the sand dunes.
Ocean products	Sea food.	Local fishermen deploy fishing nets from small boats near to the coast, which are pulled back by villagers from the beach to harvest seafood.
Aqua-culture products	Shrimps.	Representative products of the local commercial fish ponds.
Coastal plain products	Rice, Sweet corn, Pumpkin.	The three representative products of the plains of this area
Daily life environment products	Tomato, Chicken, Taro, Cucumber, Yams.	Most common household products of the area.
Local collective memories	Sugar	Sugarcane planting was introduced during the Japanese period. Many local people grew up with memories of the sugarcane landscape and it is still grown at a household scale.
	Pork	An animal feed factory has been here for a very long time, it produces feeds for local pig farms and outside Yilan county. Local villagers worked in the factory for two or three generations.

Table 3: The materials used in the meal

Category	Material	Remarks
Local material used in the tableware and presentation.	Small gravel stones from the local beaches.	For the bedding on the plate of marinated fish.
	Wood plate made from the drift wood of the local beaches.	For dishes related to ocean images.
Local materials used for table decoration.	Plant material for flower arrangements.	Collected from the fields surrounding the venue of the meal.
	Pumpkin for table decoration.	Provided by a local farmer.

Table 4: Networks of people for creating the meal

Task	Key persons and tasks		Supporter and tasks	
Creation of a meal	A chef and two assistants.	Creation of recipes and the menu; cooking.	Three local farmers.	Providing food ingredients.
			Three local residents.	Providing processed food materials.
	The B&B owners.	Building contacts to local supporters; finding local materials. Creation of recipes and the menu; cooking.	One local artisan.	Providing woodwork for the tableware.
			One local photographer.	Field photography and flower arrangement.
	Two teachers.	Project organizer; creation of recipes, the menu and the eating experience.	One film director.	Help producing film of the field recording.
Seven students	Creation of recipes and the menu; help making driftwood tableware, help preparing food materials and field recording.			

Figure 1: Images of the discussion and creation of the menu of the local table meal.



Figure 2: Images of the venue and dishes of the local table meal.



Figure 3: “The pumpkin, the farmer, the landscape, the food” Images from the field recording.



Sydney's Olympic Peninsula :

Growing the Green Games Legacy - a Showcase for Urban Resilience

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Abstract

Sydney's Olympic Peninsula extends over more than 700 hectares and provides an opportunity for developing a showcase for sustainable and resilient communities building on the legacies of the 1988 Australian bicentenary, 2000 Olympic 'Green Games' [7], highly integrated blue, grey and green infrastructure systems unified by world significant landscape architecture. With nature at its heart, the Olympic peninsula is envisaged to become a focal part of the Greater Sydney Commission's (GSC): 'Greater Sydney 2056 : a metropolis of three cities'. [1]. The GSC vision also includes a new Sydney 'Central City' District [2]:

"A city in its landscape valuing green spaces and landscape, an efficient city using resources wisely and a resilient city adapting to a changing world".

Within this district lies the *Greater Parramatta Olympic Peninsula (GPOP)* [3] and inside this; a new '*Super Lifestyle Precinct*' providing opportunities to develop an exemplar resilient and 'biophilic' city.

The Sydney Olympic Park MASTERPLAN 2030 (2017 review) [4] (Figure 1) adopts the Green Building Council of Australia (GBCA) '*Green Star Communities*' [5] sustainability framework supported by a 'honeycomb' of New South Wales (NSW) Government planning policies.

Annually over 10 million visitors attend sporting, entertainment and cultural events, 3 million people visit parklands, more than 50,000 residents live in neighbourhoods around the park and each week; thousands of students come to the park for sporting and education programs.

The Olympic Peninsula continues to attract growing global interest as an exemplar for major event legacy and education for sustainable development; particularly from Asia. Sustainability researcher Aziz says [6] (Figure 2)

“Data analysis of the (Sydney Olympic Park Authority) global mapping on Technical Insights Tours (2007-2017), 304 international and domestic visits with 11,844 visitors recorded throughout the period with no less than 25 formal visits per year. A steady number of visitors each year showed that Sydney Olympic Park is recognised as an ‘outdoor classroom’ for experts, students and public to benefit from the Olympic venues and parklands. The reliance is not just on sports and events for Olympic Legacy, but also in providing a liveable landscape for the public”.

This paper includes several ‘*early adaptation*’ case studies as pilot projects toward urban resilience by improving thermal comfort in a hotter/dryer climate, a response to wildfire and use of controlled burning as a landscape management tool and finally; steps toward future-proofing wetlands and estuarine infrastructure from tidal inundation. Together these projects seek to improve the resilience of vulnerable landscapes and liveability for a diverse set of Olympic Peninsula communities.

New opportunities and challenges for landscape architects require trans-disciplinary collaboration to further develop and adapt the Olympic Peninsula to a complex set of urban growth factors such as new public transport networks and the need to future-proof growing communities against natural hazards.

Learnings from pilot projects build on the bicentennial and Olympic legacies and highlight possibilities for the Olympic Peninsula to evolve as a showcase resilient city with nature at heart; in the centre of Sydney.

Keywords: *resilience; adaptation; green infrastructure, liveability; community; Olympic legacy*

1.0 INTRODUCTION : Building on green legacies and a hot spot for Landscape Architecture

1.1 BICENTENNIAL PARK 1988 : Innovation, celebration and education

Landscape architecture on the Olympic Peninsula commenced by playing a leading role in the planning vision, design and construction overview for the 102 ha Bicentennial Park, one of Sydney's most popular urban parks. Encompassing both passive recreation areas and nature reserves this was one of the first innovative and contemporary Australian urban parks to be constructed on broad-scale municipal landfill and fully integrated with protected estuarine wetlands. Since the park's inception it has been delivering environmental and nature based education programs annually to over 25,000 primary, secondary and tertiary students and professional workshops in urban wetland and bio-diversity management.

1.2 OLYMPIC SUMMER GAMES 2000

'big bang' park and Green Games legacy

The motto adopted for Sydney 2000 Summer Olympics/Paralympics has been the 'Green Games' [7]. Sydney's 1993 bid to the International Olympic Committee (IOC) to host the 2000 Summer Olympics included '*Environmental Guidelines for the Summer*

Olympic Games' [8]. This document provided a sustainable development framework to guide the planning, design, material selection and waste avoidance for

the 2000 Olympic and Paralympic games. These guidelines had major significant impacts on all sporting venues, the Athletes Village and major event operations. Sydney Olympic Park's rapid planning, design and delivery over a 7 year period has led it to be described as a 'big-bang' park.

1.3 Emerging World 'Hot Spot' for Landscape Architecture

In landscape architectural terms; Sydney's Olympic Peninsula has been evolving into a global 'hot-spot' with over three decades of continuous professional practice, Australian and international peer recognition through design excellence awards, extensive journal publications, case studies. Annually the parks is used as an 'outdoor classroom' by thousands of students from landscape architecture and other built environment disciplines.

The precinct has been shaped by design-led processes including expert Design Review Panels, design competitions, best practice design policies and guidelines. This has led to a richly layered body of built work including many innovative built projects ranging from intimate spaces such as the 2006 'Shipwreck Viewing Site' published in

the International journal ‘TOPOS’ (Germany) [9] to regional play spaces such as the 2015 Blaxland Riverside Park ; as the first Australian cover feature for the ‘*Landscape Architecture Magazine* ‘ (USA) [10].

2.0 COMMUNITIES OF THE OLYMPIC PENINSULA

The Olympic peninsula is comprised of a complex and evolving set of ‘*communities of place*’ including :

- Visitors – to major events, recreation from a regional catchment, tourists
- Residential –emerging high density precincts inside and adjoining Olympic Park
- Professional Workers – defence, banking, IT, government services and retail;
- Students – primary, secondary and university including significant international cohorts; and
- e-communities – connected by various social media platforms

Communities also exist at both local and global scales and within a ‘virtual’ context as shaped by social media. The issue of engaging people with parklands through social media and virtual visitation was explored by Ferris and Martin in their 2013 *Landscape Architecture Australia* journal article ‘*Going Glocal : Connecting People and Parks*’[11]

2.1. EDUCATION COMMUNITIES : Local learning with global leverage

The Authority’s local/global education events such as an annual Youth Eco Summit (YES) connect thousands of primary and secondary schools to a range of nature based learning and urban sustainability challenges. Digital technologies and Smart communication platforms are deployed to link peer to peer learning groups from regions in Asia, the Pacific and North America.

The Authority is also a member of the United Nations Regional Centre of Excellence (RCE) Greater Western Sydney (GWS) for Education for Sustainable Development. This includes a strong track record in partnering to educate students in line with sustainable development goals such as SDG 4 – Quality Education and links to the Climate Protection Programs (CPP) working with the City of Parramatta.

2.2 SOCIAL SUSTAINABILITY RESEARCH : Key Findings

Brazilian landscape planner Eveline Mussi [12] conducted research into the emergence of social sustainability in the development of Sydney Olympic Park and neighbouring areas of Wentworth Point, Rhodes and Newington (Figure 3). Mussi identified ‘regional and internal’ communities and four phases of growth since the 1993 bid for the 2000 Games categorised as:

- *Dreaming*
- *Delivering*
- *Defending*
- *Dwelling*

Mussi's fourth phase of dwelling explores differing community attitudes to the environment, 'Green Games' legacy, liveability, social inclusion, a desire for parklands volunteerism and the needs of specific residential communities.

As a more recent phenomenon starting in 2012; 'pioneer residents' first arrived to live within the park boundaries. Adjoining the park's boundaries are more established residential communities within the former Athletes Village at Newington, Rhodes and Wentworth Point falling under the jurisdiction of adjoining municipalities of Parramatta and Canada Bay.

Census data reveals that residents in the districts around the park are typically well educated, middle income, culturally diverse (with major overseas born cohorts from China, Korea, India, Iran) with a significant proportion of young families.

The projected district population of the Olympic peninsula will exceed 100,000 with some residential precincts such as the Olympic Park town centre having over 20,000 residents/km² forming some of the most dense residential neighbourhoods in urban Australia. Together with 'major event' visitors, Sydney Olympic Park has high densities and growing 'communities' of residents, students, and professional workers potentially exposed to increasing natural hazards and climate risks.

With such culturally diversity, communications and engagement with these communities to develop resiliency provides opportunities to use smart technologies to provide information on extreme weather events, potential risks and suggest alternative locations and activities.

3.0 RESILIENCE : **Future-proofing, Shocks & Stresses**

GSC Environment Commissioner Rod Simpson defines *urban resilience* [13] as :

“The capacity of individuals, communities, institutions, businesses and systems within a city to survive, adapt, and thrive no matter what kinds of chronic stresses and acute shocks they experience”.

Key principles of urban resiliency:

- Strong coordination – complex problems require collaboration and risk sharing;
- Modelling and analysis – understand vulnerabilities ahead of planning stage;
- Having a plan – be strategic, not reactive before building or undertaking improvements;
- Building back better - after a damaging or shock event take the opportunity to upgrade; and
- Capacity Building – planners, built environment designers, asset managers, place managers

City of Sydney's Chief Resiliency Officer; Beck Dawson approaches climate risks and resiliency through the dual lenses of 'shocks' and 'stresses'. [13]

Shock events are typically catastrophic and are sudden or 'big hit' events. These include wildfires, extreme heat events, storm surges, flash flooding and wind storms generated by East Coast Lows (ECLs).

Stresses are chronic, incremental and longer term. These include changes in ocean and soil temperatures, declining or shifting patterns of seasonal rainfall and trending changes in maximum and minimum air temperatures.

3.1 UNDERSTANDING VULNERABILITIES : Olympic Peninsula

Scenario modelling undertaken by federal agencies *OZCOASTS* [14], NSW Office of Environment & Heritage AdaptNSW [15] and more site specific investigations undertaken by the Authority show the Olympic Peninsula has a complex set of vulnerabilities to changing climate and natural hazards due to combinations of the following factors;

- A local geography of low lying estuarine landscapes at the confluence of the Parramatta River with freshwater riparian streams (including Haslam's, Boundary and Powell's Creeks), constructed water bodies, wetland habitats and tidal waterways means that the Olympic Peninsula is vulnerable to tidal

inundation, flash flooding and long term sea-level rise;

- A mosaic of built landscapes and remnant habitats (including threatened flora and fauna);
- Extensive areas of clay-capped landfills which are prone to drying out, saturation and runoff after intense rainfall resulting in vegetation cover becoming more easily stressed;
- *Shocks* or "Big Hits" from natural hazards such as wildfire, East Coast Lows (ECLs) such as flash flooding events are occurring more frequently with more intensity. Exposure to extreme urban heat events in western Sydney [16] mean that air temperatures can often be 5-10 degrees hotter than coastal areas of Sydney; and
- *Stresses* - King Tides/tidal inundation, salt water intrusion into fresh water bodies, hotter/dryer conditions/decreasing soil moisture/increasing rates of evapo-transpiration, elevated plant stress, loss of bio-diversity/habitat , increasing population/demand , ageing assets and critical infrastructure such as irrigation systems, path networks, bridges etc

4.0 ADAPTATION :

Understanding scales, horizons & triggers

Under AS 5334-2013 [17], the Australian Standard for Climate Change Adaptation of settlements and Infrastructure, adaptation is defined as

Changes made in response to the likely threats and opportunities arising from climate variability and climate change. Adaptation can be spontaneous or planned, and can be carried out in response to or in anticipation of changes in climatic conditions.

Scales - the Olympic Peninsula requires adaptation planning and resilience strategies at project, precinct and district levels. Land shared with neighbouring municipalities such as the Parramatta River Catchment require working groups to jointly manage risks. The Authority is an active member of the Upper Parramatta Catchment Working Group who's members also include Parramatta City Council. The Authority is also a member of NSW Government *Sustainability Advantage* program which facilitates public and private organisations to build organisational capacity in adaptation and resiliency.

Horizons – the Authority's MASTERPLAN [4] is projected toward 2030. Modelling of climate futures by other NSW, federal agencies and research bodies variously

adopt horizon years of 2040, 2050, 2070 and 2100. The GSC strategy for metropolitan Sydney runs to 2056. In any case adaptation and resiliency projects must have a clearly identified horizon.

Triggers to adapt include:

- Public safety from risks from tidal inundations of low lying pedestrian/cycle paths;
- Asset replacement of essential grey infrastructure such as bridges, roads and paths; and
- Adoption of GreenStar 'Communities' [5] sustainability framework. The Authority is now compiling a detailed Sydney Olympic Park Climate Risk Register, and Sydney Olympic Park Adaptation Plan based on AS 5334 - 2013 [17]. This will be followed by the preparation of a Sydney Olympic Park Resilience Plan.
- Potential legal provisions and insurance benefits.

5.0 RESILIENCY/ADAPTATIVE RESPONSE CASE STUDIES

5.1 CASE STUDY 1 (*Stress*)

Tidal inundation, Badu Mangroves, Bicentennial Park

For an extended period the Manly Hydraulics Lab, a NSW Government agency which monitors change in coastlines and waterways, has been recording local tidal movements in several locations at Sydney Olympic Park. Tidal inundations over popular shared paths in parklands are also recorded by wetland managers and rangers who have noted that the inundation is occurring more frequently and for longer periods.

The results and observations identified that an ageing (30 year old) bridge was being impacted by rising water levels in a highly saline estuarine environment. The following adaptive responses have now occurred:

- Replacement of the vehicle bridge with new salt resistant composite materials
- Installation of hazard signage and pedestrian/cycle gates to restrict public access during inundation periods over pathways for safety reasons;
- Engaging with NSW Geography and Science curriculum through site-based classes using this location as an outdoor demonstration site to educate students on adaptation to changing sea-levels;

- Planning for longer term drainage channel works to increase mangrove outflows;
- Floating boardwalk and outdoor classroom upgrades adopted new composite materials; and
- Installation of a remote controlled 'Smart Gate' to improve tidal flushing of the adjoining Waterbird Refuge, part of the East Asian Australasian Flyway (EAAF) [18] for migratory birds.

5.2 CASE STUDY 2 (*Shock*)

Spring Wildfire, Aquatic Centre Carpark

An uncontrolled or 'wild-fire' event occurred in a major venue carpark in the spring of 2013 during an unseasonally hot and windy day.

Fire Authorities were unable to conclusively establish the cause of the fire which led to the destruction of 40 parked vehicles. Prior to this event, there had been a very dry winter and extensive areas of native grasses in the carpark had been 'winter-pruned' - a common practice to encourage spring regrowth. Under these dryer than normal conditions grass clippings were left for mulch and possibly acted as a fuel source spreading the fire onto the tyres of parked vehicles. With gusting wind conditions, many adjoining vehicles were also impacted before emergency services extinguished burning vehicles and vegetation.

Other potential contributing factors include the car park being constructed over clay-capped landfill, with non-irrigated native plantings which under dry conditions, result in very low soil and moisture levels increasing vulnerability to fire. Due to emergency evacuation procedures there were no major injuries or loss of life.

Adaptive responses:

- Review of the Authority's Site Wide Planting Strategy [19] and replanting with alternative fire resistant low-water demand resilient exotic species;
- Installation of automatic irrigation systems to maintain higher soil moisture levels; and
- Changes in timing and approach to native grassland pruning practices.

In the parklands '*controlled burning*' is now being trialled to promote ecological diversity, weed management and fuel load reduction to reduce risks of wild-fire.

5.3 CASE STUDY 3 (*Stress*)

Extreme heat and thermal comfort in Blaxland Riverside Park

The key concept for the 2005 Hargreaves Associates master plan for Blaxland Riverside Park included grassed terracing and an elevated 'Fig Grove' to connect the people with the Parramatta River - denied to them when the site was used for

uncontrolled waste dumping over many decades.

With the number of extreme heat days (40 degrees Celsius+) in western Sydney now increasing [16]; this is impacting on outdoor recreation useage patterns in the parklands.

Adaptive Responses:

- As part of a stage 2 new regional playspace in 2012 JMD Landscape Architects [10] skilfully layered new 'play hill' landform layers onto Hargreave's stage 1 upper terrace and provided slots to funnel cooling river breezes from the summer prevailing wind direction.
- Rows of wind-socks were aligned to highlight cooling air flows through the play space.

On extreme heat event (EHE) days, now reaching up to 47 degrees Celsius, [20] play is largely restricted to pockets of shade near established trees, fixed shade umbrellas and the water plaza.

More broadly the Authority, as part of an Adaptation and Resiliency Strategy will be investigating:

- An urban greening/tree canopy strategy to protect, enhance and potentially provide offsets as development bonuses to provide compensatory forms of green infrastructure such as green roofs;
- An extreme heat policy to address visitors coming for outdoor play,

- major sporting events, and health & wellbeing of staff;
- Misting jets in future ‘cool zones’ and public places to offer outdoor respite; and
- Potential use of temperature sensors and smart phone Apps to notify local people of extreme heat events (EHE), live temperatures in specific locations and suggest alternative recreation options as part of a Super Lifestyle liveability App.

6.0 OLYMPIC PENINSULA :

Reshaping landscapes and the making of resilient communities

Revisiting the ‘Bicentennial Park Proposal’ document [21] prepared for the Park’s Management Committee and submitted to the NSW Government in 1985; this original concept plan included a bold vision for a new super-size metropolitan park located in western Sydney supported by the following key principles;

Bicentennial Park 1988-2088 [Figure 4];

- ***major open space focus in the geographic centre of the metropolitan area’;***
- ***over 700 hectares of coordinated development of residential, industrial and recreational parkland based on sound land-use planning principles.***

- ***A strong visionary concept appropriate to the significance of the area, the historical relevance of the Parramatta River Valley and the celebration of Australia’s bicentenary***

When opened in 1988; Bicentennial Park, was reduced to a smaller 102 hectare park however; it embraced many of the original principles of serving regional residential communities through recreation, preserving water bird habitat and wetlands and environmental education programs - a first for a contemporary urban park in Australia.

A decade later this original vision of a larger metropolitan park found new expression as the 430 hectare ‘*Millennium Parklands*’ in response to the transformative opportunities presented by the 2000 Summer Olympic Games; incentivised by a major event deadline and completed by a dedicated whole of government delivery agency – the Olympic Coordination Authority (OCA).

Fast forward thirty years and arguably there is now a return to this original and bolder scale of green infrastructure thinking from the GSC to integrate Greater Parramatta (Sydney’s second CBD) with the Olympic Peninsula into ‘GPOP’ [3] as a green resilient heart within Sydney’s metropolitan expanse.

7.0 CONCLUSION :

With growing evidence that the Olympic Peninsula is internationally recognised as a ‘hot-spot’ for Olympic legacy, Landscape architecture and as an exemplar for sustainable development; new opportunities exist to evolve into a national and global showcase for adaptive planning, design excellence and resilient communities.

In Roger Johnson’s compendium for the greening of cities ‘*The Green City*’[22], the urban designer reminds us that time and scale are key parts of city building when he quoted landscape architect Richard Clough from his time developing Australia’s federal capital Canberra and shaping its centrepiece, Lake Burley Griffin while working for the National Capital Development Commission;

“by quiet perseverance that good results in the design of the environment demand continuing decisions at every point and at every scale”.

It is also said that among the design disciplines, Landscape architecture is the only one that involves the fourth dimension of time. Leading Australian soil scientist Simon Leake (who developed the ‘facsimile soil’ profiles over the vast remediated Olympic era land-fill system) reminds us that as professional time travellers ;

“these landscapes were never intended to be set and forget” [23].

As part of the Australian Institute of Landscape Architects (AILA) 50th celebrations held in 2016, Sydney Olympic Park was one of fourteen precincts invited to participate in an exhibition titled ‘*Parks Changing Australia*’ held at the National Museum of Australia, Canberra.

In AILA’s words this event provided a showcase for how

“Landscape architects: reimagining and transforming the outside world and how contemporary parks are re-shaping Australian cities, increasing people’s health and wellbeing and building more ecologically sustainable urban environments”.
[24]

Landscape Architects will continue to re-imagine and transform urban places working as green infrastructure facilitators by adding and remaking many layers of built work.

Landscape Architects will continue to play a key ‘pivot’ role in trans-disciplinary coordination informed by lessons learnt from the 1988 bicentenary and 2000 ‘Green Games’ to achieve the broader GPOP vision of a liveable and resilient city. Looking further over the horizon; future generations of landscape architects may have the opportunity to fully realize the super-park ‘1988-2088’ as originally conceived by their visionary predecessors working for the NSW Government in the early 1980’s.

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10.0 APPENDIX

Figure 1 – Sydney Olympic Park and context in 2016, Sydney Olympic Park Master Plan 2030 (2017 Review)



Key



Sydney Olympic Park



Sydney Olympic Park Town Centre

Figure 2- Sydney Olympic Park Technical Insight Tour Analysis (2007-2017)
 [A.Aziz, 2017]

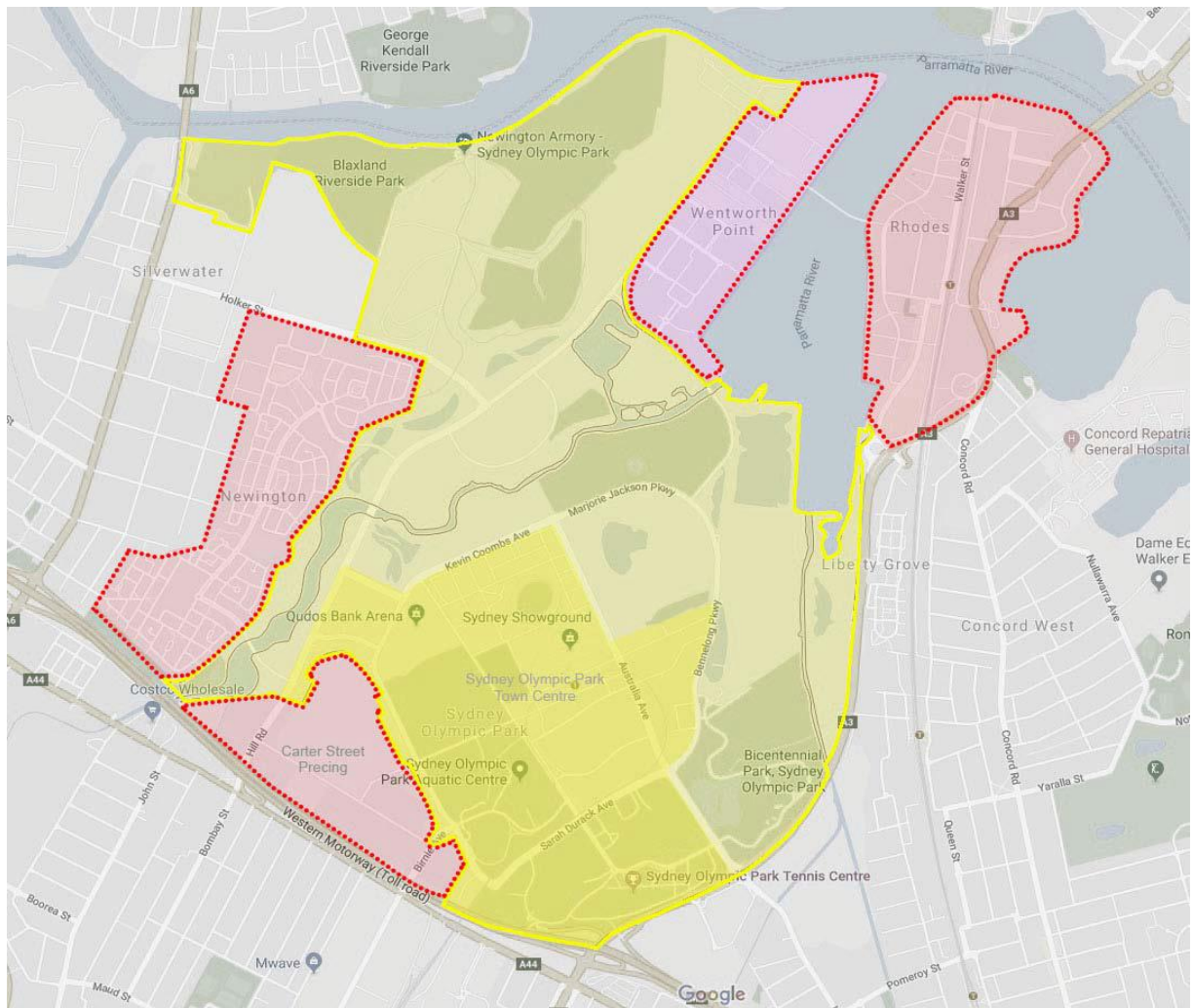
SYDNEY OLYMPIC PARK TECHNICAL INSIGHT TOUR (2007-2017)

THEMES	REGIONS							TOTAL
	Africa	America	Asia	Australia	Europe	Intl/ Others	Japan	
Water	0	0	18	10	1	0	0	29
	0	0	207	275	90	0	0	572
Environmental	0	3	35	46	3	2	5	94
	0	66	594	1001	26	85	44	1816
Olympic Games/ Olympic Legacy	0	0	4	0	2	0	4	10
	0	0	63	0	14	0	64	141
Sports	0	6	3	2	0	1	1	13
	0	139	41	31	0	40	8	259
Business (Business Development/ Marketing)	0	0	6	3	1	0	1	11
	0	0	109	57	55	0	13	234
Corporate Government	1	0	5	2	0	1	1	10
	10	0	60	77	0	12	30	189
Security	0	0	4	0	0	0	0	4
	0	0	54	0	0	0	0	54
Sustainability	0	11	22	15	0	1	2	51
	0	207	493	763	0	5	35	1503
Infrastructure/Venues/Urban Planning	0	7	6	9	0	2	1	25
	0	147	103	264	0	87	8	609
Video conferencing	0	0	13	0	0	0	1	14
	0	0	193	0	0	0	73	266
Other	0	3	9	27	0	3	1	43
	0	36	158	5893	0	132	22	6241
TOTAL	1	30	125	114	7	10	17	304
TOTAL	10	595	2075	8361	185	361	297	11884

Legend:

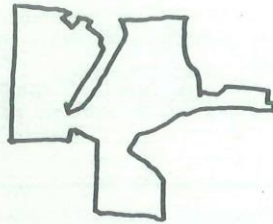
- Number of visits (frequency)
- Number of delegates (people)
- Highest frequency of visits

Figure 3- Area limits for Sydney Olympic Park in yellow, with the Town Centre highlighted, and the residential around it in red, Newington, Wentworth Point, Rhodes and Carter Street Precinct. [E. Mussi, 2017]



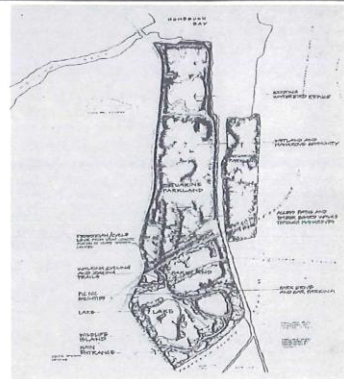
**Figure 4. A Bicentennial Event, Bicentennial Park Proposal
 Bicentennial Park Management Committee (1984)**

- a visionary generous reservation of open space for the people of Sydney within their living area — over 1000 hectares
- a public park established as one of the most “lovely and favourable suburbs in the City of Sydney” — a celebration of Australia’s centenary



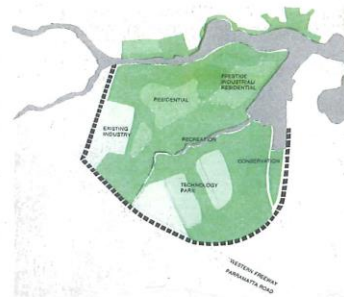
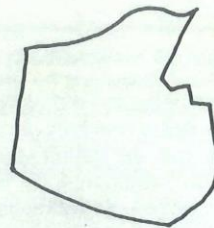
centennial park 1888

- a vital major open space and ‘green lung’ for Sydney
- a social focus for Sydney’s inner suburbs
- 84 hectares in area of which 53 are mangroves
- a park which reflects 1980s trends of recycling and environmental preservation
- too small to function as a major open space or ‘green lung’ needed for Sydney’s western suburbs
- unworthy of the title Bicentennial Park in the grand tradition set by Centennial Park



existing bicentennial park 1984

- over 700 hectares of coordinated development of residential, industrial and recreational parkland based on sound landuse planning principles
- a major open space focus in the geographic centre of the metropolitan area
- a strong, visionary concept appropriate to the significance and historical relevance of the Parramatta River Valley and the celebration of Australia’s bicentenary



proposed bicentennial park 1988-2088

a bicentennial event

Inclusive River

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Abstract

Bangkok was originated as the water base city on the Chao Phraya River bank, but nowadays, people progressively separate themselves from the unrelated environment. It is partly due to the shifting of people attitude after the flood catastrophe which hit Bangkok, in 2012. From then Bangkok becomes the solid city and people loose ownership and sense of belonging with the river. Moreover, as the city has been changed, there are city problems and future challenges.

Chao Phraya River Promenade is the government initiative project in revitalising the river by providing 10 m width and 14 km long promenade inside the river. This mega infrastructure aims to create public space and bring people back to the river, but it also changing the way city interact or settles with the river from water base to the solid city. It's going to create many negative impacts environmentally, socially, and economically. Importantly it's the top-down approach which is going to end up in building the infrastructure that destroys not only the river but also separate people from the river. This project is the wake-up call to Bangkok people to relook of what are the relationship between the city and the river in the future

Inclusive River is the territory which use human-centred approach to understand human behaviours, needs, insights throughout the design process to improve the lives of people living the ongoing and future city challenges. These creative and interactive approach requires not only collaborative platform to pull all the resources and tools from different stakeholders, shareholders, organisations and multidisciplinary to implement the territory. Also, it broadens perspectives to identify the appropriate strategies.

Friends of the river (FOR) - the river platform founded in 2015 to reflect people opinions and concerns toward river development and try to find the solution in revitalising the river and area along the river with an inclusive approach.

After applying this creative approach through two case studies; the Co-create Charoenkrung project and Bann Poon community, which the former is one of the revitalising

river districts to become the next creative district of Thailand, and the latter is the pilot project of revitalising river community, it came out with the alternative designs.

These projects had shown the possibility of transforming city to be the inclusive territory to change the perception of the city which not focus only physical space, to create new values out of the existing assets, and especially, create ‘Resilience landscape’ more effectively.

Keywords: Landscape Resilience; Human-centered approach; River Revitalization

1. Introduction

Chao Phraya River has always been and will still be the bloodline of Thai people. For the hundreds of years, it had proven and driven for locals to settle along the river. Canals natural or humanmade began to innervate the city and contributed significantly to the cityscape and the inhabitants’ lifestyle. Bangkok soon earned the epithet ‘Venice of the East’. Chao Phraya River becomes sources of life and culture which Thai people has adapted and learnt how to live well and to create the space of living with water phenomena.

Resembling all thriving metropolitan, Bangkok has been transformed much since its birth. The city has expanded far beyond the river’s banks. However, locals still live, work, and play along the Chao Phraya River. The banks’ landscape and the way of life have also grown vertically. The Sprawling uncontrollably urbanisation appears as a major issue which had occurred the complexities and varieties problems and challenges. Nowadays, Bangkok becomes more and more the solid city which separately city from the unrelated environment after the flood catastrophe in 2012. Similar to all urban rivers, the destiny of the Chao Phraya is intertwined with the town through which it flows.

Government Perspective

There are many approaches to developing the river which comes from a different perspective. The government idea is to bring people back to the river by creating the 10 m. width promenade inside the river for 57 km. which run along both sides of Chao Phraya River. This project is to ensure that the river can be accessible by everyone though the promenade which acts as the new public space for cycling and recreation. The promenade project will help in organising the untidy settlement and landscape along the river.

This policy has come from the top-down perspective without understanding the context and way of life of the people. As, Bangkok is the water-based city where our settlement has always been settle and evolve on both sides of the river. Our culture, ritual and way of life are being created and grown with the river. Constructing the promenade on both sides of the river, it will change the relationship between the city and the river.

The promenade might bring the people to the river for certain extent, but it will also disconnect river community from the river stream since it will prevent them from carrying on the way of life like it used to be. Some of the communities including boathouses who settle inside the river for many generations has to be relocated near the promenade. The tangible and intangible

value which attached to these communities will be gone. The reference point to confirm that Bangkok is the water-based city will be eliminated.

The uniqueness of the Chao Phraya River landscape is the various settlements of the palace, temple, river communities and the way of life of the people which evolving along the river. By constructing the promenade on both sides of the river, it will make the river landscape look all the same.

The promenade will block the visual linkage from the river to the river bank. We will no longer see the temple, palace and importantly the way of life of the people along the river since the gigantic concrete structure of the promenade is going to be the eyesore element which will be seen from the river.

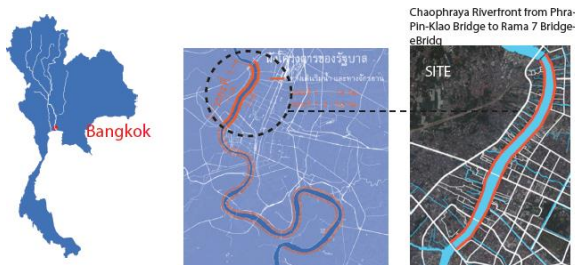


Fig. 1. Site location is 57 Km. in Bangkok area, both sides of the river, pilot area is 14 km.

The promenade will make the river narrower. The Chao Phraya River width is around 200m. By creating the 10m. width promenade inside the river on both sides, it will significantly reduce the water body by 10 %. This narrowing of the water will cause water current to be even stronger and might create problems for water taxi and water logistic in the river. Importantly these

concrete structures inside the river are going to block the river flow especially during the rainy season where the city is facing high rainfall and receiving a significant amount of water from the north. This promenade structure will create more flood risk by escalating water level to be higher and slower the flow of the water inside the river.

Chao Phraya ecology is in the decaying stage due to it has received much of polluted water from the city and factory along the river; moreover, the riparian area along the river has already been removed due to the construction of the concrete embankment along the river. By constructing the promenade inside the river, it will worsen the situation by preventing natural light from penetrating through the river and the structure itself is going to collect much garbage.

The development of the river seems to create much impact to the livelihood of the people not only one who live along the river but also at the larger group of people who live inside the city and nearby provinces as well. However, the process of carrying out this promenade project has done in a short period without having the public engagement. Importantly, the government has never asked people the right question of how shall we develop the river? Why? It is because the government had already decided that they want to have the promenade as the key answer.

Developer Perspective

During the past five years, the land along the river has been the focus of the private developer, since the most property in the city centre has been developed while the area along the river is stilling empty and

waiting to be filled in with the new programs and attractions. Once the government proceed with the underground mass transit system along the river, it also helps to push those empty lands to be developed in recent years.

However, the developer perspective of views is entirely different from the government. The promenade projects seem to devalue the land price because of the disconnecting those land to the river. The developers' attitude and approach, they want to increase value by invest in shopping malls, condominium and attractions. These developments create value but also creates problems to the river and also community along the river at the same time by bringing an outsider, traffic, pollution and changing the way of life of the people in the area. It seems that the new development did not take the existing value or asset of the community and river into account in developing the project. These developments are not able to fit or blend in and seem to be another commercial area which we can find anywhere else.

Time to rethink

Looking and analysing at the macro scale of the city, the policy which involved together with the foresight analysis of what the challenges city is facing right now and shortly. We will understand that there are many issues need to address. Moreover, we necessary to prepare our territory to respond such as Climate changes which caused the city to be permanently flooded, decaying of river community, rising of the ageing population and new generation, Decaying of river ecology, conflicting of commercial

and Tourism development with the river value. It is time we need to Rethink and relook holistically from social, economic and environmental aspects to develop the river more sustainably and inclusively.

Right Question to the Society

For the past three years since the promenade project was initiated and seeing many commercial developments is rising along the river, it has raised the concerns to all Thai in term of; who has the right to develop the river? How do we want the river to be developed? And what are the challenges which the river, as well as our city, is facing? Since what we are going to do with the river it's going to affect the entire city and the nearby area as well.

We have to put the right question to ask the society to think it through to come out with the collective vision which everyone does share. It's time to rethink and relook in developing the river for all with an inclusive approach, not the top-down process and from the one-sided perspective.

FOR as the platform

Friends of the River group founded in 2015, as a platform to raise public awareness toward river developments by asking right questions, sharing ideas and knowledge, advocates change through dialogue and discussion with stakeholders.

This platform makes it happen through pilot projects and voice people opinions /ideas to the governments and also to the society to find the common value which all stakeholders share in developing the river. We believe that river belongs to everyone

where all walks of life can be benefitted from the river. Public engagement is the process of finding the common value that everyone shares. Having the promenade is not the solution to respond to needs and aspiration of everyone. Also, it is not the right answer to tackle the ongoing and future challenges in social, economic and environment.

Inclusive process

The process is changing the way we carry out the project in conventional approach where the government set the policy then assign designer or specialist to find the answer and let the people use once the project completed. With this top-down or exclusive approach it has to cause the result to be undesirable or in acceptable by the public since it is unable to understand and answer the real need and aspiration of the people. The process did not take people to be part of the process from the beginning which also makes people not belong to the project.

The inclusive approach is the process bring all stakeholders to be part of the process from the beginning to identify problems, set visions and frameworks, find strategies, participate in the design process, and monitor the implementation. Being involved in the process of constructing and managing the project are essential. This inclusive process allows us to understand problems and assets of each territory better which help us to identify the strategy for solving the ongoing and future challenges better. Having all shareholders and stakeholders to be part of the process, it also allows them to realise each other constraints

and aspiration. This exchanging dialogue and collaboration will enable them to find common ground in developing the territory and create the active citizen who will help in taking care the community and our society in the future.

2. Case studies

2.1 Co-create Chareonkung Model

ChareOnkrung is one of the old districts situate in the Chao Praya River bank. It is the melting-pot where many nationalities are living side by side in harmony for generations. It has a unique way of life and beautiful architecture. In recent years, as the district is continually decaying, the growth of residence who abandon shophouses are more rising which caused more the high number of abandon the buildings in the area. There are also phenomena whereby many artists and people who work in the creative industry have moved in to settle their studio and residence in the area. The shift came in 2015 when Thailand Creative and Design Center(TCDC) has decided to move headquarter to the old Thailand Post office building. It will be the central incubator place to groom Creative industry. However, to groom the Creative citizen, we need not only one building, but also space or the district to create the proper ecology, to share, to exchange and do business with the high quality of life.

We apply the inclusive approach and process to transform this decaying district to be the creative district. Our aims do target not only the designer but everyone. We strongly believe that design should be part of everyday life in better living condition and

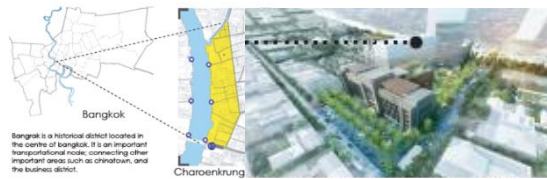


Fig. 2. Charoenkrung District is the district which all left side area next to the Choa Phraya River.

Fig. 3. New Thai Creative Design Centre.

open opportunity for their business. Everyone has the creativity in them. It took us nine months for the whole process in creating a platform to bring all stakeholders which ranging from governments officer, landlords, developer, shop owners, community, teacher, students, to talk with each other to identify problems and asset the district has. Then we work together to come out with the strategies we want to apply in solving the district problems and creating the creative district.

We found out that the district has many abandon land and buildings which has many potentials to be developed because of lacking the better connectivity from the outside and even within.

There are three strategies to be applied from Rebrand; by revitalise one of the old historical building in the Chaopraya river bank to become a new landmark by infill with a public function such as art museum.

Relink; this is the strategy in providing the better linkage and signage to make sure that pedestrian traffic will be able to navigate to and within the district efficiently. Create to create a network between the public and the environment to

foster more interactions between local residents and their district.

Revival; to regenerate forgotten urban spaces, vacant historical sites back to use as we saw the opportunities to infill with the new program that enable people to exchange and perform their ideas such as workshop building, pocket park, outdoor library, Waterfront Park.

Rebrand; to create a newfound awareness for the district, in order to keep the general public well informed and updated about their district and its surroundings.



Fig. 4. Pictures illustrate the process of brainstorming, collaborating, voting of locals in this district.

The beauty of this process is that we let people vote, choose and design the outcome. In the end, we carried out the one to one mockups of all the three strategies to show the stakeholders the future possibility and also to test the idea with the actual people to see the respond and feedback of how community and stakeholders want to look at the creative district.



Fig. 5. Adaptive Masterplan to stimulate organic growth to the creative district.

Co-create Chareunkrung has changed the way we carry out the masterplan in revitalising the district from the conventional method of top-down to be more inclusive with the people and having the actual space for people to test the future scenario.

2.2 *BaanPoon Community Model*

BaanPoon is the old community situate on the Chaopraya river bank which is going to be affected by the government’s promenade project. The community view that, this promenade will disconnecting them from the river. It will be unutilized and undermaintained which cause the promenade to be neglected and create crimes in the area. FOR had been working with the community in helping them identify community” value” which comprise of tangible value such as a traditional Thai timber pavilion, Old Chinese shrine, warehouse, old palace boundary wall. The community also has the intangible value in term of people way of life. Once we have identified these value, the community also proposes to revitalise them to be more attractive and accessible by the public by introducing pedestrian and bicycle route to invite more tourist to visit those hidden cultural value. They also propose to turn one of the warehouses to be a community museum to archives community artefact and stories. We also invite a well-known-Thai artist to create their graffiti inside the community space to attract young generation and urban dweller to visit this community.

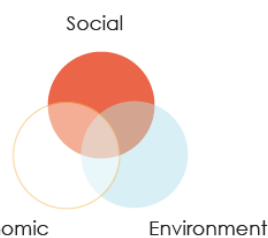


Fig. 6. Main strategies to development.

This Baan Poon Model is showed the government that there is another approach in developing the river by not constructing the promenade but by revitalising these old decaying communities along the river which has a lot of cultural value to be more attractive, accessible and relevant to the society. This approach is the collaborative effort to developing the community based on the asset or the value they have without imposing the new thing that might dilute or destroy the uniqueness of the community.

2.3 *River Platform*

The Chao Praya promenade project seems to be the wake-up call for Thai to learn from other society of how the past Model in developing the territory has caused problems economically, environmentally and socially if we continue to improve the area by using the old approach in excluding people from the process. To designing sustainably, we need to collaborate with locals, the government, shareholders and stakeholders. Moreover, people do realise their aspiration and ability; they want to contribute and be part of the making process of the territory. This “platform” can bridge the gap between the resources and all participants to work together from the beginning to create the smart “policy”, participatory “process” and sensible “product”.

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Reframing road networks as ecological corridors in India

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Abstract

Over 3.3 million kilometres of road and highway corridors traverse India [1], forming the single largest contiguous network of open space available in the country today. The transit network with 96,000 km of national highways alone, is set to increase exponentially to 200,000 km over the next few years. Expressways, state highways, major district and rural roadways are also expanding rapidly. Yet, development is limited to the carriageway, obscuring the potential of comprehensive ‘landscape corridor’ development.

Designing roads for speed and efficiency, the consequent deforestation, barriers to ecological migration, wildlife fragmentation, loss of habitat and adverse impact to water and soils changes the regional landscape ecology. Attempts to mitigate the effects of particulate emissions, noise pollution and heat and glare too are lost when landscape development is addressed belatedly. To address landscape ecology at a vast scale, create and integrate contiguous ecological open space networks and provide tangible social, cultural, economic, ecological and aesthetic benefits in parallel, is the way forward.

This paper charts out an ‘ecological corridor’ approach to road infrastructure development outlining the opportunities of place, people and context to delineate and define open space conservancies and strategies at a national, regional, state or local level.

As signatories to the Paris Accord and UN Sustainable Development Goals (SDGs) there is a keen focus on road safety, energy efficiency, climate concerns as well as important social indices of health, safety and welfare in India. Landscape architects can play a pivotal role in traversing engineering, contextual and logistical concerns with timely inputs, equitable access for its citizens and due ecological consideration. This can be done through comprehensive documentation of cultural and ecological values, addressing regional landscape planning strategies, site specific design interventions for user engagement, and capacity building and raising awareness through a comprehensive multidisciplinary framework. The impact of this approach, currently in a conceptual stage, on the second largest road network in the world would be far reaching and timely.

Keywords: Ecological framework; road networks; infrastructure development; landscape corridors; comprehensive approach

Historic road networks through India predate the current impetus of road infrastructure development for greater connectivity. In the past historic routes, such as the silk road and spice route created important connects across Asia and the world, with local towns and cities along the way integrating cultural influences of travelers and trade and flourishing. These routes have over time provided scenic interludes and places of rest for the traveler, equitable commons for the local area residents and encampments for recreation and refuge. Today, they are significant historic markers of place, people and unique cultural and heritage values.

1. Current Scenario

Over 3.3 million kilometers of road and highway corridors traverse India [1], forming the single largest contiguous network of open space available to the country. A road infrastructure development impetus by the Government of India will expand 96,000km of national highways exponentially to 200,000km in the next few years. Expressways, state highways, major district and rural roadways are also expanding rapidly.

In 2017 the government allocated over \$100 billion towards 83,000km of roads. 34,800km will be built by 2022, including the 24,800km ambitious Bharat Mala route [2]. 1,627km of roads have been added this past year alone [1].

This aggressive focus on land acquisition, road engineering and construction is

primarily limited to the road carriageway design and construction, obscuring the potential of comprehensive ‘landscape corridor’ development.

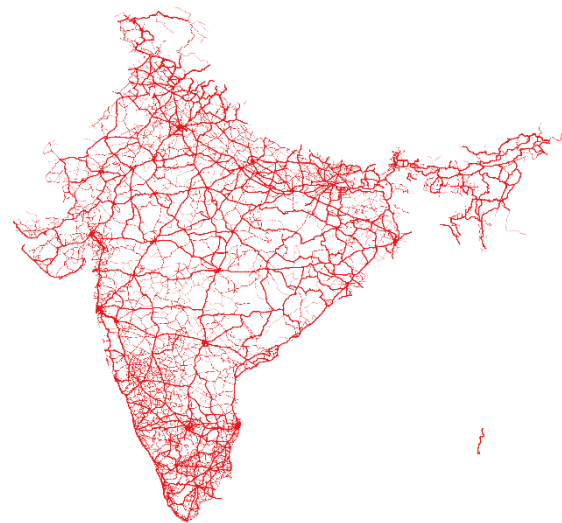


Figure 1. Existing road network across the country

2. Need for this Approach

Designing roads for speed and efficiency, the consequent deforestation, barriers to wildlife migration, ecological fragmentation, loss of habitat, and, adverse impacts to water and soils changes the regional landscape ecology. Attempts to mitigate the effects of particulate emissions, noise pollution and heat and glare too are lost when the landscape is addressed belatedly [3]. A large scale ecosystem services approach will address critical ecological, social and cultural values before they are subsumed by development at a national, regional, state and/ or local level.

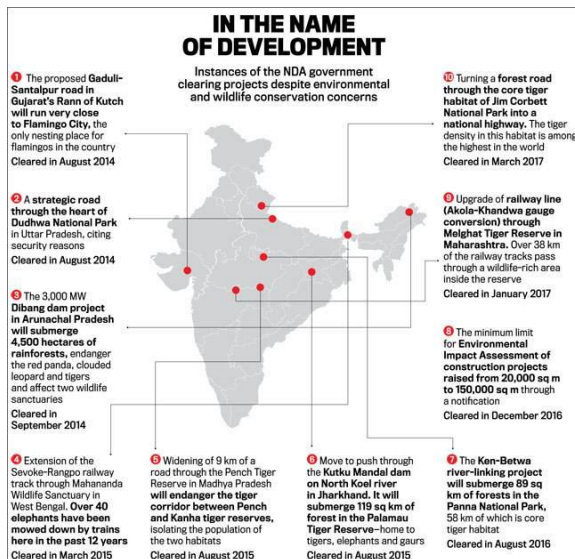


Figure 2. Some ecological conflicts identified during infrastructure development (<https://www.indiatoday.in/magazine/special-report/story/20170703-india-environment-wildlife-endangering-nda-modi-986665-2017-06-27>)

This paper charts out a landscape approach with an emphasis on the role of landscape architects, outlining critical issues and opportunities of place, people and context to delineate and define open space conservancies and strategies.

3. Infrastructure and Landscape Works

Roads as ‘Ecological’ or ‘Landscape Corridors’ can provide equitable access to open spaces. Creation of scenic tourism corridors and consolidation of open space resources will include residents, visitors and passerbys in commons so far limited to fragmented parks and pockets in urban areas.

For example, a compilation of data by sixteen National Highways Authority of India (NHAI) regional offices identifies a range of 0-62m [4] widths of land available on both side of roads for plantation and other

roadside facilities, based on land acquired. This varies by stretch according to area, land ownership and other conditions. For the 50,000km of roadways envisioned by 2022, using a conservative average metric of 0.5km available width, a minimum area of 25,000sq.km can be used for landscape development. For 3.3 million kilometers, this could be as high as 1,650,000km, at a minimum.

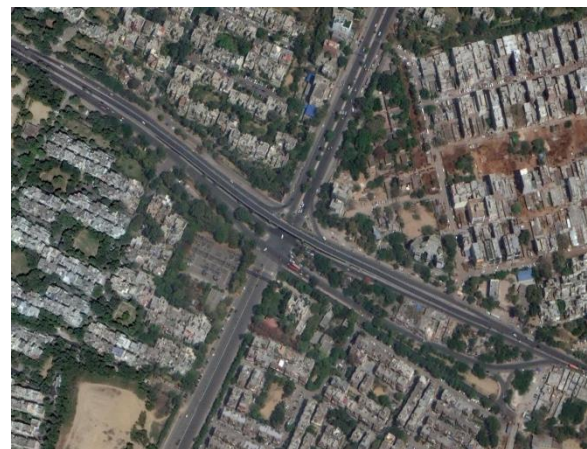


Figure 3. Typical width of land available for landscape development along urban roads (Google maps)

Yet, planting and horticulture work for highway projects is carried out after the road is complete or nearing completion. As a result, planting is accommodated in the space available, and not ideal. Planting is typically done by horticultural contractors, based on minimal specifications and limited planting palettes provided.

Further the project implementation process is decentralized, with delineated roles ascribed to different professionals and agencies. The primary stakeholders are government agencies, transport planners, road engineers and contractors. Government is represented through national, state and

local bodies, highway authorities and local governments.

Despite a growing awareness of the need for sustainable infrastructure and energy conservation, the approach to infrastructure development has not changed in recent years.

4. Landscape Architects as Stakeholders

Typically, the role of the landscape architect, if any, is in the final stages of planting and special conditions or aesthetic projects. Where landscape architects are involved, the lack of engagement before or after the design and tender phase limits the continuous engagement required to address issues that crop up.

Where landscape architects have more successfully completed streetscape projects and infrastructure works has been in private projects and in some cities, where aesthetics, aware clients, and the value of ‘place-making’ is understood. Yet the translation into the public domain and larger regional landscape is limited to a large extent by a few factors-

- Lack of a holistic approach and multiplicity of agencies involved
- No consideration or understanding of landscape requirements during land acquisition
- Lack of understanding of the role of landscape architects and their expertise in synthesizing place-based values
- Lack of insight into place, people, nature, culture, climate and economies

- Low numbers of landscape architects and outreach
- Lack of exposure to large scale planning due to smaller scale project experience of the nascent profession
- Role of academia, research and practice based expertise is fragmented

As signatories to the Paris Accord and UN Sustainable Development Goals (SDGs) there is a keen focus on road safety, energy efficiency, climate concerns as well as important social indices of health, safety and welfare in India, evident in campaigns, schemes and advocacy in force. Landscape architects can play a pivotal role in traversing engineering, contextual and logistical concerns in this scenario.

5. Unique Landscape Perspective

While the domains of economics, sociology, horticulture, forestry, water management and public health are important as well, the role of landscape architects as amalgamators or synthesizers of all these, and more, is crucial and yet, lacking.

Landscape architects can address the capacity of land- soils, topography, water management; people and cultural use of place, design, aesthetics, local crafts and traditions; biodiversity- vegetation, flora, fauna and their interconnectivity; urban and rural lands; land ethic; visuals and aesthetics; and, the technical aspects of materiality, construction, planting and maintenance.

<i>Scale</i>	<i>Road profile, road section, traffic speed, land available for infrastructure development, hierarchy of spaces and population it carries</i>
<i>Region</i>	<i>Climate, soil stability, water, air and adjacency to urban areas</i>
<i>Unique Landscape</i>	<i>Terrain, water, vegetation, wildlife, forests</i>
<i>Architecture/ Destinations</i>	<i>Significant structures, spiritual, social or economic magnets</i>
<i>Ecological Concerns</i>	<i>Air, water, noise pollution, climate change, fragmentation</i>
<i>Traditional Practices</i>	<i>Local customs, historic context, memory and identity of place</i>
<i>Commercial and Other Interests</i>	<i>Commercial forestry, agro-based products, natural resources, security concerns, transit/ tourist facilities</i>
<i>Design</i>	<i>Place-making, Spatial Design and Engagement</i>

Table 1: Issues to address in Infrastructure Development

The role of landscape architects towards reframing road networks as ecological corridors is at two levels-

- Regional Landscape Planning
- Site-specific Landscape Design

6. Regional Landscape Planning

6.1. Urban growth impacts

India's forest cover has halved over the last 50 years, with 21.35% mapped in 2015, as opposed to a stated goal of 33% (Forest Policy 1988). Rapid urbanization, deforestation and poor farm practices have resulted in large scale land degradation, depletion of soil nutrients, pollution of land, water and air and poor natural resource management. Loss of top soil of 35% of the global sediment load into oceans, from five percent of the world's rivers is one resultant [5]. Natural disasters including droughts, flash floods, cyclones, avalanches, landslides brought on by torrential rains, and snowstorms are aggravated by further land degradation.

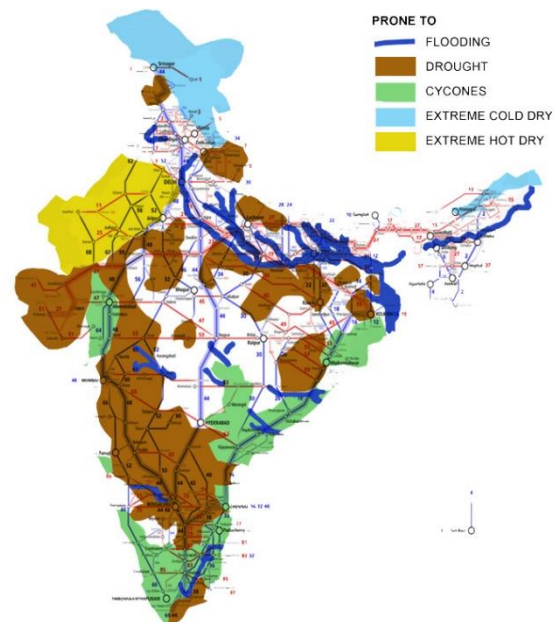


Figure 4. Areas of the country susceptible to extreme climates and natural disasters

In spite of adequate surface water resources and an average annual precipitation of nearly 4000 billion cubic meter, the average flow in the river system is estimated to be 1869 cubic km [5].

While a great deal of development is disconnected and concentrated in urban areas (31% as per 2011 census, but based on the classification of urban as 5,000 inhabitants, minimum density of 400 people per sq. km or more, and at least 75% of male working population engaged in non-farm activities, closer to 47% of 1.3 billion) the contiguous connected network can help mitigate growth impacts.

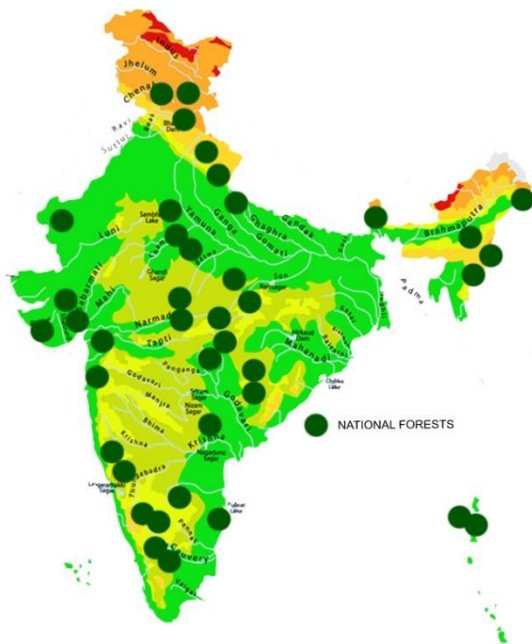


Figure 5. Elevations, major river basins and national forests

Watershed mapping, site selection, grading, storm-water management and planting can help use highway systems as repositories and models of water management and conservation. Land

availability along transit together with a clear policy of its role as open spaces sinks and buffers with a check of the spread of habitation.

6.2. Ecological Mapping

Fragmentation adversely impacts regional management of natural resources and continuity of open spaces. The opportunity to develop comprehensively not only the road infrastructure itself, but mold the entire regional landscape is available only if the topography and traditional drainage patterns, natural vegetation, critical biodiversity hotspots, forests – classified and unclassified, significant natural features, cultivation and agrarian economy, cultural and traditional practices related to the land are mapped and documented comprehensively. Maintaining the integrity of four of the world’s 34 biodiversity hotspots- in the Himalaya, the Western Ghats, the North-east, and the Nicobar Islands is in line with commitments made towards sustainable development [5]. As is the potential for open space conservancies that are not limited to designated National Forests.

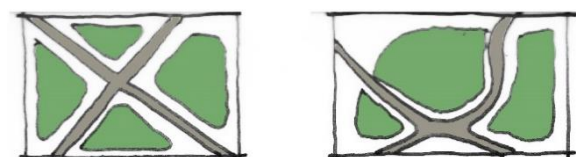


Figure 5. (a) Fragmentation (b) Consolidation

6.3. Forest Fragmentation

Felling of trees bifurcates corridors. This reduces the core area of the forest with tree fatalities 250% higher along roads in forest interior [7]. The forests from large green networks fragments into patches, limiting both the natural forests and habitation for wildlife.

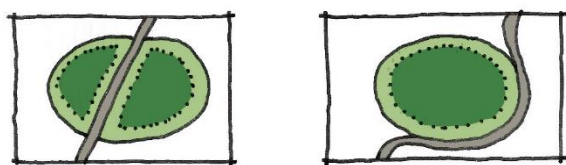


Figure 6. (a) Forest Core Fragmentation (b) Conservation



Figure 7. Roads bifurcation forest core compromises wildlife crossings (unknown)

Core area reduction also compromised wildlife migration. Wildlife die from predation and/or greater competition and lesser resources due to shrinking forests. A study from Mudumalai Tiger Reserve, found road mortality of 40 animal species, including amphibians, reptiles, birds, and mammals [6] along interior forest roads.

Other impacts include water and drainage patterns and topography changes that compromise the interdependency of trees,

shrubs, ground covers and other natural planting systems.

India has about 100,000 sacred forests, a classification based on spiritual association which has been instrumental in forest protection by locals. Traditional customs are interwoven with the ecology of place, through religion, medicine and food supplies, building supplies and livelihood. The perpetual conflict between foresters, tribal populations and ecologists on the one hand, and developers on the other however, remain contentious.

6.4. Scenic Values

With 103 National Parks and many more state ones, an extensive coastline, mountains, hills, grasslands, deserts, tropical forests and plains, the Indian countryside has vast landscapes of breathtaking yet undocumented scenic value. Taking a cue from the US National Scenic Highway System of 1973 [8], identification, designation and enhancement of distinctive landscape character and aesthetics can be undertaken with development of infrastructure for tourism and transit. China now uses GIS mapping to integrate landscape ecology through visualization techniques, interagency collaborations and inclusion of landscape architects in implementing highway projects.

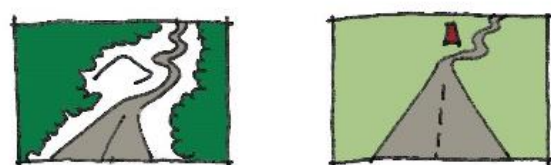


Figure 8. Designed Scenic Routes to highlight natural features



Figure 9. Scenic Highway
 (http://images.jagran.com/images/16_07_2017-trip-p-160717.jpg)

6.5. Road Safety and Disaster Preparedness

A Road Safety Campaign is currently underway to highlight the 400,000 deaths in road crashes annually, 50% of which are preventable [9]. Low pedestrian access leads to exacerbated concerns for safety, resulting in more vehicular usage, more roads and faster speeds. The role of design to resolve these conflicts has been explored cursorily.

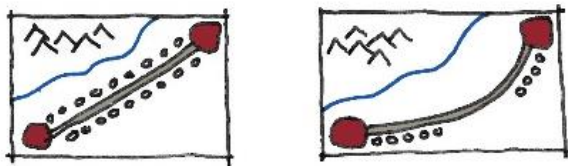


Figure 10. (a) Typical Urban Growth (b) Protecting Natural Resources, creating scenic views and areas for staging

The role of open space planning for emergency assess and staging during disasters was highlighted during the 2015 Nepal earthquake due to the high mobilization capacities and connectivity of highways [10]. With their proximity to dense

settlements and cities, outlying open spaces can act as staging areas.

6.6. Lacunae in Green Highway Policy

Commitments to the Climate Change Accord in Paris (CoP21 Summit) to reduce emissions by 35% till 2030, and the additional carbon sink of 2.5-3 billion tonnes through forest cover requires planting of 5000 million seedlings [11]. The Green Highways Policy 2015 encourages sustainable green corridor development, but the focus is limited to planting new trees and transplantation. It is flawed in its approach. Especially in the planting of “open forest” regions (30million hectares) and converting them into “Moderately Dense Forests” [12]. These and other such goals must be assessed for its appropriateness and sustainability.

6.7. Planting

Planting to screen, enhance views, staging; for comfort, commerce, conservation, preservation; and for development and tourism, should determine spatial planning priorities early on. Minor modifications during road planning- roads along the edges of habitation and transition areas instead of through forests, navigating more stable, accessible slopes in steep forested areas, planting native plants can be made.

Planting of new trees requires diversity in terms of region- species planting, landscape massing to develop interdependent viable ecosystems, consideration of supporting insect, reptilian, amphibian, animal and avian fauna native to the place, and use of native plantation. Yet, a lack of understanding of

species diversity required results in a common palette of 30-40 trees planted across the country irrespective of appropriateness. Consequently, the widespread planting of non-native, exotic species will be, and has been, invasive and damaging to local landscapes, e.g. *Prosopis juliflora* and its debilitating effect on native plants, birds and water resources. Based on the road hierarchy and region, the preparation of diverse native and naturalized plant lists is required. Planting of shrubs, grasses, groundcovers and climbers need to be diversified to bind the soil, reduce soil erosion, water run-off and create buffers to and from the road.

7. Site Specific Landscape Design

7.1. Transactional Capacities of Place

Transactional capacities [13] of place involves the negotiation of place and people, nature and culture, ecology and infrastructure. Without addressing the larger needs of different constituencies and their sense of ownership of land, their freedoms and rights, the street/ road will negate a great deal of place based tradition and unique cultural landscapes.

For example, in the northeast states, development has been limited because of lack of access. As a result, the integrity of the ecology, biodiversity and local culture has sustained, but, at a great cost to resource access for its people. With increased connectivity planned, this will change. The rapidity at which it will, and under what constraints, will determine the remaining value of the place and its integrity, not only

to its residents, but visitors, tourists and generations to come.

Highlighting the transactional capacities of place, empowering local communities and traditions and avoiding standardization of place needs to be done by engaging and identifying opportunities and threats to cohesive development.

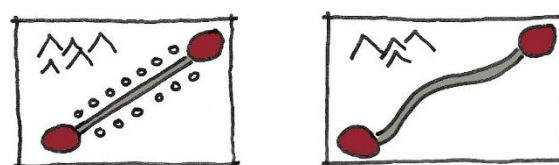


Figure 11. (a) Spontaneous Growth (b) Scenic Conservancy

7.2. Edges and Thresholds

In India, there is a very distinct condition visible along the carriageway. Where the road ends, there is typically an area of ambiguity, with no paving or planting, no transition of any kind to the neighboring or encroached development, settlement or open space. This ambiguous space, the edge, is outside the scope of the road engineer and 'public space' and that of the property owner, yet it creates disconnect and is an impediment to seamless access and engagement.

These amorphous edges, includes areas available for landscape development mentioned earlier, are the opportunity to define the right of ways, of carriageways and their locales and for engagement through negotiation. The potential to consolidate development, integrate zones of built and others of unbuilt, define and conserve view sheds to borrowed landscapes in these zones requires definition and dialogue.

7.3. Spatial Perceptions and Place-Making

Minimizing vast contradictions and distinctions of class, caste, religion, language, economic, regional and educational diversity inherent in India can reduce a sense of alienation and isolation. Designed streets and roads are equitable and provide the psychological benefits of inclusion and inculcate a sense of ownership and belonging for its diverse users.

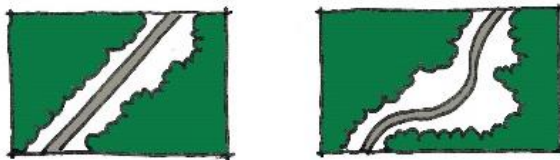


Figure 12. Planting for seasonality and appreciation

India's vast population requires an approach to design that is universal in approach. Simplicity, flexibility, coherence and accessibility along with endurance, sustainability and replicability. Aesthetics and regional specificity will avoid a one size fits all approach. The monotony of an engineering-centric construction robs places of its unique character. Composition of landscape for appreciation and interpretation that uses the seasonality of place adds value and increases associations of place and memory.

7.4. Progressive vs Defensive Design

Engaging with people who live and work along road corridors can engage and benefit from the connectivity and visibility through employment, transit facilities and access.

A lack of understanding of the users, site specific design requirements, communication, need for maintenance and enforcement is responsible for defensive design in public places. Dominated by boundary walls, fences, and other defensive design elements to defend against abuse of place and encroachments is inevitable but exclusionary. Engagement with the public, to understand and plan for the multiple variables inherent in place, to create coherence from the chaos of numbers and diversity is needed.

8. Comprehensive Landscape Approach

The unique opportunity to address landscape ecology at a vast scale, create and integrate contiguous ecological open space networks and provide tangible social, cultural, economic, ecological and aesthetic



Figure 13. Place making through planting in Pune, India

benefits in parallel to the infrastructure development is unprecedented in India.

At a regional landscape planning level, landscape architects can-

- a. Identify opportunities of place, people and context
- b. Define parameters of development for different considerations
- c. Evaluate framework for application and engage with the local networks to assess applicability
- d. Collaborate with allied disciplines
- e. Reassess and document for further applicability

At a local level, they can-

- a. Map critical regional and local contextual conditions
- b. Assess impact of development on ecological, economic, social and heritage of place
- c. Include landscape considerations during land acquisition and planning
- d. Making adjustments to the road infrastructure based on contextual conditions
- e. Help address and moderate impacts of development
- f. Treat identifiable stretches, intersections/ nodes, edges/ boundaries and landmarks as determinants of this framework
- g. Involve community and use local expertise

9. Landscape Codes and Guidelines

The Indian Road Congress (IRC), is the apex technical body of road engineers that prepares and disseminates standards and

guidelines for road development in India. In 2017, for the first time a Manual for Planting and Landscaping of Urban Roads was prepared to comprehensively address the role of planting and landscape through

- a. critical considerations of all hierarchies of urban roads
- b. integrated design with landscape and planting
- c. implementation details and specifications for horticulture practice
- d. maintenance requirements [14]

This highlighted in a paradigm shift in thinking to address issues of air pollution, heat island effect and their mitigation, water scarcity and progressive irrigation techniques (drip irrigation, recycled water, xeriscaping), protection of existing trees and green cover, and erosion control – roads in water-logged areas, and bio-diversity zones. It includes an interactive matrix for tree selection based on three climatic zones, to be supplemented by extensive place based plant selections options later.

While this manual was specifically for urban roads, it has introduced a landscape approach to the relevant stakeholders and paves the way for a larger role for landscape architects to reframe road corridors as ecological corridors.

10. Conclusion

Wherein a slower rate of growth, limited opportunities and a nascent community of professionals were limitations of the past, rapid expansion of infrastructure, have highlighted the urgency for landscape

architects to play a key role in this developing this approach.

For the nascent landscape profession, the objectives must be to-

- Build capacity within the profession to address this scale of planning intervention
- Create synergies and collaborations with allied disciplines
- Create a role for engagement and outreach with government agencies and the public
- Develop and support guidelines and best management practices for road landscapes
- Create structural setup to evaluate, audit and provide expertise across domain
- Play a role in decision making, design and implementation, technical oversight and operations and management.

While this paper emphasizes road infrastructure development, rail and metros- both underground and overland and waterway connectivity too are rapidly developing and require an integrated landscape approach.

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Greenways implementation Guidelines in Fortaleza-Ce, Brazil

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Abstract

Aguanambi Avenue is located in Fortaleza – CE, Brazil and it is susceptible to flooding on rainy season. The site has been undergoing reforms to improve urban mobility. With the main goal to promote an adaptive intervention on the avenue and its surroundings, this research discusses how Best Management Practices (BMP) can integrate the local grey infrastructure with the aim to complement the drainage, consolidating the urban resilience and providing environmental services in the Aguanambi Canal. This exploratory research promoted a case study area in order to characterize possible causes of the problem detected. An adaptive intervention study has proposed the design and distribution of BMPs on the perpendicular streets to the Aguanambi Canal. The catchment area treated the canal and its surroundings. The research has calculated from this area the rainfall volume received in rainfall precipitation of 65.2mm / h, by 10-year time return. The curbs extension dimensioning has considered a width of existing local streets. The total extension of Aguanambi Avenue is 1250m, on the Coronel Pergentino Avenue is 264m, and finally, on the local streets is 5019m. The result obtained shows the Bioretention of 17.14% of the rainfall volume precipitated with the intervention in just 4.52% of the total area. Considering the positive results, the study has developed guidelines to the constitution of Greenways through the implementation of BMPs in the road system of Fortaleza – Ce. The guidelines proposed about BMP application on the streets allow the consolidation of Greenways in multiple scales, from the local streets of a small housing complex to extensive avenues that cross the city. Through these corridors, important green areas could be connect, in order to consolidate a Green Infrastructure in the city. The connectivity between parks, squares and lagoons promoted by mobility corridors adapted to the Best Management Practices is essential to constitute a resilient city and to achieve ecological services.

Keywords: Green infrastructure; Urban Resilience; Best Management Practices; Greenways; Fortaleza.

1. Introduction

Natural landscapes has been supported the most intense cities growth since last century. Fortaleza, like many Brazilian metropolis, had its urban expansion through the degradation of several natural resources, such as rivers, lagoons, dunes and mangroves [1].

The gray infrastructure, defined as built systems in the cities to enable water and energy supply, rainwater catchment, sanitation, the road system and everything that supports human settlements [2], has led to segregation of natural areas and has caused several environmental problems for cities, such as pollution of water resources, landslides, floods and generation of heat islands.

Fortaleza's public policies have been adopting overpast solutions to solve infrastructure problems for many years. The Fortaleza's City Hall is building stations above the Água Nambi stream to get the BRT (Bus Rapid Transit) transportation system. Therefore, another water resource in this city will disappear from the landscape.

The intervention in Aguanambi Avenue shows that the application of the gray infrastructure was the main solution of the project admitted to enable the implementation of the BRT corridor (Figure 1)



Fig. 1. Bus rapid transit corridor construction above Aguanambi Canal

Overflows on the Aguanambi Avenue proves the impact of inefficient planning in the last decades that did not consider the natural characteristics of the site such as topography, water resources and floodplains. On January 8, 2017, a 55.6mm stormwater precipitation occurred in the morning and caused the Aguanambi Canal overflow [3], as shown in Figure 2. It seems little, but in vulnerable regions such Aguanambi Avenue, the consequences of this level of storm are disastrous.

Therefore, according to this information, interventions that have been promoting in Aguanambi Avenue over the years, to improve urban mobility, has intensified soil waterproofing around the Canal and has

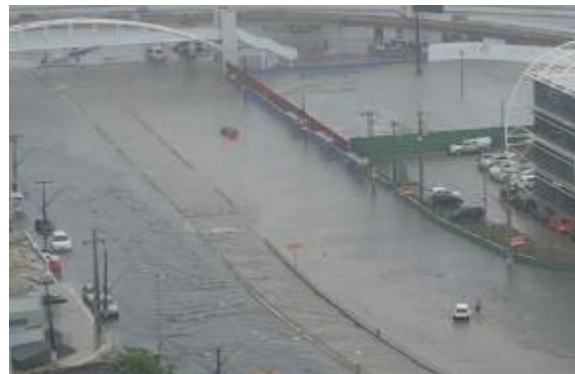


Fig. 2. Overflow Aguanambi Avenue's Canal [4]

aggravated its vulnerability during the storms.

The end of green spaces in wetland areas contributes to their susceptibility to natural events, which are increasingly common in large cities: intensification of storms, rising levels of the oceans and islands of heat caused mainly due to the emission of greenhouse gases [5]. Therefore, cities are seeking to consolidate an urban resilience to

resist to disturbances and tensions while maintaining their properties [6]. According to 2030 Agenda, one of its Sustainable Development Goals mentions the importance of "Building resilient infrastructures, promoting inclusive and sustainable industrialization and fostering innovation" [7].

Considering the current project for Aguanambi Avenue, this paper will discuss alternatives proposals based in Low Impact Development (LID) in order to show how green spaces can improve flood catchment and turn Aguanambi Avenue a resilient place.

2. Theoretical Basis

The implementation of Green Infrastructure can begin in one building sit, through a rainwater catchment system, for example, and expand to the county scale, like Sponge City in China [8]. According to Benedict and Macmahon [9], greenways or links are critical to consolidate Green Infrastructure in multiple scales and to ensure ecosystems linkages.

These greenways are fundamental for urban planning; the dissemination of this solution represents a great potential for natural resources recovery in cities, states or countries. These corridors may have different widths and behave like a connected, directional network, such as streets, avenues, or roads.

Adaptive interventions applied in cities, based on ecology, are essential for urban resilience [10]. As defined in Benedict and Macmahon [9], Green Infrastructure is an interconnected network of green areas that promotes several environmental benefits such as climate regulation and biodiversity

preservation. The Low impact development (LID) through the Best Management Practices (BMP) of rainwater has been offering the main alternatives for create Green Infrastructure in public and private spaces in the last years. According to Gehrels et al [11], the Green Infrastructure on streets and avenues can offer numerous ecological services that contribute for urban resilience. The main BMP adopted for this research are bioswales, rain gardens, rain flowerbeds, curbs extension and pervious



Fig. 3. Best Management Practices techniques (Portland, 2016: Author's paving, as shown in Figure 3).

According to Hubber et al [12], bioswales are usually located along roads, wide streets and parking lots. These solutions require support devices to direct the water flow and manage overplus rainwater volume. A rain garden is a vegetated depression to infiltrate, but does not retain the runoff, is also known as a biorretenation system. According to Bonzi [2], the sinuosity of the curbs extension interferes positively in the road system, creating the traffic calming in addition to catch rainwater. Rain flowerbeds

are like compact rain gardens, suitable for reduced urban spaces, this BMP do not necessarily have the infiltration function like rain gardens, but perform water cleaning [13]. Pervious paving reduces and distributes the rainwater volume promoting the pollutants removal and encouraging the underground layers supply [12].

This research has introduced some typologies of interventions for urban resilience considering the successive changes and the new project on the Aguanambi Avenue. It has discussed the availability of applying these different approaches in the study area in order to corroborate the developed proposal. Chelleri and Olazabal [14] classify three categories of interventions aimed at promoting resilience:

- Recovery defined as an immediate action for the system to re-establish itself; consolidated by a grey infrastructure for example;
- Adaptation, based on ecology to promote a relaxation of the existing system and prevent possible disturbances. The Green Infrastructure enable this prevention.
- Transformation, intervention based on deeper changes, through the renaturation of the system.

Therefore, this study has proposed BMP to Aguanambi Avenue in order to complement the existing drainage system and to constitute a new landscape with implantation of BMPs and application of pervious paving that could contribute to the natural surface formation and to the rainwater catchment, as well as landscape quality and beauty. Then, adaptive intervention through Best Management Practices could promote important

ecological services that contributes to urban resilience [12].

3. Methods for the proposition of Best Management Practices in the surrounding area of Aguanambi Canal.

Aguanambi Avenue expanded in the last four decades within the Fortaleza's urban network. Before its inauguration in 1972, the place was inhabited and housed a stream called Agua Nambi, an natural area for hunting, fishing and transporting canoes, according to Andrade [15].

The Aguanambi Avenue drainage system is not able to withstand intense stormwater because the lack of maintenance and undersized underground galleries. The accumulation of trash and sediments in the pipes can cause their silting [16] and thereby contribute to the reduction of their capacity. The inefficient rainwater's drainage causes floods in the main avenues of the neighborhood, harming the citizens who circulate in these corridors. Much people have already had their vehicles damaged.

The data introduced below can help to find out the rainwater volume, to size and distribute the Best Management Practices and to define its total bioretention rainwater volume capacity:

- 10-year storm event [17]
- 10- year peak flow - 65,2mm/h (mm per hour) [18]
- Runoff coefficient - 0,9 [19];
- BMP dimensions;
- BMP's rainwater bioretention volume - 0,487m³/m² [16]
- Roads' extension (Figure 4)
- Total area - 791,901m², as shown in Figure 4 (Appendix A).

In order to distribute and dimension BMP in total area, this research simulated in a local street, Artur Timóteo Street, the distribution of curbs extension because the undersized sidewalks. In addition, it was not possible put green gardens on the sidewalk. The curbs' extension distribution on Artur Timóteo Street happened according to the location of buildings access, according to Figure 5 (Appendix B).

The proposed curbs extension were with 8m², 35m² and 70m², according to their extension. Thereby, in 120m extension of Artur Timoteo Street there would be 180m² of BMP. From this result, in 1.00m it could be possible to implant 1.50m² of curb extension. In addition, for the sidewalks there would be 3,60m² of pervious paving per 1,00m street extension (Table 1).

BMP area	Bioretention /m ² (Becker, 2017)	Street Extension	Total Bioretention Volume
Curb extension 180m ²	0,487m ³	120m	87,66m ³
Permeable Floor 432m ²	0,0945m ³	120m	40,82m ³

Table 1. BMP area and capacity

Below is the information about the precipitation volume that covers the total area of 791,901 m² around Aguanambi Canal:

$$V = A \times \Delta p \times \text{Runoff} [20]$$

A = 791,901m² (area),
 $\Delta p = 65,2\text{mm/h}$ (10-year peak flow)
 Runoff = 0,9

$$V = 46.468,75\text{m}^3 \text{ (rainwater precipitation volume)}$$

4. Results

For the expected volume of 46,468.75m³ with a 10 – year storm event, the BMP system would hold 7,965.22m³ with the transformation in 35,798.9m² of the total area in Bioretention area through Best Management Practices, as shown in Table 2 (Appendix C).

The proposed system would retention 17.14% modifying 4.52% of the total area, as shown in Graphic 1 (Appendix D).

The proposed solution does not correspond to a 100% efficacy, but a minimum bioretention area, less than 5% of total, can contribute to catch a representative part of rainwater volume, acting together with the existing grey infrastructure. In addition to the rainwater retention, the rain gardens, bioswales and curbs extension can promote various environmental services, such as the pollutants reduction in water [21] and the environmental comfort improvement for recreational activities [9].

5. Greenways implementation Guidelines in the Fortaleza's road system.

Considering the case study carried out at Aguanambi Canal surrounding area, it was possible to understand that Greenways could complement grey infrastructure. BMPs in the road system could promote the connection between ecological hubs by setting up green infrastructure that plays an important role in the accomplishment of environmental services like provision, support and purification [12].

The main contribution of this research is to develop guidelines to suggest the

Greenways formation through Fortaleza's mobility corridors, purposing BMP in order to distribute stormwater management techniques from a local scale until the Municipal scale. These guidelines complement the urban qualification proposals suggested by Fortaleza's development Planning and they are in line with parameters established by the new Land's Use and Occupation Law [22] for the Fortaleza road system.

According to the Law, Fortaleza's basic road system consists in two Systems: I - Basic Structural Road System; and II - Basic Complementary Road System [22]. The structural system consists in Express and Arterial I pathways, responsible for the regional and municipal articulation road system. The complementary system consists in Arterial II, Collectors, Local pathways, which collect and distribute car traffic from neighbourhoods to Express and Arterial I pathways. Table 3 shows road system properties.

Fortaleza's road system properties				
Properties	Express	Arterial	Collector	Local
Min. width	60,00m	34,00m	24,00m	11,00 m
Min. sidewalk	5,00m	3,00m	3,25m	2,00 m
Min. central bed	9,00m	4,00m	1,50m	-

Table 3. Fortaleza's road system properties

This research has proposed a pattern of BMP distribution based on dimensions determined by Land's Use and Occupation Law [22] for different street categories from Fortaleza's road system. The proposition is according to the available space, without harming pedestrians or vehicles movement.

Therefore, this study has done a comparative analysis about BMP bioretention capacity in four kind of pathways: Express, Arterial, Collector and Local. Table 4 presents BMP dimensioning according to roads.

Road	BMP area (m ²)
Bioswales	
Express	1500
Arterial	500
Collector	*
Local	*
Rain gardens	
Express	280
Arterial	280
Collector	280
Local	*
Rain flowerbeds	
Express	120
Arterial	120
Collector	120
Local	120
Curbs extension	
Express	**
Arterial	**
Collector	160
Local	80
Pervious Paving	
Express	1000
Arterial	800
Collector	650
Local	500

Table 4. BMP dimensioning according to roads.

Bioswales: match with generous central beds on Express roads, where its performance is better. The research has established three meters for the minimum bioswale width. It has restricted bioswale just for Express and Arterial roads.

Rain gardens: the study has designed it with at least 14m² (2m maximum width and 7m minimum length) on the Express, Arterial and Collector road's sidewalks. So, rain gardens do not get into local streets where the sidewalk has at least 2 or 2.50 meters [22]. This BMP provides free access for vehicles and pedestrians inside buildings.

Rain flowerbeds: it is a rain garden with reduced size, its dimensioning is 6m² (6m length and 1m maximum width). This model provides access spaces for vehicles and pedestrians inside buildings and match with Collector and Local roads.

Curbs extension have 10 m² and match with Collector and Local roads. Express and Arterial roads are not allowed to have speed control through traffic calm. Curbs extension provide access spaces for vehicles and pedestrians inside buildings.

Pervious paving matches with all kind of roads.

This research has calculated rainwater volume considering the BMP areas above presented. This analysis has considered the worst situation, adopting 100% for runoff. Below is the information about adopted data:

- Runoff Coefficient - 1.
- 10-year peak flow - 65.2 mm / h (Δp)
- Corridor extension – 100 m

If the roads have different widths, obviously the rainwater volume (V) changes according to each road typology (Table 5).

Road	Area (m ²) per 100m extension road	Rainwater volume (m ³)
Local	1400m ² (14x100)	91,28m ³
Collector	2400m ² (24x100)	156,48m ³
Arterial	3400m ² (34x100)	221,68m ³
Express	6000m ² (60x100)	391,2m ³

Table 5. Rainwater volume and roads dimensioning

Considering the chart above, the BMP's performance is according to different Fortaleza's roads. Table 6 presents the bioretention results in Express, Arterial, Collector and Local roads.

Road	Bioretention volume (m ³)	Bioretention capacity (%)
Bioswales		
Express	730,5 m ³	186%
Arterial	243,5 m ³	109%
Collector	-	-
Local	-	-
Rain Gardens		
Express	136,36 m ³	34%
Arterial	136,36 m ³	61,5%
Collector	136,36 m ³	87,1%
Local	-	-
Rain flowerbeds		
Express	58,44 m ³	14%
Arterial	58,44 m ³	26%
Collector	58,44 m ³	37%
Local	58,44 m ³	64%
Curbs extension		
Express	-	-
Arterial	-	-
Collector	77,92 m ³	49,7%
Local	38,96 m ³	42,7%
Pervious Paving		
Express	94,50 m ³	24,1%
Arterial	75,60 m ³	34,1%
Collector	61,42 m ³	39,2%
Local	47,25 m ³	51,7%

Table 6. BMP capacity bioretention

The results demonstrate that the BMP performance changes according to roads types. Four among the five BMP present better performance in smaller corridors, Collectors and Local streets, according to Graph 2 (Appendix E).

In order to classify the best combinations between BMP and roads for bioretention rainwater, this study has suggested three evaluation levels: Regular, Regular - Satisfactory and Satisfactory – Excellent, as shown in Table 7.

Table 7. BMP performance classification

Regular: in this situation the BMP performance are below 35%. Therefore, the most efficient combination is better.

Regular - Satisfactory: they are favourable combinations that bioretention can reach 70% of the rainwater volume.

Satisfactory - Excellent: BMP can exceed 100% rainwater volume catchment, functioning as a backup system for unusual stormwater runoff. It helps conventional drainage infrastructure.

In conclusion, any situation is favourable. A regular performance does not mean that BMP application is not important because these practices provides important environmental services. The classification in Table 8 suggests the most efficient combinations and in what road the BMP has greater rainwater bioretention capacity.

BMP	ROADS			
	EXPRESS	ARTERIAL	COLLECTOR	LOCAL
BIOSWALE	●	●	✗	✗
RAIN GARDEN	✗	●	●	✗
RAIN FLOWERBED	✗	✗	●	●
CURB EXTENSION	✗	✗	●	●
PERVIOUS PAVING	✗	●	●	●
● RECOMMENDED				
✗ NOT RECOMMENDED				

Table 8. BMP application recommended

Considering the presented recommendations, it is possible propose some guidelines:

- Rain flowerbeds and curb extensions match with smaller roads, because they fit in the narrower sidewalks and streets, playing a

BMPs performance classification	
Regular	0 – 35%
Regular - Satisfactory	35,1 – 70%
Satisfactory - Excellent	Above 70%

satisfactory role about runoff retention and contributing to the traffic control in residential local roads.

- Rain gardens match with collector and arterial roads, this BMP composes commercial streets landscape projects, encompassing a larger influence area and playing an important role controlling flooding points that damaging mobility in these avenues.

- Bioswales should contribute to the capture and transport of runoff on express roads, characterized by wide sidewalks and central beds, where have space for this type of BMP. Bioswales application can promote the increase of green areas, creating a permeable corridor that integrates distant neighbourhoods.

- Pervious paving are an important complement to increase the runoff bioretention, especially in densely built areas where it is necessary to apply solutions in order to increase the permeability rate.

The guidelines proposed above for BMP application in the road system allow the consolidation of Greenways in multiple scales, from the local streets of a small housing complex until an extensive avenue that crosses the city. Green Infrastructure

consolidation through these greenways in Fortaleza city could connect important green spaces. The connectivity between parks, squares and lagoons, promoted by mobility corridors adapted to the Best Management Practices, is important for a resilient city construction.

6. Conclusion

Proposing an adaptive intervention in the Aguanambi Canal surrounding was important to show that BMP application could complement grey infrastructure in vulnerable areas in order avoid flood. It allows the resilient spaces consolidation in the City.

Different kinds of roads influence the BMP distribution and performance in local streets or large avenues. The first investigation at Artur Timóteo Street has contributed for the following studies carried out in order to construct the Greenways implementation guidelines.

These guidelines could be part of development Fortaleza City Planning. The BMP network could create green areas on streets and avenues forming Greenways in order to integrate squares and parks in the city. Implementing rain gardens on the streets could increase the public policies about appreciation of green spaces. In addition, stakeholders could take care of squares, streets or a little garden.

Finally, Green Infrastructure is able to prevent, through its regulatory properties, the negative impacts on natural resources because urban growth and grey infrastructure. Consolidating Green Infrastructure in Fortaleza through the Greenways could ensure environmental and urban quality, improving rainwater drainage

and enabling a resilient city for Fortaleza's citizens.

Acknowledgments

We thank University of Fortaleza (UNIFOR) for support this work.

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Appendixes

Appendix A



Fig. 4. Total study Area

Appendix B

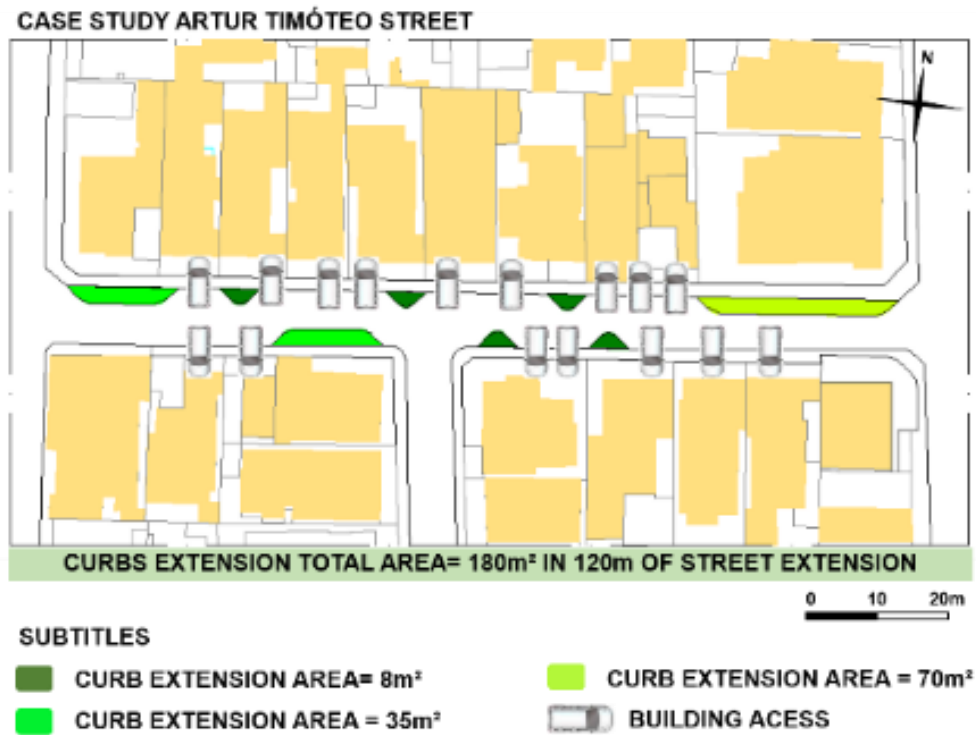


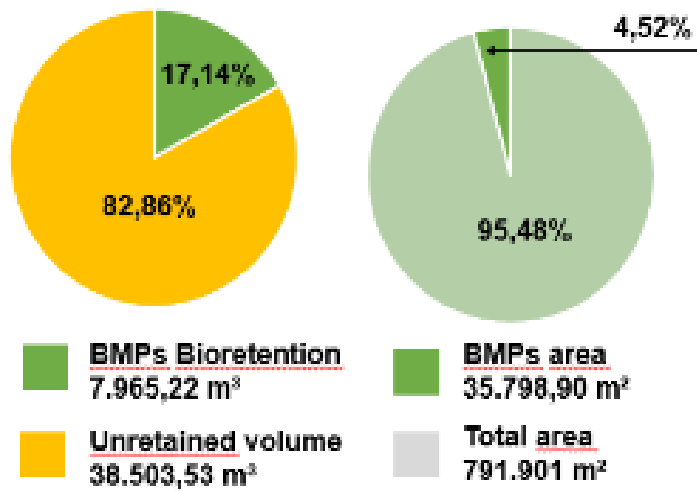
Fig. 5. Case study for curbs extension sizing at Artur Timóteo Street

Appendix C

BMP bioretention rainwater volume and total area		
1.250m extension Aguanambi Avenue with 3m ² of rain Garden each 1m	Bioretention area 3.750m ²	Bioretention rainwater volume 1.826,25m ³
1.250m with 4m ² of pervious paving each 1m	Pervious area 5.000m ²	Bioretention rainwater volume 472,5m ³
264m extension Coronel Pergentino Ferreira Avenue with 1.5m ² of curb extension in central bed each 1m.	Bioretention area 396m ²	Bioretention rainwater volume 192,85m ³
264m with 4m ² of pervious paving each 1m	Pervious area 1.056m ²	Bioretention rainwater volume 99,79m ³
5.019m extension local roads perpendicular to the Canal, with 1.5m ² of curb extension in central bed each 1m	Bioretention area 7.528,5m ²	Bioretention rainwater volume 3.666,37m ³
5.019m with 3.6m ² of pervious paving each 1m	Pervious area 18.068,4m ²	Bioretention rainwater volume 1.707,46m ³
Total Area and Volume	Total area 35.798,9m²	Total bioretention volume 7.965,22m³

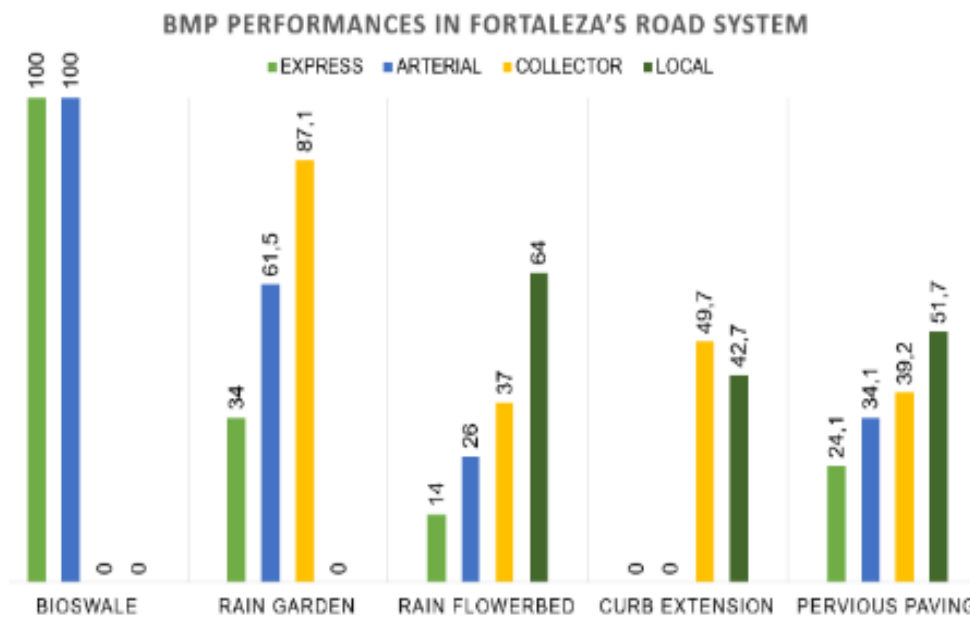
Table 2. BMP dimensioning on the streets

Appendix D



Graph 1. BMP bioretention volume capacity and calculated area around Aguanambi Canal

Appendix E



Graph 2. BMP bioretention performance in the Fortaleza's road system

Study On Effectiveness Of Strategies To Re-Establish Landscape Connectivity Of Expressways; With Reference To Southern Expressway Sri Lanka.

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Abstract

Construction of highway is the most emerging massive development tendency in Sri Lanka. With these development activities, there are a lot of environmental and social issues started. Land and subsequent Landscape fragmentation is one of the main issues that highly effect to the environment by the construction of expressways. This paper designates, post construction landscape study on the effectiveness of the landscape connectivity structures to restore connectivity. Geographic Information Systems (GIS), least cost path tool has been used within the selected two plots; 25km along the expressway to identify animal crossing paths. Animal accident data use as the measure for determining the most contributed plot for landscape connectivity. The number of patches, Mean patch size, Class area use as a parameter to determine the most effective land use class to reestablish the landscape connectivity.

The scrub, grass and marsh were the most positively affected land use typologies for increase the landscape connectivity. It represents the growth increased by 8% within the 12 years of time. From the least cost analysis within the plot one, 28.5% of total animal crossing structures are within the high resistance land use classes. Southern expressway used reinforced compressed earth technologies and It has been controlled the growth of the climax community. According to all findings, it could assume that involvement of the landscape crossing structures contributes to re-establish connectivity, but it is not enough to restore the majority of disturbance performed by the expressway. Connectivity measures used within the study can use as a tool for re-evaluate future involvement of highway crossing structures. Proper placement of the highway crossing structures leads to increase the rate of connectivity. The study recommends that monitoring the all stages (preconstruction, construction and post-construction) of the project and preliminary design, and the involvement of the research applied connectivity assessment strategies help to overcome the complication regarding the re-establishment of landscape connectivity; using the highway crossing structures that facilitate the growth of flora and fauna.

Keywords : Landscape fragmentation; Habitat Lost; Least Cost Path; Migration corridors

1. Introduction

Land-use and land-cover changes are so pervasive that, when aggregated globally, they significantly affect key aspects of Earth System functioning. They directly impact biotic diversity worldwide [1]. Which leads to many environmental concerns. In this decade construction of the highways takes priority in the developing Sri Lankan context.

In developing Sri Lanka the road network at present is deemed insufficient to support the growing traffic load. Therefore the latest trend in Expressways to facilitate fast land based transportation. This include, the Colombo-Katunayake Expressway (E 03), which is fully functional, the Southern Expressway (E 01) that operates up to Matara and planned to be extended up to Hambantota, the Outer Circular Highway (OCH) that has been completed from Kadawatha to Kottawa and the Northern and Central Expressways which are still at the final design stages.

On the other hand it obviously disturbs the environmental and leads to many issues within the future. Roads precipitate fragmentation by dissecting previously large patches into smaller ones" and by creating a barrier to movement and dispersal between adjacent habitat patches [2]. Massive amount of land modifications has to be done in order to initiate and construction of highways. Fragmentation of the landscape is the one of the main issues that cause by the highway.

Road and highway construction affects wildlife through the direct loss and fragmentation of its habitat by introducing a source of additive mortality for wildlife populations, and by disrupting animal movement and dispersal [3]. Most of the

countries have several methods to mitigate landscape fragmentation the highways. Highway crossing structures have been constructed in many parts of the world in an effort to mitigate negative effects of exclusion fencing on wildlife populations [3].

The main focus of the research is to identify the degree of contribution of highway crossing structures in Sri Lanka whether enough to mitigate the landscape fragmentation. According to the selected study dimensions. Geographic information system (GIS) / Land use maps and Least-cost modelling use as theoretical approaches for determining the level of landscape connectivity.

This study will help to identify the issues and strategies that helps for future highway projects to enhance landscape fragmentation mitigation techniques and to explain about the importance of landscape architectural involvement of highway crossing structures to mitigate landscape fragmentation. It expresses the importance of proper placement of crossing structures. Further it will provide evidence for the need of the involvement of professional Landscape Architects to address the landscape issues during the all stages of the project.

2. Landscape Fragmentation and Mitigation Strategies

2.1 Landscape fragmentation

“Landscape fragmentation is mainly defined as the breaking of habitat ecosystem or landscape into smaller pieces which is usually caused by human activities” [4].

“The concept of fragmentation refers to the transformation of the landscape, often driven

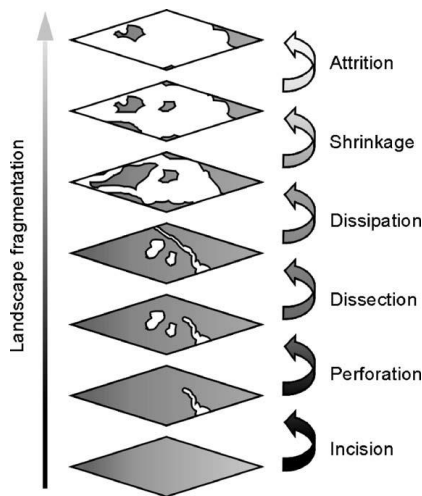


Figure 1: Schematic representation of the fragmentation process and its different stages.

Source: [4]

By disturbances, from a uniform to a more heterogeneous and patchy situation” [5]. Following image shows the schematic representation of the fragmentation process and its different stages. In gray it represents the original land cover, and in white the anthropogenic or new land cover.

2.2 Causes of Landscape fragmentation

There are many factors that induce fragmentation. Anthropogenic activities and new expansions of the lifestyles highly disturb the natural setting of the environment and it’s highly effects on landscape fragmentation. Landscape fragmentation due to roads, urbanization, and other human development has major impacts on wildlife, including many species of concern [6].

Transportation corridors, Farmlands, Transmission lines, Industrial zones, urban expansions and man-made reservoirs highly

promote landscape fragmentation in different ways.

2.3 Landscape fragmentation due to expressway construction

Landscape fragmentation caused by transportation infrastructure has a number of detrimental effects like reduction in size and persistence of wildlife populations, changes of local climate, and increases in pollution and noise from traffic. Therefore, data on the degree of landscape fragmentation are needed for assessing the sustainability of human land uses.

As early as 1970, wildlife biologists began publishing research on the effect of roads on wildlife populations as barriers to movement [7].

Following figure shows the degree of landscape fragmentation changes referring the degree of human impact.

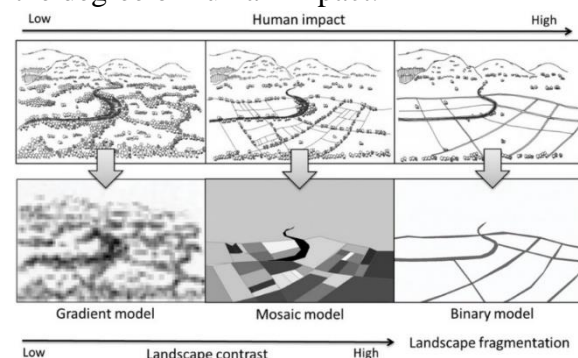


Figure 2: Human impact on landscape fragmentation

Source: [8]

2.4 Mitigation of landscape fragmentation in southern expressway

During the project processing period of the Southern Expressway that started in 1996,

environmental assessments were prepared by authorized institutions and authorities. “The expressway route is located, as much as possible, along the foot of the hill slopes to minimize the loss of farmland and the relocation of residential building.” [9]. Committee of the Southern Expressway development project includes various monitoring teams and a cluster of responsible professionals to measure the effects on the existing mechanisms. The completion report presents the process and mitigation measures they have given for the success this project. According to the Southern Expressway reports they were concerned about avoiding wetlands and existing flood plains, ensuring the aesthetic value of the area by tree plantation, minimize the tree removal during the construction and proposing over passes and under passes to increase permeability. They had considered mitigation measures for noise and visual intrusion caused by the expressway.

3. Landscape connectivity and transit corridors

3.1 Connectivity

‘Connectivity’ can be broken down into ‘structural connectivity’ and ‘functional connectivity.’ Structural connectivity refers to the physical relationship between landscape elements whereas functional connectivity describes the degree to which landscapes actually facilitate or impede the movement of organisms and processes. Functional connectivity is a product of both landscape structure and the response of organisms and processes to this structure.

Thus, functional connectivity is both species- and landscape-specific [10].

They’re having three main types of connectivity

- Habitat connectivity
- Landscape connectivity
- Ecological connectivity

1. Habitat connectivity

Habitat connectivity is the connectedness between patches of suitable habitat for a given individual species. It may be defined at the patch scale or at the landscape scale [11]. The term is chosen to include the word ‘habitat’ to emphasize its species-specific nature.

2. Landscape connectivity

Landscape connectivity is a human perspective of the connectedness of native vegetation cover in a given landscape. It may be expressed using various buffer- or distance-based metrics that can be calculated from maps of human-defined land cover. The term is chosen to include the word ‘landscape’ to emphasize its anthropocentric nature the concept of a landscape is a human construct [12].

3. Ecological connectivity

Ecological connectivity is the connectedness of ecological processes across multiple scales, including trophic relationships, disturbance processes and hydro ecological flows. The measurement of ecological connectivity is not straightforward and depends on which aspect of ecological connectivity is to be estimated. Despite this difficulty, ecological connectivity is an important concept that is not adequately

captured by existing definitions of connectivity [10].

3.2 Landscape transit corridors

1. Habitat corridor

Habitat corridors is the capacity to facilitate movement, which occurs in different patterns and processes, and at different scales depending on the species or ecological process of interest. Thus, habitat corridors need not be linear or narrow and must be defined from the perspective of the organism or process being targeted for conservation [13].

2. Migration corridor

Migration corridors are used by wildlife for annual migratory movements between source areas [13].

3. Dispersal corridor

Dispersal corridors are used for one-way movements of individuals or populations from one resource area to another. Dispersal is critical to the maintenance of genetic diversity within populations of species and to the persistence of fragmented populations which may require regular immigration to avoid local extinction [13].

4. Commuting corridor

Commuting corridors link resource elements of species' home ranges to support daily movements including breeding, resting and foraging. As such, commuting corridors facilitate localized movements throughout the landscape important to daily survival and reproduction [13].

3.3 Types of Highway Crossing Structures

Following highway crossing structures used within most parts of the world to increase landscape connectivity.

1. Landscape Bridge
2. Wildlife Overpass
3. Multiuse Overpass
4. Canopy Crossing
5. Viaduct or Flyover
6. Large Mammal Underpass
7. Multiuse Underpass
8. Underpass with Water Flow
9. Small- to Medium-Sized Mammal Underpass
10. Modified Culvert
11. Amphibian and Reptile Tunnels

4. Data collection Methodology

Research Objectives

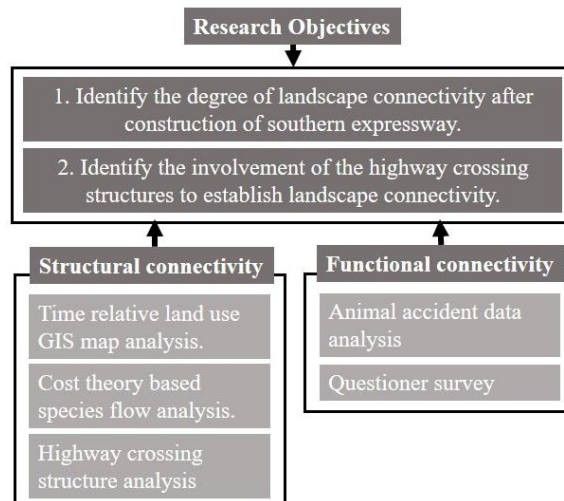


Figure 3: Research objectives and Data collection method

Source: Author

1. Identify the degree of landscape connectivity after construction of the

southern expressway from the construction stage to the present situation.

2. Identify the involvement of the highway crossing structures to establish landscape connectivity.

5. Case study selection criteria

Southern expressway (E01) is the first and the oldest expressway in the country. The project started in the year 2002 and by 2011, it was open to the general public. The southern expressway selected as the main case study. The case study selection criteria differ from each other according to the study dimensions. Following diagram briefly shows the case study selection criteria.

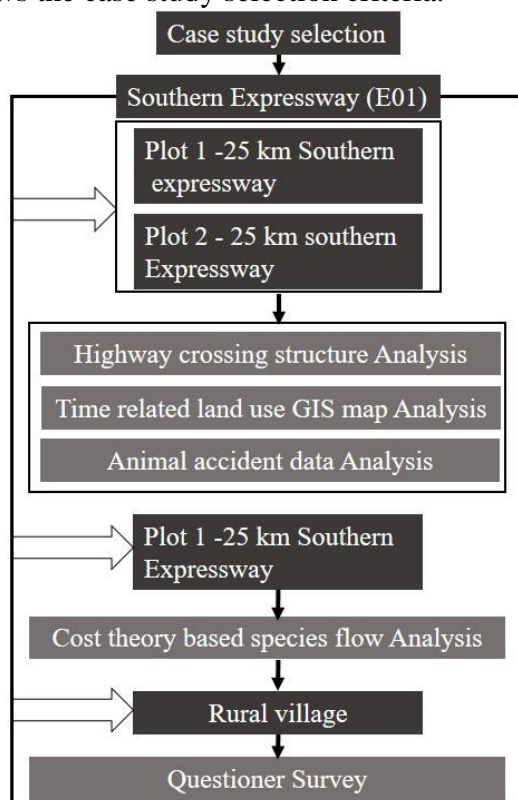


Figure 4: Case study selection

Source: Author

5.1 Structural connectivity study plot selection

This is focused to comprehend the landscape structure and land use pattern to identify how they affect ecological corridors, circulation pattern and continuity of that area.

Selected a specific plot consisting of a maximum variety of vegetation (including forest patches), an interchange environment, and drains to study the fragmentation and degradation of the landscape structure. And also availability of GIS and Highway crossing structure data have been used to select the appropriate plots. This is a comparative study of the landscape transformation within the period of pre-construction, under-construction and post-construction stages of the Southern Expressway.

5.2 Functional connectivity study plot selection

This focuses to find the degree of functional connectivity by analyzing animal accident data and questionnaire survey. "Habitat fragmentation occurs when changes in habitat configuration occur as a result of the breaking apart of habitat, independent of habitat loss." [14]. Increased number of collisions between vehicles and animals become the main reason for habitat fragmentation.

The people living since the year 2000 within the village were selected as the participants for the questionnaire survey. As they have experienced all the stages pre-construction, under-construction and post-

construction stages of the Southern Expressway. And also availability and variety of animal accident data have been used to select the appropriate plots.

5.3 Case studies

Time relative land use GIS map analysis, Highway crossing structure analysis and Animal accident data analysis use 2 plots within the southern expressway. Each plot contains 25 km along the southern expressway, which starts from the Kottawa highway interchange. One plot contains 24000 ha area of land beside the expressway. The frequent animal crossings and accidents were identified using the accident data records of the expressway. A five-year time frame from the opening year of the Southern Expressway was selected to analyze the accident data. One plot used for the Cost theory based species flow analysis, which has most of the landscape connectivity structures according to the ‘Highway crossing structure analyses.’ Questionnaire survey is conducted from a rural village called “Keebiya” which has higher number of landscape connectivity structures intersect.

6. Theoretical approach

Landscape ecology focuses structure, function and change of the landscape.

Structure: The spatial relationship among the distinctive ecosystems or elements.

Function: The interactions among the spatial features.

Change: The alteration in the structure and function of the ecological mosaic over time [15].

6.1 Landscape structure

“Landscape structure expresses the spatial pattern of landscape elements and the connections between the different ecosystems or landscape elements. Landscape structure assesses relationship between ecosystems as measure, number, size and shape” [16].

6.2 Landscape metrics

“Landscape metrics help us to understand changes in landscape from different Perspective (Visual, ecological, cultural). Landscape metrics have greatly contributed to the landscape ecology studies” [16]. Landscape metrics could be calculated under Patch, Class and Landscape levels.

6.3 Least-cost modelling

Least-cost modelling is one of the GIS-based techniques used to create regional-scale wildlife movement models in a manner that makes it possible to identify potential linkage areas across highways [17]. Identification of least cost path and least cost distance is achieved by using raster landscape resistance map. Cells represent the estimate the resistance to species movement [18].

The least-cost path is the route that offers an organism the greatest probability of survival in traversing the entire distance between source and target patch [19]. Least – cost path modeling use resistance layer to define the level of hardness of movement by using different land cover types.

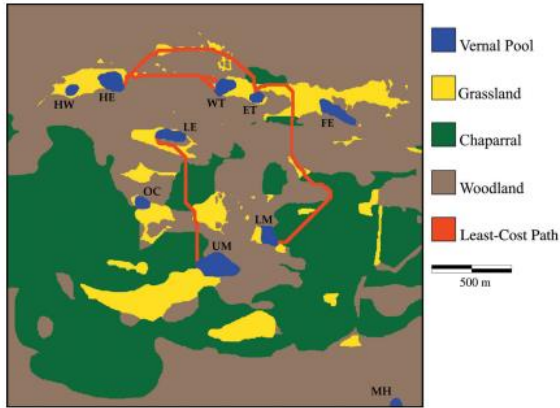


Figure 5: Least cost path within Land use map.
 Source: [20]

7. Data collection And Analysis

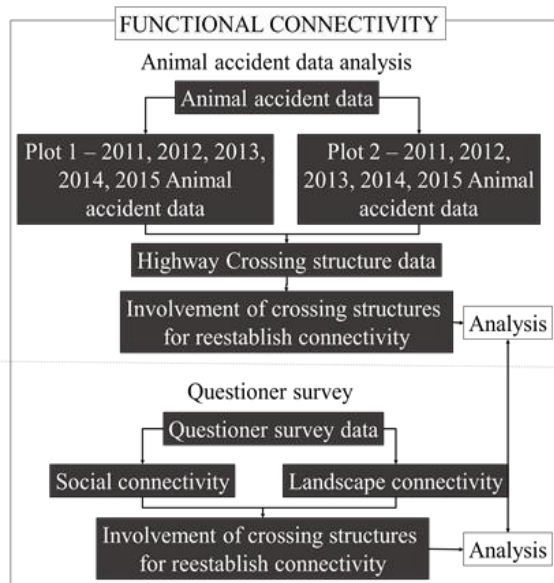


Figure 5: Overall method of selected data and data analysis for functional connectivity.
 Source: Author.

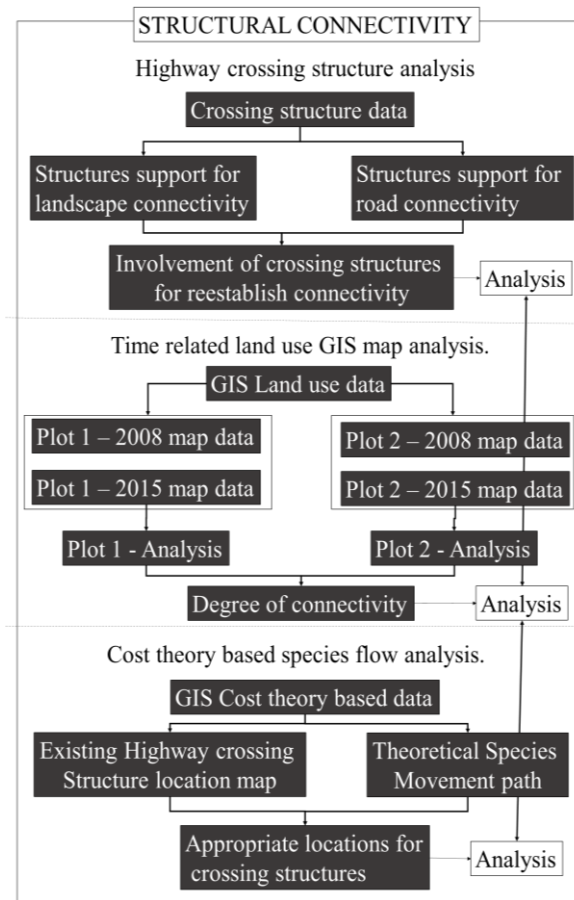


Figure 6: Overall method of selected data and data analysis for structural connectivity.
 Source: Author.

Figure 5, 6 shows the overall method of selected data and data analysis of landscape structural and functional connectivity used within the study.

7.1 Highway crossing structure Analysis

Crossing structure categories	Sub categories	L	N	LxN
1. Overpass with the vehicle move	• 8m bridge	8m	11	88
	• 12m bridge	12m	6	72
2. Underpass with the vehicle move	• Box culvert	8m	6	48
	• Arc culvert	8m	7	56
3. Small underpass connect water and land	• Box culvert	6m	12	72
	• Arc culvert	8m	19	152
4. Underpass with the water flow	• bridge	20m	2	40
	• Arc culvert	8m	3	24
	• Circular culvert	2m	2	4
	• Box culvert	8m	4	32
Total length obtain by the highway crossing structures within plot 1				588

L – Average Length, N – Number of Structures, LxN – Total Length

Table 1: length obtain by the highway crossing structures within plot one

Source: Author

Total length of highway within the plot one and plot two represent 25 km. Within the plot one 588 m covers with the highway crossing structures from the total length, which represents 2.3 % and plot two covers 486 m from total length, which represents 1.9 %.

According to the highway crossing structure analysis. Highway crossing structures are mostly created by considering the availability of water connectivity nodes, road connectivity nodes and species flow. Analysis express facilitating landscape connectivity for the species flow and animal movement barely consider when creating highway crossing structures within southern expressway.

7.2 GIS Land Use Analysis

Compare the changes of parameters within selected two plots are important to analyze the changes between plots, that leads to determine the involvement of highway crossing structures to reestablish connectivity

Class Level	Landscape connectivity level %					
	CA(ha)%		NUMP%		MPS(ha)%	
	Plot 1	Plot 2	Plot 1	Plot 2	Plot 1	Plot 2
Home Garden	1.008	1.014	1.0510	1.091	0.959	0.929
Plantation	1.010	0.999	1.009	1.017	1.000	0.982
Paddy	0.990	0.999	0.957	1.015	1.034	0.984
Forest	0	1	0	1	0	1
Other(scrubs, grass, marsh)	1.01	1.033	1	1.521	1.010	1.033

CA: Class Area, NUMP: Patch Number, MPS: Mean Patch Size, ha: hectare, % percentage

Table 2: Landscape connectivity level analysis, plot one and two

Source: Author

According to the table, plantation paddy and other (scrubs, grass, and marsh) shows a slight enhancement of connectivity. The increment of the plantation and paddy lands are mostly caused by anthropogenic activities. It can't be considered as a measuring factor for connectivity reestablishment. Especially the increment of the land cover types which is categorized under other (scrubs, grass, and marsh) can be seen under both plot one and plot two. These Land Use classes mostly provide the facilities to animal habitats and it also naturally creates features with the minimal anthropogenic involvement.

By comparing plot one and plot two, a higher increment can be seen within plot two. In the connectivity structure analysis there are lot more connecting structure within the plot one

rather than plot two. This expresses the idea that the number of crossing structures do not define the level or frequency of connectivity reestablishment within southern expressway.

7.3 Cost theory based species flow Analysis

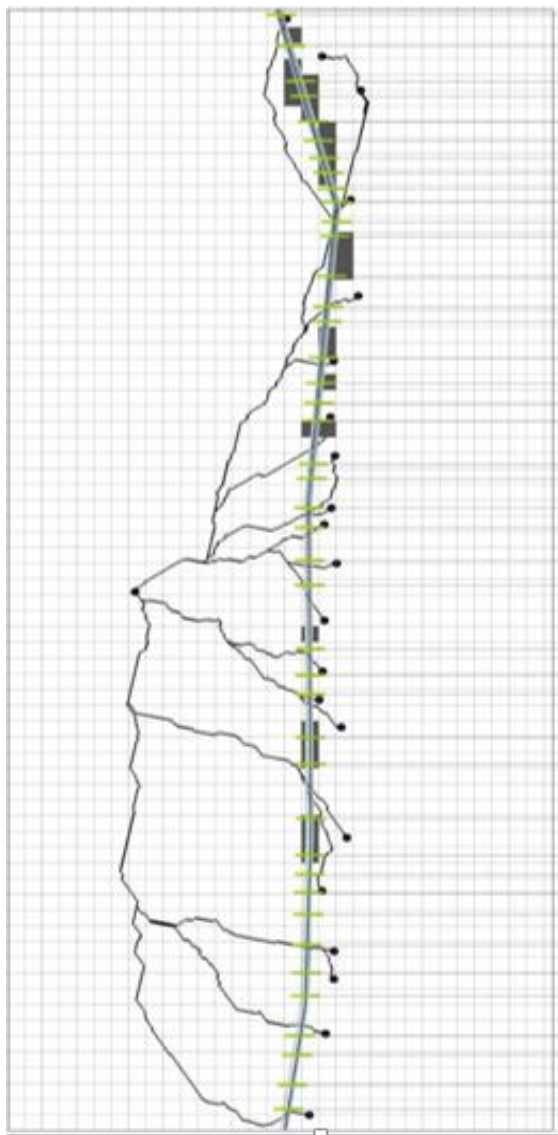


Figure 7: Least cost paths and connectivity structures location analysis grid

Source: Author

Cost modeling illustrates the most appropriate landscape corridors by using land use pattern and resistance values

Figure 6 shows the least cost path generated from the ArcGIS program and existing locations of highway crossing structures that mostly cater for landscape connectivity. Gray colour horizontal lines indicate the existing structures. Black colour lines indicate the least cost path.

Black colored rectangles indicate the places that are not suitable for landscape connectivity structure according to the land use pattern. The areas marked by the black rectangles are having a higher resistance value than other areas.

In southern expressway there are quite a number of structures that tend to support the landscape connectivity. 28.5% of total animal crossing structures are within the high resistance land use classes, which partially suitable as landscape connectivity corridor. Proper placement of the highway crossing structure should be considered within the early planning stage of the project. The cost theory base analysis with the updated and well detailed land use maps and contour maps leads to do proper analysis relate with the placement of the landscape crossing structures.

7.4 Animal accident analysis

Analysis shows animal accidents frequency of two plots which are not affected by number of connectivity structures. It may be affected by other factors such as climate change and other natural phenomena. But it expresses the idea that a number of landscape crossing

structures are not the only factor for reestablishing landscape connectivity. It's also affected by the suitability of highway crossing structures to the individual place itself by considering the specific characteristics, animal behaviors and suitable types of crossing structures.

7.5 Questionnaire survey

Questionnaire survey is used to identify the functional connectivity of the landscape in the ground scale.

Analysis express, behavioral changes of animals can be experience after construction of the expressway. It shows landscape fragmentation effects on animals within the context. Participants mentioned population enhancement of the peacocks and pigs, animal accidents can be experienced within the context. Which means they were having environmentally unbalancing occurrences due to the construction of the expressway. This analyze express the idea that they are having functional evidences of landscape connectivity structures within southern expressway and the animals were using the landscape connectivity structures rarely.

8. Conclusion

The research outcomes express the main idea that the landscape crossing structures used within the southern expressway (E01) partially contribute as expected to restore the connectivity within the context which was fragmented by the construction of southern expressway, but they are having evidences identified by the research, the mitigation measures done by the southern expressway

project to re-establish landscape connectivity is not adequate to restore the damage.

Analysis of the evolution of the landscape pattern by using data from the land use maps helps to determine the degree of connectivity over time and crossing structure analyze shows the degree of involvement of the landscape crossing structure to reestablish connectivity. Cost analysis helps to determine the suitability of existing locations of the landscape crossing structures by using least cost modeling. Functional connectivity of the landscape is decided by the analysis of animal accident data and the questionnaire surveys.

Animal crossings were used frequently within the southern expressway. The disruption of free movement of wildlife has resulted in frequent vehicle collisions with wildlife as they attempt to cross the expressway. Some of the modulation techniques used in expressway construction has to be improved with the proper understanding of the context. The analysis shows the existing placement partially considers the landscape pattern, animal movement corridors and the vegetation distribution. Proper placement reduces the number of animal accidents and keep the ecological connectivity between patches.

More reliable and context generated design is essential to provide better solutions to reduce the negative impact towards natural processes due to construction of expressways. It needs the knowledge of expertise and should do proper research within the planning and pre construction stages of the project. When compared it is comprehensible that the facilities provided for landscape connectivity is less than the facilities provided for human infrastructure

connectivity. Strategies used for re-establishing the landscape connectivity may not be equal as the strategies used for human infrastructure connectivity, but it should be adequate to manage the balance of the natural system.

Special features such as track devices, inferred camera systems and sand bed tracking to determine landscape connectivity are used in developed countries. Researches with those mentioned advance technologies will help to identify more accurate species movement paths and can lead to proper placement of species transit corridors.

The preliminary stage of a project for the design and location of the connecting structures highly need the contribution of professionals like ecologists and landscape architects. Their contribution within the planning stage, construction stage and the functional stage also impacts the final outcome.

This is the time to direct these transportation development strategies towards the creation of sustainable transportation system. The future expressway projects such like the Kandy north expressway, southern expressway extension and emerging road development projects across the national parks like 'wilpattu' need special attention. With the proper consideration of the socially, economically and environmentally sustainable enrichment within the all stages of the projects help to attain the maximum benefit for the country. The involvement of well experienced and skillful professionals, especially within the fields of ecology, planning and landscape architecture are also a crucial factor for above mentioned achievements.

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Introducing alternative project frameworks through landscape design

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Abstract

In an era of globalisation and environmental instability, the ‘landscape’ is often perceived merely as the physical context rather than as the core element to establish a vision for a whole region, create values, share memories and play a key role addressing the global challenges we face. The focus of this paper is to enhance and emphasise the impact that spatial strategies have in sustainable design and how landscape practice can be instrumental in future-proofing and protecting our cities. The paper forms part of a wider research project examining innovative landscape strategies across Europe, assessing the extent to which low carbon, sustainability and spatial quality can be delivered effectively at the urban and strategic scales. We argue that a sophisticated process needs to be put in place in order to be able to deliver landscape schemes that appropriately identify and address current environmental and social challenges.

This paper discusses the outcomes of two major pioneer landscape infrastructure projects in the Netherlands (the ‘Room for the River’ and the ‘New Dutch Waterline’) that have demonstrated new ways of engaging with both climate and aesthetic elements during the conceptual and implementation phase of a strategic scheme. The Room for the River is a landscape adaptation programme addressing water level management, while the New Dutch Waterline aims to regenerate inundation sites by introducing cultural and social activities while preserving the landscape infrastructure. Exploration of the impact that policy and legislation have on the landscape demonstrates that governance plays an important role in ensuring the success of a strategic landscape project. An investigation of urban and rural projects dealing with climate adaptation through these two projects shows that a multidisciplinary focus is a significant factor in the development of an effective project framework.

We conclude that the establishment of a project framework, clearly supported by legislation and policy, will make a real difference in the way that professional practice and politics deal with landscape infrastructure. The integration of environmental and quality concepts from the early stages of the project process, and the attention to the importance of design, can ensure effective implementation and smooth communication during the development of a landscape scheme, leading to future resilience.

Keywords: landscape design; sustainability; climate adaptation; project framework; flooding

1. Introduction

Research observing and evaluating strategic landscape schemes across Europe that have developed pioneer ways of envisioning, processing, managing and delivering large-scale projects has resulted in the identification of best practices that enhance sustainability and spatial quality in regional landscape-based schemes. As Stephenson [1] states, ‘presenting landscape as “space” has a long pedigree in assessment practice, but conveying its rich and messy place-values is still a rarity in practice’. The interpretation of low carbon is often challenged, with practitioners, researchers and others questioning whether it is based on activities, lifestyles and voluntary behaviour change or in policy frameworks influenced by regulatory forces [2].

The significance of this paper comes from the examination of two case studies in the Netherlands, the Room for the River (*Ruimte voor de Rivier*) and the New Dutch Waterline (Nieuwe Hollandse Waterlinie), which demonstrate how water safety, hydrological efficiency and sense of place contribute to low carbon and design quality. Through identifying the lessons learned, the real benefits of a well-thought-out and sustainable design as well as the importance of the governance in decision making, we explore how the two schemes have generated an innovative way of dealing with the strategic scale and how this affects the landscape infrastructure and the environmental scene in the Netherlands. We identify a series of innovative steps that these strategic projects have followed from establishing the vision, integrating design at an early stage, to the interaction of governance and public participation and the

successful delivery with further outcomes to the regional or national planning process. The whole project process is conceptualised as an alternative to the common current project frameworks, resulting in large-scale schemes that effectively address environmental challenges, behavioural change and quality of space.

2. The vision for sustainable strategic spatial schemes

Introducing a powerful vision for a sustainable landscape project that deals with environmental challenges while, at the same time, enhancing social and cultural characteristics and delivering economic benefits is not an easy thing. Nevertheless, we suggest that it should be one of the fundamental steps in order to bring landscape design to the forefront of sustainable development. The ‘design concept’ for landscape, as it also might be called, can describe the story of a place, make it inspiring, attractive and appealing to visitors and locals.

The Room for the River and the New Dutch Waterline are two pioneer national landscape programmes dealing with climate change, water level rise and quality of space. Their focus lies in the effective delivery of large-scale developments that address environmental challenges and educate people about the landscape.

2.1. Room for the River

The Room for the River is a climate adaptation programme that was introduced as an alternative to traditional planning approaches and was intended to form a more sustainable way of dealing with increased rainfall and rising sea levels. The serious

flooding that affected the Netherlands in 1993 and 1995 was the trigger for a change in the planning and management of the river catchment areas (Fig. 1, Appendix), resulting in the development of this programme. It is a national-scale design strategy, ensuring a high level of protection against rising water levels in 34 locations across the Netherlands, while introducing a vision for a carbon-neutral life. Aiming to improve the overall environmental quality in the river region and having developed a method for the assessment of the designs proposed, this scheme is also a good example of how the low-carbon concept can be covered in spatial strategies.

2.2. New Dutch Waterline

The ‘New Dutch Waterline’ is also a national landscape programme consisting of approximately 60 different fortifications across the Netherlands (Fig. 2, Appendix), focusing on the preservation and revitalisation of the landscape infrastructure and aiming for enhanced sustainability and quality of space. The fortification network was originally designed in the 19th century as a military defence system to enable controlled inundation through sophisticated landscape engineering, but was never used, leaving a historic and cultural landscape now in need of revitalisation.

The vision of this scheme was to create new values for the fortifications, aiming to preserve and regenerate the existing structures while improving their visibility and accessibility to the existing landscape. The successful implementation of the programme, together with the emphasis on sustainability and landscape quality, has resulted in improvement of the existing historical landscape, creation of valuable public space and a unique identity to the

landscape; and has led to nomination as a tentative UNESCO site.

The two Dutch case studies are successful examples of a visionary narrative, introduced by landscape design and expressed through drawings and text, a process that allowed the vision to be developed and transformed over time. Designs embedded into the project process have created beneficial outcomes for public engagement and delivery, by improving communication and visualisation of the landscape ideas. The two schemes demonstrate the significance of a landscape concept presented visually, and the need for the landscape project process to be perceived in a different way than is commonly the case today, blending ideas with drawings and text following a vision for sustainable future.

3. Project process framework

The examination of the two case studies presented here reveals an innovative project process that builds upon the proposed vision. The structure followed by both Dutch schemes introduces an alternative way of working, compared with the common landscape infrastructure project frameworks. The establishment of a vision has secured environmental uncertainties, and embedded key ideas such as low carbon and spatial quality in project delivery.

On examining the frameworks evolved by the pioneer studies, we suggest that the schemes were not only planned to deliver a piece (or pieces) of infrastructure, but to create sustainable places and cover environmental and societal needs, paying respect to the cultural aspects. Looking and evaluating the landscape, the area and the society, a series of concepts and ideas have been identified resulting in a new

combination and effective use of methods and techniques (eg. legislation, continuous evaluation, timing) that follow an overall alternative project framework.

A sophisticated process focusing on spatial understanding, a different way of ‘conceptualising and shaping the project’, the integration of key ideas into policies and politics and the importance of early planning at the implementation and delivery of a large-scale scheme, are all important elements for the regional design project and have played major roles in both the Room for the River and the New Dutch Waterline. In particular, a framework focusing on the conceptualisation and the actions shaping the scheme’s vision has the potential to affect governmental values as well as decision making, with consequent impacts on project delivery and outcomes.

Regional- and strategic-scale schemes are often conceptualised, established and delivered by the project management or administration process, controlled by governmental institutions. They often follow a ‘common’ and ‘conventional’ process of management and delivery, and it seems to be only when there is multidisciplinary interest and a pressure for a low-carbon vision, as happened at the two case studies, that an alternative project process is likely to emerge.

We suggest that a sequence of processes referred here as ‘shaping the project/alternative project framework’ needs to be established and introduced for all major infrastructure schemes. Such administrative frameworks can develop on a strategic scale (as with the example projects discussed here) and can form a significant part of decision making, securing the way in which quality elements can be spatially implemented. Van den Broeck [3],

discussing administrative processes and policies, has suggested that ‘it is a challenge to develop a new kind of “frames” and a new way to use them for judgement and decision making aiming at spatial quality, however these frames [are meant to] to ensure legal certainty’. As shown by the successful outcomes of the Dutch projects examined here, such frameworks are likely to secure the effective delivery of a sustainable scheme and become a powerful example of large-scale implementation.

3.1. Key points of these project frameworks

Specific elements integrated to their project frameworks have impacted positively on the delivery of the programmes of the two innovative strategic schemes presented here. We suggest that the elements identified play a major role in the way in which a vision is communicated and understood during the project development. The key practices identified are: vision, early integration of important messages, communication, continuous evaluation of the project process, policy and legislation, governmental support, education and awareness, active and continuous public engagement and use of design as a driver for business regeneration and economic outputs.

One of the main outcomes of the study is that concepts such as spatial quality and low carbon, that may be challenging owing to their elastic and variable definitions, can be effectively delivered when they are properly planned and integrated in the earliest stages of a landscape project. The importance of ‘timing’ for key messages in a landscape design secures their integration within the overall vision and highlights the importance and benefits of their delivery. For example, the Room for the River demonstrates a variety of key actions based on a strategic

project framework. This framework focuses on key concepts such as hydrological efficiency and spatial quality, the way in which they have been carried through from the beginning (concept) to the implementation phase and the actions of the stakeholders involved.

Another vital element in the project framework, but one that is often introduced at a later stage, is strong communication. A less effective communication strategy within the project management can cause implementation delays and result in a diversion of its environmental scope. In strategic schemes, the diverse stakeholders need to be clear about the vision and then use tools, communication channels, drawings and vocabulary, introduced through the project framework, that will help them transition from the conceptual to the implementation phase.

Early integration of important ideas, a solid project framework and legislation have significant impacts on decisions made during the landscape process and result in new ways of project delivery. Successful integration of these elements in the 'routine framework' of a landscape scheme would enhance landscape identity, delivering a scheme with strong environmental messages and producing enhanced landscape quality in the perceptions of its users.

4. Different approaches in the Dutch projects

Individual methods, such as those described above, have probably been used in previous landscape schemes, however it is their combination in addition to the creation of a strong policy framework guarded by external expert teams and governmental institutions that has resulted in the

successful implementation of the pioneer schemes Room for the River and New Dutch Waterline. Their landscape process demonstrates how design can change public opinion on sustainable landscapes and the way in which policy and legislation secure project delivery.

Policy

The Dutch system appears to be quite progressive in the integration of such concepts, but for this to be implemented, policies need to be in place to support the management of the process [4]. The legislation introduced and facilitated the schemes, settled design at the core of the process and helped in the creation of a unique team to evaluate the projects' progress regarding spatial quality. The fast pace with which the project framework is often established makes it challenging for such concepts to be properly introduced, therefore the innovative method of a dedicated team has offered significant outcomes to this point. The European Climate Adaptation Platform explains that 'the old policy [in the Netherlands] was based on discharging surplus water to the sea as quickly as possible, the new policy became to first retain water, then store the water and finally discharge the excess water. The new water policy was later linked to nature development and implementation of the EU Water Framework Directive' [5]. Similarly, the two projects examined here fulfil legal requirements with key elements of water safety, secured their integration within the process and their implementation in the landscape scheme.

Stakeholder Collaboration

The programme framework developed for the Room for the River illustrates how

the different stakeholders communicated and collaborated in securing the goals set by the administration. It deals with the integration of conceptual ideas being developed across the different projects and the way in which they can be secured during the landscape process. The main bodies involved at a strategic scale are illustrated in Fig. 3 (Appendix) and are the 'Programme Office', the 'Landscape architecture team embedded in the Programme Office', the 'Water management team', the 'Spatial Quality team', and 'Deltares', the external quality and sustainability team [4]. Additional institutions, organisations and individuals have also taken part in various stages of the programme.

The Programme Office and the individual project teams are responsible for the final decisions; however the other bodies participating in the programme, such as Deltares, the external Quality team, evaluate specific quality elements such as water efficiency, landscape quality, environmental elements and more. The Landscape team has a continuous communication role between the Programme Office and the Quality team, supporting the project development. The Water Management team is embedded in the main structure of the scheme and it is responsible for the evaluation of water safety, sustainability and low carbon elements. Deltares is responsible for a second evaluation of the environmental aspect, and also secures the water management process.

Addressing all scales

The focus of processes has followed a sequence from the broad scale, through various intermediate stages, down to the very detailed characteristics of a specific location.

Demonstrating the close involvement of governmental institutions not only in strategic but also in local scale for the Room for the River, it was found that the Ministry of Infrastructure and the Environment established an administrative collaboration that was set as a partnership agreement with the Ministry of Economic Affairs, Agriculture and Innovation, Werkendam City Council (near Noordwaard - one of the 34 project locations), Rivierland Water Board, Province of North Brabant (province of Noordwaard) and the Department of Public Works South Holland [4].

Design as a major communication tool

Design needs to be established as a requirement of the project framework for the scheme to be able to respond appropriately to the setting and the social and cultural needs of the area. Drawings have a significant role in this strategy, communicating ideas and engaging stakeholders throughout the process. Both national schemes had a close relationship with designers and a Quality team, aiming to secure not only function but also sense of place and public engagement. More specifically, the concepts of spatial quality, low carbon and design had not been used in the same holistic way in such large-scale projects before [4], which makes it an innovative conceptual framework in landscape strategies. Given the success of the two projects, this has a major potential impact for the future spatial planning and design policy of the Dutch government.

5. Why they are successful

We suggest that the delivery of the landscape schemes is an outcome of their success in creating a holistic plan and project framework embedding all the different elements presented above in a way that all play a key role in the landscape design process. We argue that the political dimension facilitates the landscape project, and impacts on political actions related to the landscape design and the whole region. A series of important steps (clarification, shaping the project, politics, policies, institutional involvement, and timing) are necessary in order to secure the delivery of the key qualities and elements. The development of alternative project frameworks by the national programmes in the Netherlands would not have been achieved without strong support from the government and the creation of new legislation, securing a smooth delivery of the landscape projects. Whether dealing with historic landscapes and sensitising the society or having the desire to create a landmark project, addressing climate change, while the same time enhancing economic and social values, these strategic developments clearly had the effective support of the government before and during the project process.

Highlighting the importance of procurement processes in the implementation of landscape design, Moore [6] has stated that ‘to have any real chance of providing a sustainable and lasting blueprint for the landscape, this way of working needs to become wholeheartedly absorbed into all of the decision making institutions and organisations responsible for policy, strategic or regional planning at a national or international level’. The projects discussed here have illustrated that legislation and politics in relation to landscape design can be an effective way to

engage with the land and the region and guide the development of a new way of thinking, as well as acting both in public and private sectors. Spatial quality, water safety, hydrological efficiency, community engagement and landscape preservation are addressed in the policies and legislation of these national programmes, helping to ensure their integration within the narrative and therefore their successful delivery within the scheme [4]. Increasingly it is recognised that ‘there is no alternative for countries but to incorporate low carbon measures in their development policies. The reality of climate change demands it, and there are also clear benefits in pursuing such for policies’ [7]. Both the Room for the River and the New Dutch Waterline have made significant progress in the interrelation of politics and the landscape, changing public opinion and establishing specific laws for the landscape scale in relation to climate challenges.

6. Conclusion

Successful delivery of sustainable strategic schemes is not a one-way process, and requires the engagement of various actions. We suggest that policies, legislation and the establishment of a project framework all have significant impact on the extent to which key ideas are being delivered at the strategic scale, and secondly that design plays a significant communication and interpretation role for those concepts, allowing better integration in large-scale strategies.

The establishment of an alternative project framework that addresses the needs of each project individually is considered necessary, but it requires support from policy and governmental legislation,

especially on a broader scale. The suggestion for such a framework focuses on recognition of the increasing importance of concepts such as low carbon, climate change, spatial quality and visual representation for improved communication. Therefore a process that will successfully provide integration of all these individual elements to a large-scale scheme will be a step towards long-term and real sustainable implementation and a formula to more clearly address climate challenges through landscape architecture.

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Appendix

How we are making room for the river



Deepening summer bed

The river bed is deepened by excavating the surface layer of the river bed. The deepened river bed provides more room for the river.



Water storage

The Volkerak-Zoommeer lake provides for temporary water storage when exceptional conditions result in the combination of a closed storm surge barrier and high river discharges to the sea.



Dyke relocation

Relocating a dyke land inwards increases the width of the floodplains and provides more room for the river.



Strengthening dykes

Dykes are strengthened in areas in which creating more room for the river is not an option.



High-water channel

A high-water channel is a dyked area that branches off from the main river to discharge some of the water via a separate route.



Lowering of floodplains

Lowering (excavating) an area of the floodplain increases the room for the river during high water levels.



Lowering groynes

Groynes stabilise the location of the river and ensure that the river remains at the correct depth. However, at high water levels groynes can form an obstruction to the flow of water in the river. Lowering groynes increases the flow rate of the water in the river.



Depoldering

The dyke on the river side of a polder is relocated land inwards and water can flow into the polder at high water levels.



Removing obstacles

Removing or modifying obstacles in the river bed where possible, or modifying them, increases the flow rate of the water in the river.

Fig. 1. Diagrams demonstrating the nine different methods proposed by the Room for the River programme addressing water safety. The methods were used in considering the location, the geographical characteristics and social impact. Source: Room for the River.



Fig. 2. Left: Map of the ‘New Dutch Waterline’ landscape scheme showing the defence line and the locations of the fortresses that have now adopt different uses. Right: Showing the whole defence line, the locations around the fortresses that could have been inundated in the past and are now regenerated open areas. Source: public material – collected from Water Museum, the Netherlands.

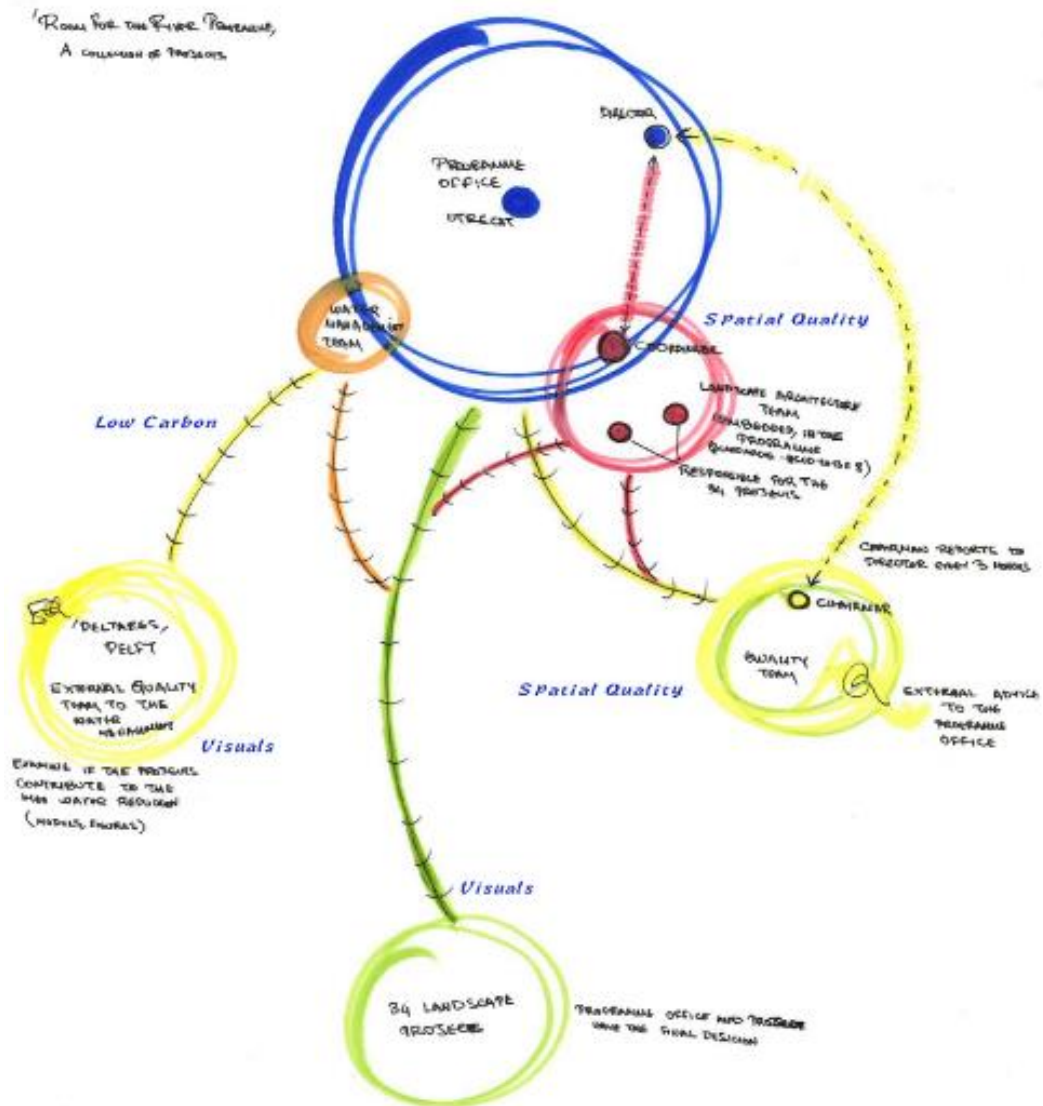


Fig. 3. Programme framework for the Room for the River illustrating the main stakeholders participating in the scheme (Author's based on interviews with staff from the Room for the River).

A study of the planning and design process of Green infrastructure focusing on green street approach: Guidance to successful implementation

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Abstract

Green infrastructure pursues sustainable and affordable development approaches to promote resilient urban environments. It is becoming more useful for being able to prevent the destruction of limited natural resources and amending the degraded environment of urban areas as providing multiple (environmental, social, and economic) benefits to a community rather than pursuing a single-purpose approach (e.g. stormwater management). Regardless all the potential benefits, one of the challenges in promoting the application of green infrastructure is the “uncertainty” about what it can provide and how it is implemented. One way of promoting successful application of green infrastructure with emphasis on multiple benefits will be understanding the implementation process because it can help to provide consistency in decision making and understanding what is required for overcoming uncertainty. To have specified investigation, the study looks into different processes of implementing green street (one of 11 elements of green infrastructure recommended by the US EPA) for a better understanding of multi-step protocols of the implementation processes. It brings into focus on what needs to be considered regarding procedures, resources, disciplines, stakeholders, and others throughout different steps of the implementation processes. The study aims to provide an overview of an established green street oriented implementation process and promote its effective application by investigating different processes and empirical insights of city officials who worked on green street projects. Primary data collection was a semi-organized interview with city experts who worked on green street projects from selected six cities. The list of target cities are not exhaustive but the criteria for the study was 1) cities with strong history of implementing green street and with projects completed more than one year ago, 2) cities allowing convenient access to rich documentation on the projects, and 3) cities with available experts who had worked on green street projects in their respective municipal departments (which could include Parks and Recreation, Environmental Protection, or Planning and Development, for example). There was an additional round of interviews with other city experts who worked on green street projects (nominated successful projects by city experts from the first round of interviews) to obtain more detailed data regarding the implementation processes. The data was primarily analyzed using content analysis based on

cultural psychology, which includes multi-step qualitative analysis followed by flowcharts/diagrams and a member check method. The analysis presents the implementation of green street projects involves a breadth of important considerations, such as Setting Priorities, Funding Sources, Involvement of Multiple Parties, Planning & Design Protocol, Public Outreach, Operation & Maintenance, and Challenges. Various resources, techniques, and procedures are therefore required for the implementation process. As taking them into account, the author suggests a suitable framework to guide the process for successful implementation for planners and designers, especially who are in the early part of adapting a green street. It also aims to provide more understanding of green street and the implementation process for the promotion of its installation and acceptance by planners and designers and even by the public for the future of the urban resiliency.

Keywords: green street; green infrastructure; design process; sustainability; urban resiliency

1. Introduction

Green infrastructure pursues sustainable and affordable development approaches to promote resilient urban environments. Although it is useful to prevent destruction of natural resources and to provide the urban areas with environmental, social and economic benefits, one of the reasons promoting the application of green infrastructure can be challenging is the “uncertainty” of its intangible benefits and lack of general knowledge among the public and planners [1]. Therefore, understanding the implementation process of the infrastructure is important and may help promoting successful application of green infrastructure. It will help to provide consistency in decision making and understanding what is required. The study looks into different processes of implementing green street (one of 11 elements of green infrastructure recommended by the US EPA) for a better understanding of multi-step protocols of the implementation processes. It brings into focus on what needs to be considered regarding procedures, resources, disciplines, stakeholders, and others throughout different steps of the implementation processes. The

study aims to provide an overview of an established green street oriented implementation process and promote its effective application by investigating different processes and empirical insights of city officials who worked on green street projects.

1.1. Importance of Green Street

Green streets are designed to deal with stormwater runoff at the source by closely mimicking natural processes in urbanized watersheds. They are primarily implemented on a public right of way. They are often more environmentally and economically effective than conventional storm or combined sewer systems.

As an element of green infrastructure, an ideal green street projects are designed using a complex strategy for pursuing urban resiliency and sustainability. It can, like green infrastructure, “act as a synthesis of a number of other areas of planning (greenways, green spaces, high-density planning) to promote a coherent discipline for future development” [2]. The multiple benefits of sustainable development are the ultimate goal for green streets considering site contexts. This means that green streets need to emphasize the network system approach that can successfully integrate multifunctional disciplines to

promote their influence throughout the site. The green street approach is now being adopted by many localities, the projects are widely recognized as providing effective and “affordable solutions that meet many objectives at once” [3].

2. Methodology

The primary methods chosen for the study is a semi-structured interview with experts from different municipalities who worked on green street projects to obtain their insights. It is to evaluate the processes in detail based on their specific experiences and opinions in the field [4][5] regarding how decisions were made and what procedural actions were taken.

The six-sample cities, which performed rigorous green street approaches have chosen through purposeful sampling [6] and the criteria of the selection are: 1) Cities with a relatively long history of implementing green streets with those projects completed more than a year previously, 2) cities allowing convenient access to rich documentation (municipal reports, articles (news, journals), websites) on the projects, and 3) cities with available experts who had worked on green street projects in their respective municipal departments. The sample cities are Seattle, WA, Portland, OR, New York, NY, Philadelphia, PA, Washington D.C., and Arlington, VA. In addition, another round of interviews with city experts were conducted for the four case projects selected from the list of successful green street projects nominated by the experts from the interviews including case projects frequently mentioned through websites of design firms or municipalities allowing a variety of sample projects and data. Selected projects are Broadview Green Grid (Seattle, WA), Holman Pocket Park and Green Street Bike Boulevard Project (Portland, OR), Maynard Avenue Green street Project (Seattle, WA),

and College Avenue Promenade, (Blacksburg, VA).

The collected first interview data was analyzed with a content analysis of psychological phenomenology developed by Ratner [7] to study aspects of green street implementation, with a focus on how green streets were planned and constructed (attributes of considerations regarding the implementation of green street). Interview contents were analyzed and relevant statements were grouped and summarized as ‘central theme’, then central themes were grouped and categorized as ‘general theme (upper level of the central theme)’ [7]. The method was chosen to effectively analyze the contents of interviews as a whole rather than focusing on interview questions to categorize the contents. The next analysis focused on developing a model process of green street implementation involving three phased analyses: The interview responses only regarding typical implementation processes in the six sample cities were analyzed. These data are categorized following the simplified four-staged landscape planning protocol: project initiation, design, construction, and operation & maintenance (See Figure 1) with a deductive approach. The four-staged model made the comparison of different processes in the sample cities more effective and convenient. In addition, the second-round interview focused on specific performances (actions in the decision-making process) that have been conducted for four successful green street cases were analyzed. The results were also categorized and added corresponding to each stage (See Figure 2).

A member check analysis was adopted in the process of creating a green street oriented model process not only to increase validity [8], but also to develop a green street oriented model process. The created preliminary model process was presented back to the expert participants for their review and, feedback and the model

process was modified and finalized accordingly.

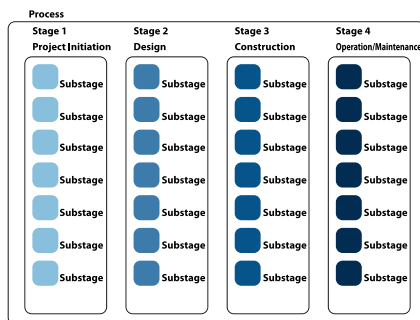


Figure 1. Diagram of the four-stage process. Sub-stages (blue squares) are the detailed protocols of each stage.

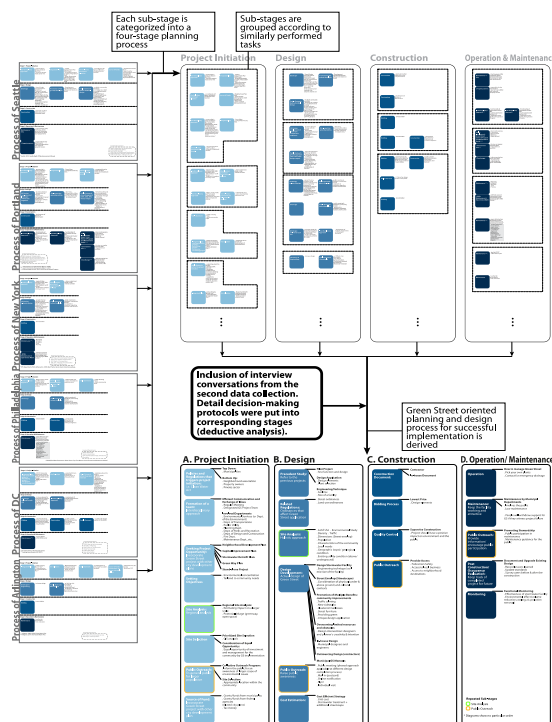


Figure 2. Protocol of developing green street planning process.

3. Analysis

3.1. Attributes of Planning and Design of Green Street

The first analysis presented a breadth of important attributes of considerations (7 general themes and 31 central themes) in the

planning and design of a green street (See Figure 3).

First, Improving Stormwater Quality and Quantity (CT.1); Inclusion of Additional Benefits (CT.2); and Change in Priorities (CT.3) were identified as sub-attributes (central theme) to be considered in the green street implementation process. They were grouped under **Setting Priorities** (GT.1, general theme). Stormwater management was a common priority for all of the six sample cities. Additional benefits were also mentioned as priorities in building green streets in three cities. The most considered benefits were neighborhood improvement, traffic calming, traffic functionality, environmental improvement, and cost effectiveness. Some of the sample cities changed the priorities of their green street projects over time depending on city's needs.

Second, Fund/Grant from Local Municipality (CT.4) and Federal Fund/Grant (CT.5) were identified and grouped under **Funding Sources** (GT.2). Experts identified two primary funding/grant sources from municipalities and federal agencies. All sample cities received funds/grants from their municipalities regarding city development plans (capital improvement and neighborhood development), which were not strictly limited to stormwater projects. Funding for the projects also tend to be a mix of funds/grants from different agencies, often offered communities expertise and resources.

Third, City Initiated Projects (CT.6), Public (online/resident) Initiated Projects (CT.7), Private Developer Initiated Projects (CT.8), and Projects Involving Multiple Departments (CT.9) were identified as sub-attributes and grouped under **Involvement of Multiple Parties** (GT.3). For all of the sample cities, municipalities were the main agents initiating green street projects. This is understandable considering its primary location in the public right of way, but some of projects were also initiated by

communities or private developers. In general, green street projects involve multiple departments during the implementation process. In the sample cities, the interdisciplinary approach meant that various departments were involved, particularly environmental departments (mainly with a stormwater management focus) and transportation departments (mainly with a city improvement focus), followed by parks and utilities. An interdisciplinary approach to projects allowed for new ideas and professional collaborations, but it also often caused conflicts of interests or confusion.

Fourth, Available Space for Implementation (CT.10), Consideration of Site Contexts (CT.11), Consideration of Pedestrian Safety (CT.12), Improvement to Life (CT.13), Improvement from Previous Design (CT.14), Effective Stormwater Treatment Performance & Implementation (CT.15) were grouped under **Planning & Design Protocol** (GT.4). Experts mentioned design protocols that focused on efforts to include additional benefits, such as improving pedestrian safety or promoting better living. Green streets also can simply provide effective stormwater management by rigorously utilizing available space in the right of way. Though the sample cities had design standards and manuals, experts tried to consider various aspects beyond the manuals and standards by considering site contexts.

Fifth, Public/Community Meeting (CT.16), Phased Public Outreach (CT.17), Public Education (CT.18), Individual Conversation (CT.19), Sending out Flyers (CT.20), and Plant Palette Selection (CT.21) were grouped under **Public Outreach** (GT.5). Public outreach was an important process of obtaining insights from the public as well as informing the public regarding what would happen so that they could prepare for the construction in their neighborhood. Moreover, it was an opportunity to get consent from the public

for the project. The public outreach could take the form of public meetings with communities or local community groups regarding design decisions, collecting opinions, informing about construction schedules, and/or visiting individual homes to hear opinions. Other forms of communication include flyers, postcards, and emails for people who live and work adjacent to green street projects.

Sixth, Municipal Involvement (CT.22), Public Involvement (CT.23), Private Contractor (CT.24), and Inclusion of Monitoring (CT.25) were grouped under **Operation & Maintenance** (GT.6). Maintenance was mainly conducted with municipal involvement, though no significant responsibilities were given to particular parties. Also, in some cases only 'light maintenance' was used. Some programs made an attempt to include public involvement, in their maintenance programs, but this mostly entailed simple tasks such as weeding and collecting trash. Some cities have considered or hired private contractors, for maintenance. And some of the programs made use of inclusion of monitoring to test how green streets were functioning in relation to current use and future improvement.

Lastly, Challenges in Setting Priorities (CT.26), Site Constraints (CT.27), Economic Considerations (CT.28), Technical Challenges in Design and Construction (CT.29), Community Resistance/Concerns (CT.30), and Difficulties in Public Outreach (CT.31) were grouped under **Challenges in Green street Implementation** (GT.7). Challenges in setting priorities arose from disagreement between municipalities and the public in the decision-making process. Much of this disagreement arose from the different goals and priorities of the parties involved. Because green street facilities typically need to contain a certain amount of water and underground installations, especially concerning underground conditions,

difficulties may arise. Green street projects often depended upon obtaining the needed funds and pursuing affordable construction. Since green streets were a relatively new approach, technical challenges in design and construction, also came into play. Some of the projects met with community resistance or concerns, regarding having green streets in their neighborhoods and enduring the disruptions of construction. Lastly, difficulties in public outreach concerning community education was discussed.

design, construction, and operation & maintenance.

When developing the preliminary model process, for project initiation stages, the experts' discussion centered on how the sample cities prioritize site selection, seek project opportunities, and work with other departments (interdisciplinary approach). In the discussion of design stages, public outreach was discussed as an important means of receiving feedback from the public and getting users involved in the design procedure. In the discussion of construction stages, bidding procedure was described and maintenance stage has not shown any particular discussion but light maintenance throughout the year.

During the member check process to finalize the model process, all the experts approved of the division into four stages of the model process, but there were various opinions on the sub-stages included in each stage. The first item the experts noted was that public outreach could take place more than once and fulfilled different purposes at different stages in the process. The second point raised was that the site analysis could be done in two stages: project initiation and design. Lastly, public outreach was to obtain public support for the project, design development was to provide actual benefits to the community, and the construction sub-stage was to ensure the design was built as intended. The feedback was reflected and a green street oriented process for successful implementation was presented diagrammatically in Figure 4.

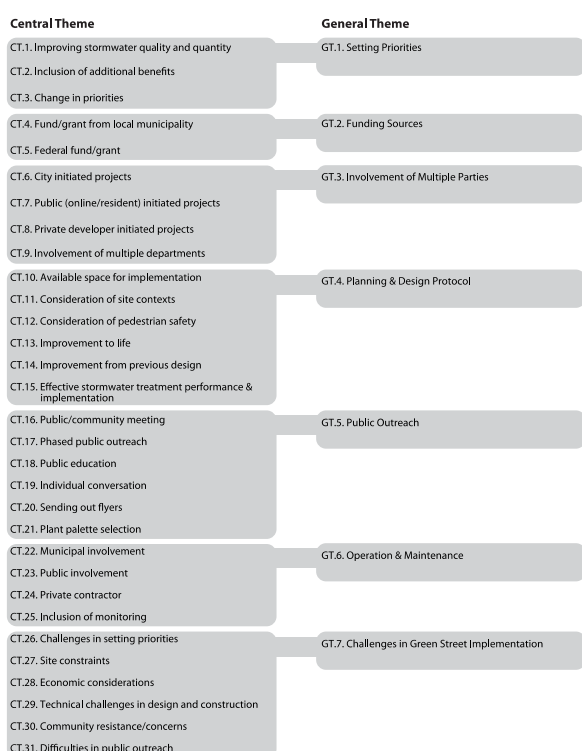


Figure 3 Attributes of considerations in planning and design of green streets

3.2. Green Street Oriented Planning and Design Process

In this section, each sample city's process and distinctive procedural performances of selected case projects were examined and a green street oriented planning and design process for successful implementation was derived. The overall performances in each city were categorized into a four-stage process: project initiation,

4. Conclusion & Recommendations

projects are also likely to provide the additional benefits to the community.

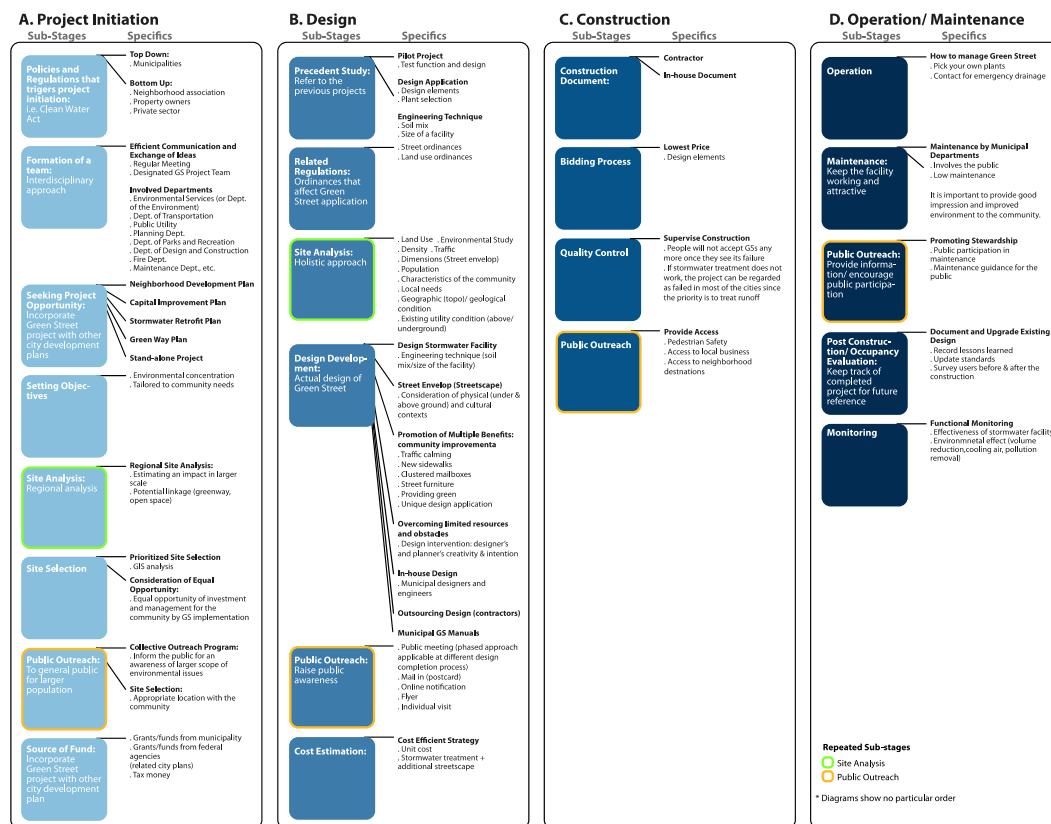


Figure 4. Green street oriented planning and design process: Final

Green street projects include multiple considerations, different human resources, techniques, and materials, required throughout the planning and design process. It requires a suitable framework to guide the entire process that clearly shows necessary steps and decisions. The following sections present procedural performance recommendations for successful green street implementation based on the analyses.

4.1. Accommodate Multiple Visions and Designate a Champion for the Project

The presence of stakeholders or interested parties whose strong vision and clear objectives guide the green street project and can help to ensure that all those involved remain on track as they progress through the different stages of green street implementation. So then, green street

Although a clear vision of the desired endpoint is important, having a champion (either an individual or an agency) who takes responsibility throughout the process is critical for the success of a project since “goodwill [to continue the project] seems to be most effectively garnered by influential individuals within the implementing organization acting as program advocates or ‘champions’” [9].

4.2. Maintain Good Communication Among Related Departments for Effective Interdisciplinary Collaboration

It was clear throughout the research process that green street projects were truly interdisciplinary in nature due to the fact that they are implemented in a public right of way and deal with stormwater runoff. The departments related to Transportation and

Environmental Services are likely to be the most heavily involved. Planning and Parks Departments come in a close second, and other departments, such as Utilities, Maintenance, and Fire Departments, may also be included. The funds, plans, and priorities of green street projects inevitably differ from one project to another. Each department can play its part in successful communication by remaining constantly aware of the potential for conflicting objectives and misunderstandings, and conflicts can be resolved by regular meetings or forming formal interdisciplinary green street teams.

4.3. Understand and Respond to Needs of the Public and Stakeholders

In this research, the public was one of the critical components for implementing successful green street projects. Local people are the ones who will be utilizing the street and interacting with the design elements. It is therefore critical to study what the public's needs and expectations from a given project. It is also hard to satisfy every agency and individual who might be affected by green street projects, thus, as concluded in the previous chapter, public outreach should be considered during all of the stages of a green street implementation process. Public outreach also provides a means of collecting opinions from users and explaining the rationale behind the selection of a project site. A phased outreach approach that syncs with different design completion stages appears to have particular success. At the construction stage, public outreach can be used to inform residents about the construction schedule and available amenities to keep local businesses operating. In the operation & maintenance stage, public involvement in maintenance can be promoted as part of a stewardship program.

4.4. Consider the Whole Street Envelope When Planning and Designing Green Street

In order to maximize the potential benefits of green street practices, a project should be considered together with the street envelope as a whole rather than simply as an isolated system (See Figure 4). This is the case because green streets are located adjacent to where people live, work, and play. However, in the current manuals and design standards, drawings seldom include site contexts such as buildings and street furniture or dimensions of the sidewalk/roadway, along with other factors that consists a street as a whole. Moreover, stormwater treatment facilities need to perform infiltration, provide planting beds, and incorporate underdrain pipes if necessary. Consequently, especially for green street practices, underground conditions need to be investigated through on-site inspections because they can differ from existing documents. Thus, not only the surface areas of a site, but also its underground conditions must be taken into account to ensure the success of a green street project. Figure 5 shows an example of a green street application that considers the site contexts as a whole. Various applications of a green street approach are presented in Figure 6.

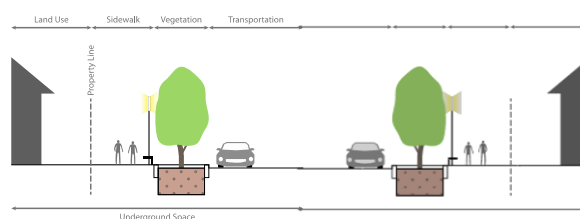


Figure 5. An example of a street envelope: design considerations in a green street practice including land use, sidewalks, planting areas, roadways, and underground conditions.

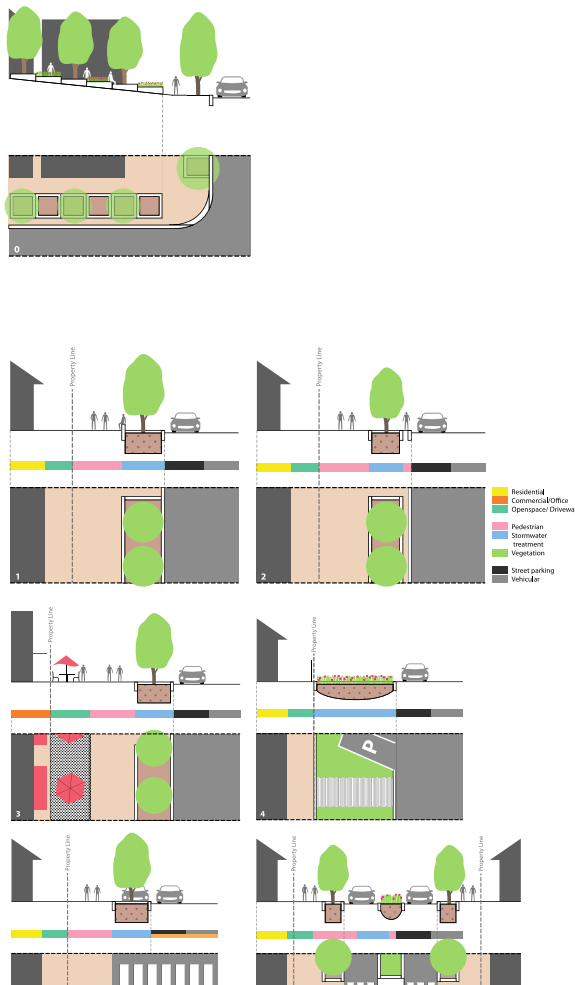


Figure 6. Examples of green street practice: 0. Green street on slope with planter type cascades; 1. Green street with wider sidewalk and seat wall; 2. Green street with wider sidewalk and landing space for street parking; 3. Green street with outdoor activity area in conjunction with sidewalk; 4. Green street with wider and leveled stormwater planter, access to the building, and diagonal parking space; 5. Green street with extended stormwater planter for traffic calming; 6. Green street with stormwater planter in median for safe crossing.

4.5. Integrate Green Street Practice with Primary Municipal Plans and Other City Development Plans to Secure Funds and Address Multiple Benefits

To promote the multiple benefits that can be achieved with the implementation of green streets, integration with larger development plans can be an effective

strategy. Adding the green street approach to municipal plans can provide useful opportunities to obtain stormwater management-related funds, freeing up municipal funds to pay for other streetscape improvements. It can also be a useful solution for any communities with stormwater related issues but not enough budget. Also, if a funding shortage is experienced, designers and planners may seek for a partnership with other agencies, such as the U.S. Environmental Protection Agency (EPA), U.S. Department of Transportation (DOT), U.S. Department of Housing and Urban Development (HUD), U.S. Department of Agriculture (USDA), U.S. Department of the Interior (DOI), and more (Environmental Protection Agency, 2014).

4.6. Integrate Maintenance Plans into Green Street Master Plans

Once the construction stage is complete, maintenance becomes the most important aspect of green street projects because they all require a certain level of maintenance. Despite its importance, maintenance represented a surprisingly low priority for those implementing green street projects. This low interest in maintenance can also affect public acceptance of a green street. Drainage and infiltration systems require constant care to deal with the public's concerns and keep green street facilities running smoothly. A clearly needed change is to incorporate a maintenance plan into the design and construction stages for easier operation and improved public acceptance. Low maintenance strategies can also be incorporated and deciding on a principal agency for the maintenance could be helpful. Another approach, which has proved successful, is creating a plant palette that allows users to select the plants they would prefer to have near their homes. Public participation in maintenance has the benefit of securing residents' interests in and

engagement with the projects in their neighborhoods.

4.7. Archive and Share Related Research and Knowledge by Conducting Post-Construction/Occupancy Evaluation and Monitoring

Green street is a relatively new strategy, with the oldest project in the United States (the SEA Street in Seattle) going back about seventeen years. Since green street practices typically include living plant materials, the techniques adopted need to consider the suitability of plant species and drainage systems in a given facility with particular living environment, site conditions, types of practices implemented, target pollutants, and users' preferences. Thus, the techniques and knowledge are still in the development stage and it takes time for the system to fully function and be evaluated. Post-construction evaluation or monitoring was seldom mentioned by the experts throughout the interview responses. Post-construction monitoring and evaluations can contribute to the development of more advanced techniques and minimize the potential for mistakes and bad practices in future projects.

4.8. Develop and Provide an Appropriate Green Street-Oriented Process for Each Municipality based on the Derived Model Process in This Research

Planners and designers can use the model process (Figure 4) developed in this research as a checklist to ensure that the necessary protocols and resources are in place to maximize the additional benefits for successful green street implementation. The sub-stages that are listed under the four main stages in the model are collective elements, and planners and designers should choose the sub-stages that most closely match their local conditions and available resources at both the municipal and site levels. The

provision of a process that has been tailored to suit the needs of a particular municipality and local community will contribute to the achievement of a successful green street project.

Green streets need to be considered as a complex strategy rather than a simple stormwater treatment solution. Green street oriented planning and design process can have the plan to include social and cultural contexts along with required design elements and site conditions for future resiliency of urban communities.

Acknowledgement

The author would like to thank Professor Patrick Miller and Professor Dean Bork for their valuable insights and knowledge provided to this research.

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Life• Commemoration• Post-earthquake reconstruction: The Design of Three Bridges Square in Feixianguan Town, Lushan Country

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Abstract

The Three Bridges Square in Feixianguan Town of Lushan County is an important livelihood project in the “4.20 reconstruction after strong earthquake in Lushan”. Because of its special natural and cultural environment background, it bears the role as the door to “gateway” and it records the nature and humanities history of Lushan County. It has witnessed the responsibility in Lushan for someone who has supported the entire construction process after the disaster.

The project follows the important instructions of the country's post-disaster reconstruction and the guiding principles of regional planning. It responds to the complex environmental issues like some bases covered by earthquake-hit areas , as well as to protect the ancient Tea Horse Road, the entrance to Tibet, the Red Army’s ancient bridges and 318 national highways in terms of four aspects : the planning and positioning, traffic organization, layout of function, and coordination of characteristics.

Through using of cantilevered platforms and expanding the use of beach land by reasonably using of terrain heights to ease the tense condition of land use. The design start with the actual needs of local people with considering local traditional activities and the materials and construction techniques to effectively resolve problems in local self-building.

Keywords: Earthquake aid construction; Post disaster planning; Square design; Local construction

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1. Introduction

On April 20, 2013, an earthquake with a surface wave magnitude of 7.0 occurred at the junction of Longmen Town, Baosheng

Town and Taiping Town in Lushan County, Ya'an City, Sichuan Province (30.3°N latitude and 103.0°E longitude). The

maximum intensity of it was 9 degrees and the area affected by the disaster was about 18,682 square kilometers. There were 4045 aftershocks in the earthquake area and 1.52 million people were affected. The 4·20 Lushan M7.0 earthquake had caused huge losses to social economy and people's property, immediately, the nation launched an emergency response plan after the disaster and spared no effort in emergency rescue and transitional resettlement, and quickly started the recovery and reconstruction of the area.

In order to meet requirements of the Party Central Committee of CPC, State Council and Sichuan Provincial Party Committee and Provincial Government's decision-making for post-earthquake recovery and reconstruction of the "4·20" Lushan earthquake, and in accordance with important instructions of Secretary Xi's on May 2 in "Report of the CPC Sichuan Provincial Committee on the earthquake relief work of the "4.20" Lushan strong earthquake that are "Comprehensive and accurate assessment of disaster losses, obeying rule of the people-oriented, showing respect for nature, overall consideration, being based on the current, meeting long-term scientific reconstruction requirements, and starting the disaster recovery and reconstruction work as soon as possible", it should guarantee the restoration of post-disaster reconstruction in Lushan to be carried out scientifically, efficiently, and in an orderly manner. Making it sure to actively and steadily restores the normal life, production, study, and working conditions of the people in the disaster-stricken areas, and promotes the recovery and development of economic and social disasters in the disaster-stricken areas. The Three Bridges Square

project is a key project for reconstruction work. The design follows the macro control of the entire disaster area and the overall control of the regional planning. "The construction of the post-disaster area is a process of reconstruction. In this process, Foresight and historicity in planning is equally important."

As an ancient city with a history of more than 2300 years, Lushan county is the only way for the ancient Sichuan Tibet tea horse road and the important node of the red culture in Sichuan Province. Feixian guan is the South Gate of Lushan, also, the first pass of Sichuan-Tibet. It has always been one of the goods and distribution center of the four major counties all around. Now, there is still a historical trace of prosperity.

The national highway 318, which was built after the reform and opening up, is known as China's most beautiful road. This road is still the main road to Tibet at present. Countless backpackers and cycling Team entering the Tibetan area through Feixianguan, Three Bridges Square is precisely built in this juncture, which is called "the first throat" on the Sichuan Tibet line.

The site is triangular shape (Figure 1). One side is facing the Xing Jing River and the Baoxing River, and the other two borders are connected Tianquan and Lushan country by the National Road and the provincial road, which occupy the place of the intersection of the traffic, and form the first stop for the relief and reconstruction.

Therefore, the environment in which the project is located is relatively complex and the design is faced with multiple challenges. Its concept is to integrate the expressive themes of the 4·20 earthquake disaster, in the meantime, it also needs to follow the macro



Fig. 1. Contrast photograph of before and after completion

ideas of the superior planning. In the implementation, the comprehensive consideration includes that the base is located in the ancient Tea Horse Road, the location of the road, the value of transportation to Tibet, the importance of the entrance of Feixianguan Town and other natural environmental issues, and the geographical characteristics of residential areas in northern Sichuan, historical values of the Red Army Bridge and the bridgehead, and other cultural and environmental issues like the use for the surrounding people and future tourists, and the specific response to regional planning guidelines and national instructions are also should be included.

2. Planning and positioning

As the leading unit in the post-disaster reconstruction, the China Regulation Institute was commissioned by the State Council to resident and design. In the master plan of Feixianguan Town, it proposed to integrate tourism development with sustainable development of the local economy and integrate urban and rural development and

new rural construction. Through the effective allocation of space resources, the orderly arrangement of construction projects to deal well with the relationships among tourism development, urban construction, resettlement, environmental protection, tourist markets, community interests, cultural heritage, industry interaction, regional development, etc. Regarding 4A scenic spot as a standard, to conduct construction of a high-quality tourism area and to complete tourism infrastructure and improve adaptability, feasibility and persistence of supporting service facilities to lay a good foundation for the dynamic cycle of planning, construction, operation and management of Feixianyi area.

As an important spatial node leading the area, Three Bridges Square also occupies the largest flat open space in the planned field, and its opportunities and challenges coexist. It is necessary to "seek common ground" and follow the guidance and control of planning. It is also necessary to "reserve difference" to explore the way in which it balances the contradictions between multiple site elements and thus shoulder the value and mission of leading the region.

The commemorative nature of the plaza determines the image landmark and the particularity of the design. The Three Bridges Square is also an important junction for the planning of three important tourist routes: the regional cultural line, the traditional commercial leisure line and the sports ecological line, and strives to achieve "Livable, suitable for business, suitable for travel", closely follow the regional orientation of people's livelihood (Figure 2).

It will become an important part of the disaster area's revitalization of tourism development, business operations, and tourism service systems. Relying on the unique natural landscape environment and profound historical and cultural heritage to provide a good venue for the development of the district and it will be the main celebration platform for the festival in Lushan County. It will fully consider the actual situation of the disaster area and the needs of the people and effectively improve the urban and rural living environment. We must take into consideration the actual situation of the construction of the disaster area, the damage situation and the direction of development after the earthquake, and reasonably adjust the distribution of cities, towns, townships, villages, and infrastructure and productivity in the disaster area so as to make it highly historical, practical, and possible.

3. Traffic organization

The Three Bridges Square is located at the entrance of the main entrance to Tibet, the northeast side of it is the 210 Provincial Highway of the Tibet Autonomous Region, and the southeastern side of it is the 318 National Road. The base is close to the river

and the roads get together and have close contact with the town. It is a rare flat area in the mountains, not a deep mountain, and most of the area is pastoral scenery. With convenient transportation and favorable



Fig. 2. Layout of regional planning, green space system, function distribution and landscape system planning.

location, the special historical role of Feixianguan since ancient times will surely make it a gateway to Lushan's tourism development.

National Road 318 begins in Shanghai and ends at the Friendship Bridge in Tibet. It is currently the longest national road in China. It covers the plains, hills, basins and highland landscapes across China's eastern, central and western regions with covering the connotation of Water Village Jiangsu and Zhejiang, Tianfu Basin culture, and Tibetan cultural landscapes. It has various scenery changed from the Chengdu Plain to the Qinghai-Tibet Plateau all the way to the alpine valleys with the feeling of beauty, magnificence, grandeur, surprise, uniqueness and adventure, as a result of the described above, it is chosen as China's landscape avenue by China National Geographic magazine. Feixianguan is located at the beginning of the Sichuan-Tibet line and is the veritable Sichuan-Tibet key link. The Provincial Highway 210 starts in Feixianguan Town and connects the National Highway 318 to the domestic road section of National Highway 317 in Malang to north. It is the most convenient passage connecting Sichuan West and Sichuan Northwest. The national road can contact Ya'an City and road of the direction to Tianquan County, and the provincial road can contact Lushan County. Three Bridges Square has served as a key link to the lives of several important disaster areas.

Under the advantage of convenient transportation, and in line with the concept of "three lines interweave" in planning and positioning, The Three Bridges Square is not only an important node in the landscape organization mainline, but also core public open space in the three interwoven theme



Fig. 3. Regional road planning map



Fig. 4. Three interwoven theme line

line (Figure 3,4), include regional culture line, traditional commercial leisure line and fitness ecologic line.

As Feixianguan's entrance to the "facade", the square takes river as the core to create a view of the river (Figure 5), creates a



Fig. 5. The diagram of the relationship between the square and the market

situation that relies on landscapes of mountains and water, shows a feeling in many paintings, and promotes regional tourism development. The use of subsidence in layers retreats to reduce traffic disruption to the site and enables people to get closer to the water surface (Figure 6).

At the same time, the reduced layout of the ground and the roof of the fold line will buffer and divert the surrounding traffic. The Plaza has no openings on the national road. Instead, as the entrance and ground parking



Fig. 7. Photo at the intersection of the National Road and the provincial road



Fig. 6. Photos along the river

market area is set down on the side along the river to form a circle around the road to achieve a the goal of a pleasant road with the separation of people and vehicles (Figure 7).

4. Layout of function

The regional is orientation of “livable, suitable for industry, and suitable for tourism”. Accompanying with the government's plan to guide the transfer of population and industries to the low-sensitivity counties, Feixianguan, and Qingren, hundreds of thousands of square meters around the site has been established. As a result , people's resettlement houses and bazaars with the color of western Sichuan have brought a strong atmosphere of life and secular culture to the mountains. As a traditional regional culture, the folk “market” activities are well preserved here twice a week. The site design of Three Bridges Square also needs to provide a large hard space for the market. The influx of a large number of people demands new functional requirements for the construction of Three Bridges Square (Figure 8).

guidance are set on the side of the provincial



Fig. 8. Pictures of traditional activities

highway, and a walking path connecting the



Fig. 9. General layout of multi scheme comparison in process

However, there is a limited area of the site against to the large number of problems that need to be resolved. The site is bounded by the rolling mountains of the Lushan Mountains in the northeast, and is the Tsing Yi River in the southeast, the site is close to the 210 Provincial Highway and the 318 State Road.

Under the restrictions of national roads, provincial roads, rivers, and mountainous terrain, the land for restoration and construction is limited. It is also necessary to satisfy the functions of commemorative activities, life services, and tourism assistance, as well as to form a concentrated open space and shelter space such as the objective requirements, all of the design bears many pressures.

After comparing with multiple projects, the design has abandoned the concept of expression in the form of highlighting the commemorative significance, and instead chose to use life participation to interpret the value of commemorative ideas (Figure 9).

As Mr. Qi Kang believes, the memorial square is no longer a house considered to a dead person but a broader meaning, which embodies a kind of living monument to commemorate people and things; and it is not only a memorial land, but also a land for public activities.” so that the square is truly established for the public, used by the public.

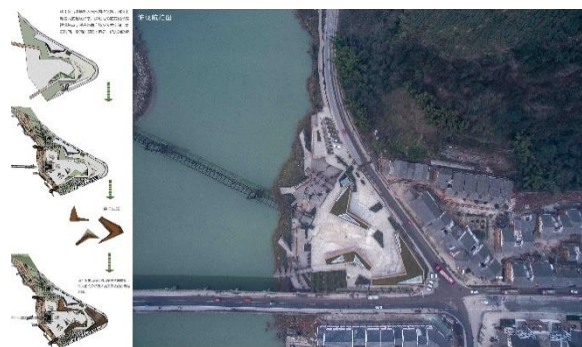


Fig. 10. Bird's eye view of Three Bridges Square

The design breaks the limitation of land use with free form of asymmetrical, and pays attention to the use of terrain height difference to the full with adopting end-bearing piles to solve the defect of tidal flat geological conditions, then drives the supporting column into the rock formation below the mudflat, and uses the method of “waterproof coating to strengthen the waterproof of concrete column (Figure 10).

The water level is used as a benchmark to design a waterfront landscape wooden trestle and corridor, which will substantially increase the square area to 5,668 m², an increase of 30%. The full use of the original shoaled land plots to be included in the landscape plaza. Combining Feixianguan Bridge with the lakeside waterscape to make maximum expansion of site will alleviate the tension of site, and enable the Three Bridges Square to allow integrated services functions



Fig. 11. With the lakeside waterscape to make maximum expansion of site

for sightseeing, recreation, and commemorative performances and the China Unicom corridor under the bridge also needs designing in the surrounding market area to supply the area of the regional market so as to give back the use of public open space to the people in the disaster area (Figure 10, 11).

5. Coordination of characteristics

Lushan County where Feixianguan is located is a famous hometown of Han Dynasty cultural relics. The cultural heritage of the Han Dynasty is abundant. Taking full advantage of the topography of Feixianguan to restore the intention of closing entrance of Feixianguan to create a "portal" landscape image. As an important spatial node of cultural tourism routes, combing its context of cultural Feixian, pavilions of Feixian, Erlang Temple, Wangmu palace control the architectural features of Three Bridges Square (Figure 12).

The architectural styling in the plaza draws lessons from the trend of the roofline of the Han Dynasty buildings and villages, and completes the space continuity that is based

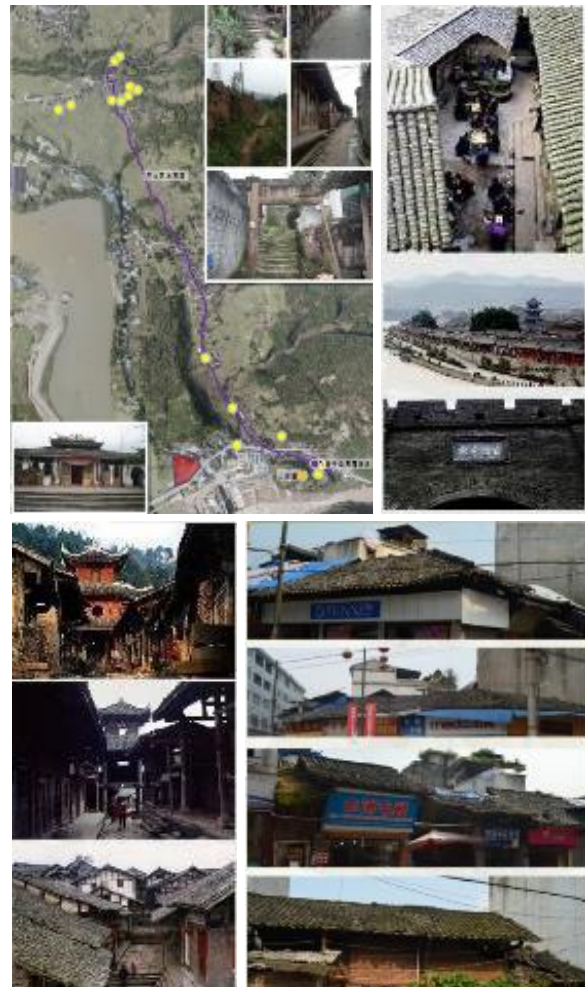


Fig. 12. The architectural features of the dwellings and the remains of Han Dynasty in the region



Fig. 13. Architectural style and photos of surrounding buildings

on the traditional western Sichuan style and makes the site integrate into the undulating background of the mountains (Figure 13).

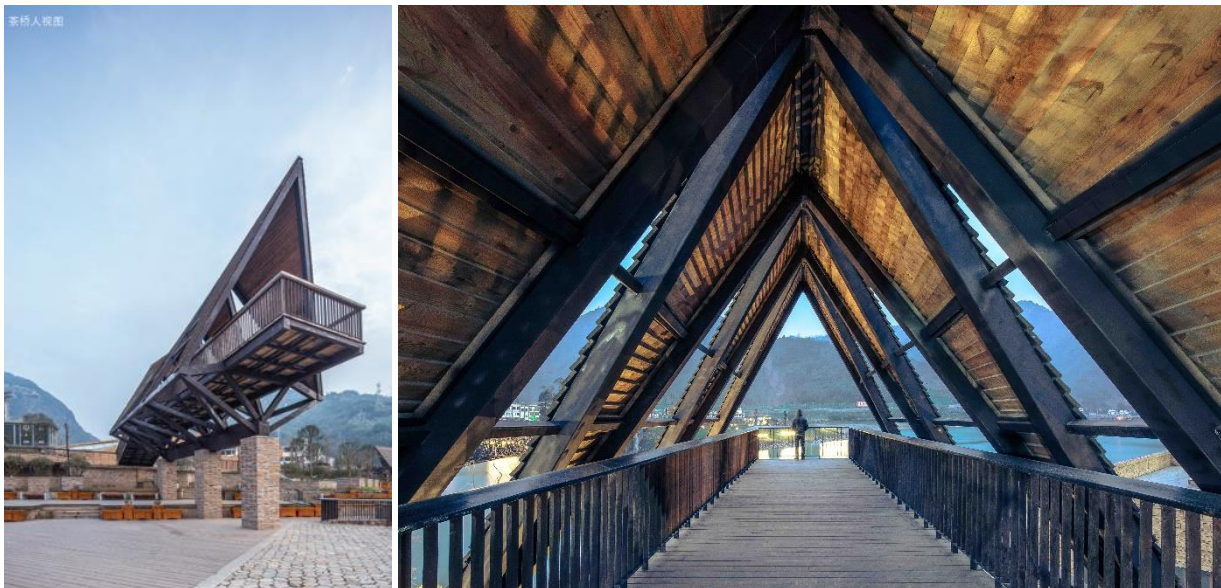


Fig. 14. Image photo of the pavilion along the river

The overall layout also uses the matrix of the fold line to introduce the landscape art of the mountain into the network system of the large local grid, forming a visual focus through the twisting and changing of the lines, organically combining the square with the building, and expressing the tremors of the earth and setting the image in an instant. Material selection conforms to the texture of the earth, mountains, rocks found in the surrounding environment of the site.

For the protection of historic buildings, the Red Army Bridge and its bridgehead, for the sake of its structural safety considering for its long-standing disrepair, closed exhibitions are adopted. Vegetation is used to close the roads around the bridgehead, and two selected viewing pavilions arranged around the center of the Red Army bridgehead are used to enjoy landscapes on bridge. The viewing pavilion is made up with the material of the Red Army Bridge. It is downhill from

the ridge line, and the bamboo-wood slope roof is arranged to form trigonal prisms. The structures on both sides are raised upward to form a cornice. With regard to form intention, once again it metaphorizes the form of residential houses in western Sichuan with forming a viewing pavilion that integrates regional features (Figure 14).

Through this carrier, designers have integrated the relationship between the square and the cultural environment, and the commemoration of reality and history to provide the Red Army Bridge and its bridgehead with an infinitely expandable emotional space and enrich the space-time experience of the visitors.

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BIOPHILIC CITY



FULL PAPERS



Research on Urban Restoration Function of Garden Show Based on Urban Brownfield Value Renewal

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Abstract

With the rapid development of urbanization, the number and the size of various types of brownfield in urban areas are increasing, and the disordered expansion of the urban brownfield has caused the waste of resources, the destruction of urban ecological environment, as well as the disordered development of the city. An analysis of this sort makes the garden show, which until now has been discussed only in the landscape of the exhibition itself, the green space system planning and the urban planning terms, accessible for the importance of renewal of the value of urban brownfield. Based on the analysis of the relationship between the garden shows of western countries represented by Germany after World War II as well as those of China, and the value renewal of urban brownfield, this paper summarizes the characteristics of garden show in the renewal of urban brownfield value, such as prospective, location, ecological and eventual, and accompanies with its restoration methods in order to provide references for holding garden show and achieving urban brownfield value renewal.

Key words: Urban Brownfield; Value Renewal; Garden Show; Regeneration

1. Introduction

Garden show is a kind of festival exhibition with the theme of garden or horticulture ^[1]. It was first held in Europe and often appeared as an accessory of a large-scale comprehensive exhibition in order to cater for the social development needs of Europe in the 18th century, which included advances in plant science, the establishment of related plant associations and increased public interest in plants. After World War II, the social economy of the European countries needed to be revived urgently, as a result, the garden construction began to flourish while the site selection and planning of the garden show began to be integrated into the urban development. It has

played a positive role in promoting the social, economic and ecological levels of the host city and its surrounding areas, especially in providing ecosystem services to citizens through the renewal of urban brownfield values

Based on the analysis of the relationship between the garden shows of western countries represented by Germany after World War II as well as those of China, and the value renewal of urban brownfield, this paper summarizes the characteristics of garden show in the renewal of urban brownfield value accompanied with its restoration methods in order to provide references for holding garden show and achieving urban brownfield value renewal as well as offering ecosystem services.

2. The value of urban brownfield

The term "brownfield" is a concept corresponding to the green space in planning terminology. A series of problems, such as idle land and environmental pollution caused by urban brownfield have had negative impact on urban economy, society and ecology, thus, the renewal of urban brownfield value has become the only way for the sustainable development of the city [2]. There are many values of urban brownfield, such as ecological value, social value, cultural value and so on. The ecological value of brownfield is based on environmental protection, which means if a large area of brownfield can be effectively managed, it can bring huge ecological benefits and provide ecological services to citizens. The social and cultural values of brownfield are produced as the development of human society to a certain stage, in fact it is the memory of development of a city. The reasonable exploitation and development of this kind of brownfield can shape the culture of the city. As a landscape medium for the renewal of urban brownfield value, garden show is of great significance to give full play to brownfield value.

3. Urban restoration experience of garden show based on the renewal of brownfield value

3.1. Germany

3.1.1. Rehabilitation of postwar urban debris

After World War II, western countries entered a post-industrial period. Due to the desire of improving the urban environment and making better use of urban land, most

western cities began to work on post-war reconstruction during which landscaping was concentrated in urban areas so as to restore urban public space [3]. In this period, urban brownfield was dominated by postwar urban ruins. Thus, garden show is a medium for the renewal of the value of postwar ruins and brownfields which revived the land damaged by the war.

In 1951, Hanover held the first federal garden show in the history of German with the aim of restoring the ruins of cities by restoring the city parks that had been destroyed in the war in order to give the Germans courage to start a new start after World War II [4]. The following five federal garden shows also aimed at restoring or rebuilding the ruins of the postwar cities. During this period, the garden show took advantage of building new urban parks to repair the war caused urban brownfield.

3.1.2. Restoration of abandoned land at high speed of industrialization

With the rapid development of German industry after the war, natural resources and ecological environment were constantly destroyed. Since the 1980s, industrial landscape has no longer become a symbol of national strength of Germany. The rise of knowledge economy made the heavy industry become a representative of no competitiveness and pollution. After 1980, Germany, as the most conscious awakening of ecological protection country, became the pioneer of Europe and the whole world in the field of urban brownfield reforming [5], under which background, the federal garden show began to try to find a new way to solve the problem of urban brownfield pollution and gave play to the value of urban

brownfield through landscape planning strategy so as to complete site ecological restoration and site ecological service value.

During the transition period of Ruhr District, a Germany's old industrial zone, there were several federal garden shows and several state garden shows held. In 1969, Dortmund hosted the 10th federal garden show, which was located at an abandoned iron ore plant and turned a manufacturing industrial brownfield into a long-term urban green space for local people. The 1997 Gelsenkirchen Garden Show used ecological means to retain some industrial structures on the site of the original mine site as a historical continuation and to transform them into the Nordstern Park so as to fully reflect the cultural value of industrial brownfield in urban. After the show, it served as a city open space to fully play the ecological service function.

In 1983, Munich obtained the right to host the garden show. The garden show was located on 60 hectares of abandoned land in the western part of the city, which was the development area of the city according to the general public concept space planning of the city designated by the city in 1965. However, there was no park in the densely populated residential area consisted of more than 200,000 people in the southwest of the city due to historical and geographical reasons. Thus, there was a more obvious demand of residents to build a green space^[6] (Fig.1). The city's brownfield would be transformed into a green space, by taking the opportunity of holding garden show making up for the lack of public space in the western old city.

During this period, the garden show began to assume the function of improving the urban environment and promoting the development of the region. The site planning of the garden show had been restored from a single war wasteland to gradually developed

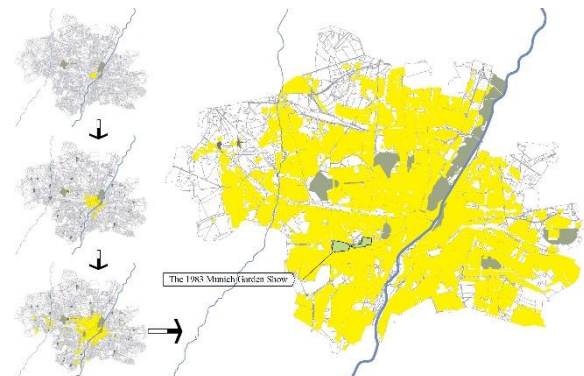


Fig.1. Urban evolution and distribution of green space in Munich in 1993.

into the restoration of urban manufacturing industrial brownfield restoring the original ecosystem of urban brownfield.

3.1.3. Restoration of multiple types of brownfield in the context of urban innovation

After 1990s, a large number of urban land using in the West faced the problem of transformation. The idea of sustainable development has gradually affected the urban renewal movement in western countries^[7], during which period, garden show faced with various types of urban brownfield, and began to re-optimize, re-combine and reuse all kinds of urban brownfield resources in different ways to realize the urban economic and social re-development.

Due to the fact that urban brownfield had no longer been a single postwar wasteland or a manufacturing industrial brownfield, German garden show showed a diversified trend of development. One of the most important types of brownfield was the transformation of military bases. The 1995 Cottbus Garden Show, the 1999 Magdeburg Garden Show, and the 2001 Potsdam Garden Show all completed the revival of the urban military wastelands. In particular, the Potsdam Garden Show was the most typical, in which it selected a number of scattered lands in the city, mainly based on the military bases left behind by the Soviet Union after the withdrawal of troops, and integrated the broken urban green space, and re-create pedestrian streets, squares, parks and so on to achieve the perfect interpretation of the site ecological service function(Fig.2). The 2005 Munich Garden Show realized the successful transition of the old airport site to the new urban district by constructing a green frame of the new district and forming a perfect regional ecosystem(Fig.3). In the 21st century, garden show has not only realized the transformation of urban brownfield, but also taken this as an opportunity to fully tap the various values of various types of urban brownfields to give full play to the ecological service function of green space. (Tab.1)

3.2. China

In recent years, all kinds of garden show in China have developed rapidly and the scales have been increased, which have gradually become the driving force of the development of the large or medium-sized cities and a new growth point of regional

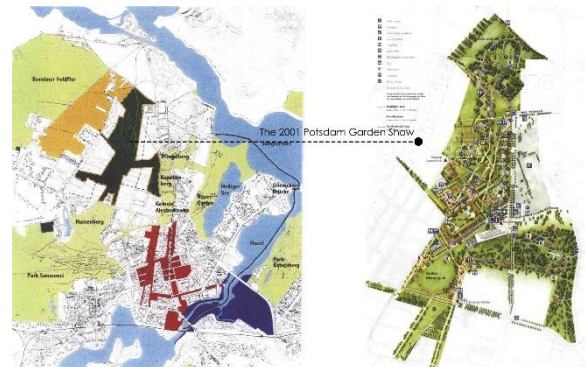


Fig.2. The sites of the 2001 Potsdam Garden Show



Fig.3-1. The sites of the 2005 Munich Garden Show



Fig.3-2. The “U” green frame of the Riem formed by the 2005 Munich Garden Show economy [8]. The development of Chinese garden show began in 1999. At first, it’s



Fig.3-3. Present situation of land use after the 2005 Munich Garden Show

only taken as a tourist attraction for the city to promote the development of the city. Since the 21st century, the types of urban brownfield have shown a trend of diversity. Garden show has also focused on the renewal of urban brownfield value and the improvement of urban ecosystem.

The 2011 Xi'an Garden Show was located in Xi'an Chanba New District. It focused on strengthening the ecological management of the Chanba River Basin in accordance with the development idea of "River treatment drives regional development and development of the new area supports ecological construction", which solved three ecological disasters of garbage siege, illegal sand mining and river pollution in the Chanba River Basin. After the show, it became an important part of green barrier of Chanba New District. The 2015 Wuhan Garden Show directly selected the base site at the Jinshan Landfill. The garden show restored the landfill site and protected the garden site, while at the same time, it used the garden show to realize the intensive utilization of regional land resources and turned the brownfield into a park establishing the blend of environmental ecology and social and people. The 2009 Jinan Garden Show, the 2013 Beijing Garden Show, and the 2016 Tangshan Garden Show were all hold on different types of urban brownfield sites, which endowed the city with new vitality by taking the garden show as the medium. (Tab.2)

4. The characteristics of garden show based on the renewal of brownfield value

4.1. Ecology of landscape renewal

Due to the serious pollution on most urban brownfield, ecological restoration must be the first task of urban brownfield value renewal, which determines the ecological properties of garden show. First of all, in the early stage of the garden show, the ecological restoration and vegetation community establishment are carried out by reusing and disposing the waste resources of various kinds of abandoned land in the city in order to realize the self-repairing function of the site. Secondly, the garden show often leaves high quality green space, which can effectively adjust the urban greening structure and reconstruct the urban public space system as well as to perfect the city green corridor and ecological network. It provides comfortable space for people to spent their leisure time and enjoy entertainment while also provides habitat for all kinds of small animals in the city.

4.2. Place for spatial design

Urban brownfield is used to be a relic of land in a certain era carrying the memory of people and being a carrier of the historical relics of the city. In the process of planning and designing of the garden show, the elements of the past are often preserved and modified through careful design to create a new and old fusion of the landscape in order to enable people to feel the history and memory of the site itself and allow visitors to read the history of the venue. Taking the garden shows as the planning tools to renew value of the urban brownfield make the city

itself become the carrier of history and a book to be read. The public development of the renewal of urban brownfield value through garden show can not only create the space for the city, but also create public place for the city, and form the sense of place and identity of the citizen while bringing new vitality to the declining urban space.

4.3. Eventuality and sociality of the exhibitions

Garden show is conducive to mobilize all aspects of resources and initiative as a short period of horticultural urban events, during which some large-scale urban construction projects can be completed which, otherwise, are not able to be finished by conventional policy means^[9]. It has a certain degree of sociality which means it force people to pay more attention to the development of the community because of the extensive attention and participation of the exhibition. After the exhibition, people would like to pay attention to the future of social public activities. Thus, it not only provides a popular leisure space for the dull urban life, but also completes the transformation of the urban land nature by perfecting the ecosystem structure, which promotes the development of the surrounding areas so as to attracting investment, increasing employment, and improving social stability.

4.4. Forward-looking development strategies

The garden show can combine its own development with the urban development strategy^[7], especially for the long-term consideration of the location of the garden

show and the regional development after the show because of its large-scale, and the comprehensive social benefits, intensive attention and influence it brings. The grand event of garden show is combined with the renewal of urban brownfield value and the development of the city. First of all, the government analyzes the present situation of urban brownfield combining the urban development strategy to take the garden show as the prelude of renewal of urban brownfield so as to formulate the complete site development strategy and operation mode. For example, the balanced development of the locality and integrity of the new and old city should be payed great attention to and we should purposefully use the old urban area to create new public space when choose the location of garden show^[10]. Secondly, after the garden show, the site will be transformed into the specific urban space to be integrated into the urban development strategy according to the scientific space development and renewal plan made by the city.

5. The restoration mode of garden show on the renewal of urban brownfield value

5.1. Urban public space restoration model

In the case of using garden show to realize the value of urban brownfield, the restoration mode of urban public space is the most commonly adopted, i.e., in all kinds of urban brownfield base sites, the treatment of site pollution is realized by means of ecological restoration, and the planning and design strategy of landscape architecture is adopted to form a vibrant public space.

With the change of urban development model from incremental development to stock renewal, there is a serious phenomenon caused by "the law of the jungle" in the limited space of the city, especially of the public space proportion which is decreasing instead of rising, and the scale is being compressed constantly. Therefore, garden show often changes the use of urban brownfield in the form of parks and green space, which naturally becomes an effective way to solve the shortage of urban land resources and ecological space in the process of renewal of urban brownfield value. Nowadays, this mode of restoration is becoming more and more common, especially in cities where contaminated land consisting of old docks, ports, landfills and other renewable urban brownfield are being helped by the garden show ^[11]. Construction of urban green corridor, urban parks and outdoor entertainment venues provides citizens with a variety of urban public space, which gives full play to the ecological services function of urban brownfield.

5.2. Compound land tenure restoration model

The restoration model of different land titles, such as residential and commerce, is mostly adopted for the brownfield located in urban core areas with relatively completed infrastructure in the surrounding areas, or for brownfield that is renewed to promote the construction of new urban areas. This model has a significant impact on attracting investment and increasing tax and fiscal revenues, as well as promoting economic development. However, because residential areas and commercial districts need a ecological environment, the comprehensive

restoration model combined with residential and commerce can only choose the less polluted urban brownfield to develop and construct ^[12], or choose the site where the ecological restoration by degrading the pollution material has been carried out before the garden show. For example, the 2005 Munich Garden Show was hold at the site of the less polluting new airport in the Riem New District, after which 2/3 of the land was used for residential and commercial purposes.

5.3. Combination of "top-down" and "bottom-up" modes of repair through show operations

The garden show, as a means of updating the value of the urban brownfield, is run in a "top-down" manner under the leadership of relevant government departments or institutions at all levels considering the initiation of the garden show, the establishment of the related organizations and the important sources of funds in the early stage. However, the implementation and operation of each sub-project in the garden show is promoted in a "bottom-up" manner, which means it is not entirely implemented by the government's blueprint ^[13]. The implementing plans or designs of some sub-projects are selected through the project competition of landscape, which is gradually implemented through the "bottom-up" model including public participation consisting of designers, citizens, government, and so on. Encouraging people to participate in the planning of the garden show with the greatest enthusiasm indirectly realizes the renewal of the value of urban brownfield.

This combination of "top-down" and "bottom-up" repair models allows a larger number of actors to be involved from the outset which includes governments, regulators in the planning phase and the developers, stakeholders in the stage of development and construction as well as the citizens in the use phase, and etc. This model can fully play the role of multidisciplinary coordination and public participation in the implementing process of garden show so that the public, governments, developers and other roles can benefit from it, which is a win-win process.

6. Conclusion

Since the development of the modern garden show, it has been more than 60 years, during which the planning strategy of the western garden show in the renewal of urban brownfield value has been changed from a single strategy of war abandoned land transformation to become a complex and diverse planning and development strategy dealing with various types of urban brownfield, and a relatively complete development model has been formed which includes the before, during and after stage of show. In this way, I hope to learn from the valuable experience of holding garden shows of different countries and cities in order to closely combine the planning and design of garden show with the renewal of urban brownfield and the provision of

ecosystem services by exploring the development mode and restoration mode of garden show under different conditions.

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Appendix

Tab.1 The German Garden Show and the renewal of the urban brownfield value

Background	Example			
	Year	Host City	Site Selection	Land Use Type after Show
Deteriorating cities after the war are in urgent need of reconstruction	1951	Hanover	War wasteland	Parkland
	1953	Hamburg		
	1955	Kassel		
	1957	Cologne		
	1959	Dortmund		
	1961	Stuttgart		
High industrialization and economic development bring serious land pollution	1969	Dortmund	Abandoned iron ore mine	Parkland
	1983	Munich	Stone quarry divided by highway	
	1995	Cottbus	Military wasteland and landfill	
	1997	Gelsenkirchen	Coal mine wasteland	
The idea of sustainable development has been deeply rooted in the hearts of the people, and has paid much attention to the multiple values of all kinds of brownfields	1999	Magdeburg	A war reserve for armoured vehicles	Parkland
	2001	Potsdam	Military base	Parkland and Residential land
	2005	Munich	Munich Riem airport site	Parkland, Residential land and Commercial land
	2007	Gera	Heavy metal mining area	Parkland

Tab.2 The China Garden Show and the renewal of the urban brownfield value

Year	Host City	Site Selection	Land Use Type after Show
2011	Xi'an	Chanba River Basin	Parkland
2016	Tangshan	Coal mining subsidence area	
2013	Beijing	Yongding riverside landfill	
2015	Wuhan	Jinkou landfill	

Exploration of The Development Mode of Community Agriculture Landscape Unit in Urban-West Philadelphia Black Community Wasteland Recycling As The Study Object

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Abstract

Urban development are faced with many problems, such as the lack of the pressure of grain production, high unemployment, etc, which prompted people spontaneously in the community in the messy "exclusive" in the rapid development of urbanization whose planning and management experience are not mature enough. The urban fabric of many North American cities has been radically altered over the past few decades, and a combination of dispersed settlement patterns, decentralized and abandoned urban cores, economic downturns, political shifts, rapid suburbanization, and deindustrialization have led to large inventories of vacant land. The issue of urban vacancies, and the processes that created them, has been well documented in such seminal work as *Stalking Detroit* and *Shrinking Cities*. Much of this vacant land is now contaminated or in various states of decay and dis-use; the time is ripe for innovative reclamation efforts. Today, Philadelphia has one of the highest per capita vacancy rates in the country. Through the method, engagement of critical resources and business models, and community input, such production can become an integral component of a neighborhood environmental system of green infrastructure that includes stormwater management, bicycle and pedestrian circulation, soil production and composting operations, along with recreational programming. The project in the black community of Philadelphia builds on past efforts of city agencies and organizations to advance conceptual ideas to a prototype tree production operation. It will allow testing of species and growing methods to ascertain suitability, allow refinement of spatial requirements, generate research data on efficacy, and provide a laboratory for the development of a long term maintenance and management strategy.

Keywords: suburban landscape; therapeutic landscape; garden health; landscape architecture

1. Introduction

Populations around the world are growing and becoming predominately urban, fueling the need to re-examine how urban spaces are developed and urban inhabitants are fed. One remedy that is increasingly being considered as a solution to inadequate food access in cities, is urban agriculture. As a practice, urban agriculture is beneficial in both post-industrial and developing cities because it touches on the three pillars of sustainability: economics, society, and the environment. Historically, as well as currently, economic and food security are two of the most common reasons for participation in urban agriculture. Urban agriculture not only provides a source of healthful sustenance that might otherwise be lacking, it can also contribute to a household's income, offset food expenditures, and create jobs.

A garden or communal farm is a place where people come together for mutual benefit, often enhancing the common social and cultural identity for city residents. Larger urban farms also participate in community enrichment through job training and other educational programmes, many of which benefit underserved populations. Finally, urban agriculture can play an important role in the environmental sustainability of a city. As a form of green infrastructure, urban farms and community food gardens help reduce urban heat island effects, mitigate urban stormwater impacts and lower the energy embodied in food transportation[1].

Urban communities can form farms of extensive-metropolitan region in transition areas between cities and suburbs. During this period, entrepreneurial farmers are connected

to urban consumers through direct market which includes farmers' voluntary markets.

2. Transformation of the wasteland in West Philadelphia Black Community

As Philadelphia continues to grow into a world-class city, the issue of urban blight must be addressed. Pocked with thousands of vacant lots, the city was faced with a unique opportunity to turn concrete deserts into inner-city oases. The urban fabric of many North American cities has been radically altered over the past few decades, and a combination of dispersed settlement patterns, decentralized and abandoned urban cores, economic downturns, political shifts, rapid suburbanization, and deindustrialization have led to large inventories of vacant land. The issue of urban vacancies, and the processes that created them, has been well documented in such seminal work as *Stalking Detroit* and *Shrinking Cities*. Much of this vacant land is now contaminated or in various states of decay and dis-use; the time is ripe for innovative reclamation efforts. The economic realities of urban reclamation strongly suggests that today's solutions must be resilient and phased over time; the cost of regenerating vast acreages of potentially toxic land and the public's desire to see immediate progress indicates that interventions must be carefully crafted, embraced by the public, and cost-effective.

As an urban land use activity, agriculture presents itself as oddly out of place. It seems wholly "incompatible" with the management of space under the rule of the commodity form in the global city with its astronomical "ground rents" and inflationary, even speculative, real estate markets. Urban

community gardens embody a pattern of resistant use and the re-codifying of space wherein local neighborhoods assert control of places for communal uses that lie outside the purview or control of the market. These gardens are thus heterotopias in the making. The project of this paper was selected in the west Philadelphia black community and west fairmont park, surrounded by low-income, low-wage and high-vacancy communities. However, the community is adjacent to large public Spaces, and there is a huge space for development.

2.1. Analysis of the status quo of the vacant communities.

The community is a representative black community in west Philadelphia, as the number of African americans in the west park is 73.7 percent, and the age of the population is mainly concentrated in the young adults, who are between 20 and 44 years old, accounting for about 36 percent of the population.

The low employment rate has led to a lack of vitality in the community and the accumulation of a large number of unemployed black youth, which result in few immigrants moving into west Philadelphia. Throughout the western garden area gradually appeared the vacancy area and the high altitude area. Without interference, it will lead to higher vacancy rates and a larger area of the upper air. Most of the family income is between \$40 and \$50, which is in low income groups in the United States. So how to increase the income of local residents, how to raise the employment rate and how to reduce People's Daily expenses is the focus of the project.

The dismantling of empty and abandoned buildings costs about \$15.5 million a year for government funds, and they have lost taxes on these wasteland, which often exceeds the value of the wasteland itself. These wasteland will bring tax economic losses and security threats to the surrounding communities. The landowners around the wasteland are likely to give up the house because of the security factors and the poor commercial interests, which leads to a vicious circle around the wasteland. The present situation of the site is mainly the trash left behind by buildings, mostly for abandoned brick, gravel, sandy soil and so on, covering a small amount of vegetation, and there are remaining trees on the edge.

2.2. The implementation of urban agriculture strategy for vacant community.

Urban Arboreta's hybrid design will increase storm water absorption, improve air quality, and add value to the community. Community farms intends to establish a template for possible replication. Primary goals will focus on building and sustaining nurseries that grow and sell product to the City of Philadelphia, other municipalities, and commercial or residential developers. The site will be designed to include public space and support education and job training programs to support the community. Initially funded by the Knight Foundation, Community farms will seek additional funding from foundations and philanthropic donations for ensuring sustainability and future expansion of the project.

As such, Urban Arboreta in the community farm aims to satisfy a "triple bottom line" of proving economically sustainable, while also

improving the environment and increasing community engagement.

1. Economics

Community farm must be financially sustainable. Sale of trees and shrubs must meet the primary objective of economic viability, such that revenue from the urban tree nursery allows for self-sustainability. Successful business operations will serve as proof of concept of replication of Urban Arboreta throughout Philadelphia.

2. Environment

Partnership with the Philadelphia Water Department will mitigate overuse of the city's drainage and sewer system by employing the development of community farm to increase storm water runoff management. Riparian buffer product grown and sold by Urban Arboreta will enhance watershed health, while the transformation of a formerly-impermeable lot into fully-permeable nursery grounds will aid in ground-level water absorption.

3. Community

Community farm will truly thrive with the addition of community buy-in and a sense of ownership from the surrounding neighborhood. Citizens will play, learn, and volunteer. Economic multipliers include shared green space, improved municipal environment, and potential partnerships with schools and other civic groups.

Community farms are mostly small green spaces within five acres, and the two community gardens are designed to include agricultural landscapes and nursery for urban arboreta. Considering the economic factors, the design must be carefully calculated landscape scale, the scale is not confined to irrigation, compost and soil, fertilizer production, planting media mixing and

storage and other material storage, services, and security.

The research and design for the community



Fig.1. Design site status analysis

green space system in this area which is the research template will meet the community production standards and coincide with the vision created by the community landscape. City agencies and schools work together to construct a community farm that will provide a nursery management technology of on-the-job training and the skills can solve some problems of employment, support the public services.

2.3. The vision of the community garden

The vision of the community garden is the function of "production" and "transaction" in community farms and community seedling bases through the improvement of the environment and the regional economic circulation of the community. Both of them are based on "expansion and construction-stage economic cycle-economic output". Community gardens gradually gain better returns through low investment, and gradually scale up until they are planned. The operation of agricultural landscape in social garden is mostly family business model. Seedling and management are hard physical labor, but also a way of life for staff. The winter nursery works mostly for sale, mass transfer and preparation for the growth of spring trees.

The "farming symbiosis model" of community farm application is a sustainable green food production system, combined with aquaculture (farmed fish, chicken) and hydroponics (the cultivation of non-native plants).

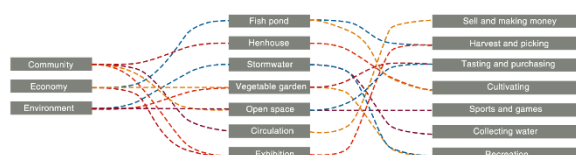


Fig. 2. Construction of community farms.

2.4. The establishment of the community farms.

Community farm in the community garden and plant nursery base will meet some of green plant needs in the city and daily vegetable supply for residents in the community as well as providing professional training in nursery production technology and improving the quality of urban environment so as to create a positive open space for residents.

In the gardens, four plastic sheds that can be grown and nurtured in the community and "Bare-root tree planting area" and "rapid potted planting area" of different plants were designed here in the context of taking into account the problem of uneven rainfall in Philadelphia and combining rainwater harvesting and respecting the status quo. Nurseries and crops grown in the garden are sold on community farms and proceeds will be used for garden expansion and maintenance. Seedling methods include container seedling, ground plant and pot-in-pot. The container has the advantages of simple operation, convenience and

removable, which is conducive to transplanting and retailing.

Having established the most suitable growing methods, as well as outlining potential peers and competitors in the nursery market, this report next addresses the potential for customers. In general, three customer segments are identified, which include strategic partnerships with city agencies, obtaining status as a preferred vendor, and directly servicing local business and consumers. The bidding process for obtaining a landscaping contract with the city of Philadelphia is first addressed, with further insight on partnering with existing contractors in a subcontractor relationship to provide nursery stock for ongoing projects. A strong emphasis then focuses on Philadelphia Water Department's Rain Check program, which subsidizes small business' efforts to simultaneously green their premises while also improving storm water runoff management. This initiative may serve as a key driver of sales, as Urban Arboreta can both provide riparian buffer stock directly to customers, as well as potentially consult with consumers on how best to develop their land for storm water runoff management. Finally, a comprehensive list of shared riparian buffer species recently purchased by both Philadelphia Water Department and the Department of Parks.



Fig. 3. Community south farm garden plan.

The south side garden of the community is based on farm seedling base and aquaculture where are mainly planting bed, fish pond, chicken house, home vegetable plot, bare-root tree planting area, export exhibition venue and central plaza. Both community gardens are designed with soil fertility ponds and septic tanks to improve the soil environment. Community garden plants choose local plants and drought-resistant perennial herbs, as well as common fruits and vegetables.

2.5. The operation of the community farms.

The Philadelphia rain flood division (PWD) partnered with the Penn state horticultural society (PHS) would help the Philadelphia neighborhood reduce the stress of the rain and the project's rainwater management has free fund support. The beneficiaries of rainwater management devices and measures are local residents, customer groups of community gardens and local contractors. By selling seedlings and vegetables, community gardens can help achieve the goal of rainwater management in Philadelphia and reduce runoff.

It is necessary to take into account the plant seedling of different size containers (from 1 gallon to the size of suitable planting device). The nursery water is often used for running water, and there are lakes and rivers and other surface water. Small-scale nurseries use public water, and rainwater is collected from the roof of the nursery to help with irrigation. Community gardens are operating throughout the year, however, there is a great demand for rain flood facilities especially in spring and summer.

Considering the mostly perennial seedlings, the existence of potential risks of

the project: First, the influence of customers on seasonal demand of seedlings and vegetables; Second, the time period for community gardens to provide plant and food materials to contractors or residents, which are not conducive to profitability.

Farming symbiosis can help improve the supply of communities with limited food sources because of the low food prices, organic, and mostly local production.

It has the potential to completely change the way that the food source in the city, The new mode of production transforms the gray space of community green site into production space so that can bring income to the family and integrate into the urban environment more easily.[3]

“The garden is the smallest parcel of the world and then it is the totality of the world,” wrote Foucault. The community garden is a small parcel of agricultural land in the urban behemoth that is the Greater West Philadelphia region. Each huerto familiar at West is a site for the reconstruction of the gardeners’ sense of place. This involves simple acts of auto topography in which they etch a story with elements drawn from the home world, the very plants and landscaping practices that allow them to produce a familiarized space. The survival of these heterotopias must confront the totality posed by its opposite – the commodity-form ever yearning to usurp and fetishize space as a merchantable good destined for consumption as fodder in the expansion of the neoliberal grid city.

3. The role of national policies and social guidance in the operation of community farms.

3.1. The role of national policies and social guidance for urban agriculture.

In metropolitan areas throughout North America, long characterized by sprawling residential suburbs and more densely developed city centres, there is a growing interest in urban agriculture. Some cities, such as Portland, Oregon and Vancouver, British Columbia, support local farming that provides a growing supply of fresh produce to residents. Some older industrial cities with large amounts of vacant land, such as Detroit, have a few vibrant local growing projects and many ambitious plans for large-scale production on the vacant land resulting from decades of housing abandonment[4]. Many cities have had active associations of community gardeners, some of whom produce food for local consumption[5]. The Growing Power project, which began in Milwaukee, Wisconsin, has become a prominent model for expanding production beyond the scale of the typical community garden[6-7].

Agriculture is in the basic position. The national policy mainly promotes the smooth progress of various industries by law and regulation and supervision mechanism. As a branch of the urbanization development of traditional agriculture, the agriculture landscape can't be separated from the government's policy guidance and a benign government examination system. For example, Since the hairstyle urban agriculture action plan of Toronto, many urban agriculture projects have appeared in Toronto. These projects are located in the

open space, on the roof and in the yard of the school, and become the means of building and strengthening the community[8].

Secondly, the implementation of a new thing is inseparable from the concern and influence from the society. Germany has taken four new short films, "green dawn" for urban gardens, spreading urban gardening and its social and cultural activities in different dimensions: Urban Agriculture in the Princess Garden in Berlin; a community farm as a starting point for urban development; a Turkey teenager cooked in a cultural garden in the green park; guerrilla. The moving "Rose" in the garden[9]. The intervention of education, the construction of demonstration projects and the commercialization of edible landscapes can make more people understand the multi-dimensional role of landscape architecture, and realize that urban and agricultural production can coexist harmoniously.

3.2. The principle of creating edible landscape in community.

Proper planning guidelines indicate that when designating an area as suitable, that knowledge of past site history, existing soil properties and distance from possible nearby sources of pollution, especially traffic, be taken into account in order to prevent crop contamination. Similarly, the overuse of chemicals needs to be prevented[10]. Exceedingly high heavy metal concentrations in urban grown fruits and vegetables must be strictly related to specific safe zones in the city where plants are going to be grown. [11]As such, when plants are cultivated near pollution-emission sources, risks of heavy metal contamination are increased approximately 1.5-fold when fruits and

vegetables are grown 10 m from the road as compared to 60 m. [12]. Examples of more effective governance instruments and experiences are also needed to better identify successful approaches for integrating citybased food production into urban sector policies and urban land use planning instruments, and to facilitate the development of safe and sustainable urban agriculture[13].

Future research should also address the application of climate-smart agriculture practices for the design, planning, and management of urban GI and NBS to mitigate climate change effects, increase food security, and provide sustainability-based guidelines[14].

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Urban River Landscape Planning Based on Water Environment Evaluation – Case Study of Panlong River

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Abstract

With the development of the urbanization process, the urban water system has been seriously damaged and sensitive. The combining of water environment and water landscape is an important task to be considered of urban river landscape planning. This paper constructs the evaluation index system of urban river landscape. The weights of each index layer is determined by Analytic Hierarchy Process (AHP), and also constructed by distance index method. Taking Pan Long River as an example, the evaluation model was used to evaluate the landscape environment of the PanLong River. The AHP method combines quantitative evaluation with qualitative evaluation, which has certain guidance to the landscape environment planning of urban water system.

Keywords: Analytic Hierarchy Process; urban water systems; landscape; evaluation

1. Introduction

With the development of urbanization, urban water ecology is seriously damaged, and the contradiction between urbanization water ecology is increasingly prominent.^[1] Most of the river water quality in the city is polluted, and the biological diversity is gradually decreasing. The river landscape is facing many ecological problems. It is an important method to solve the river ecological problems and improve the landscape effect by combining the ecological restoration method of water body with the urban river landscape construction process, which can also promote the restoration of the river ecological system to a benign state.

In 2017, the Ministry of Housing and Urban -Rural Development issued the guidelines on strengthening ecological restoration of urban remediation, which called for "restoration of urban ecology, improvement of ecological functions, restoration of urban functions and improvement of environmental quality". This document has become a good opportunity to restore the urban river landscape ecology. Since then, many cities began river landscape planning and construction, but most of its landscape planning did not pay attention to the restoration of water ecology, the effect is not much different from the past.^[2] The river landscape planning and construction in most cities is only based on aesthetic and cultural needs, and has not effectively restored the river ecology or solved the water problems. This paper attempts to explore the specific

methods of river landscape planning from the perspective of the relationship between river landscape planning and construction and urban and ecological restoration.

River landscape construction based on water ecological restoration has important ecological significance. This is conducive to balancing the relationship between water resources and human activities, improving the ecological environment, perfecting the urban functions and enhancing the quality of the landscape. At present, the river landscape design based on water ecological restoration has not been studied deeply in China. Due to the large number of rivers in China, the urbanization process of most cities shows the urgent need to restore water ecology.^[3] This research has made some progress in plant landscape planning and green infrastructure. Most of these studies start from the perspective of ecological restoration technology, and rarely involve the planning steps and methods of river landscape based on water ecological restoration.^[4,5,6] Based on this, this paper will describe the methods, steps and connotation of river landscape planning through comprehensive water environment management and the expression of characteristic landscape.

2. Methods

2.1. Research Object

Panlong River is located in Kunming, central Yunnan province, with a total length of 26km, a widest point of 56m, a narrowest point of 19.2m, and an average width of 30m. Panlong River's upstream is the Muyang

River, which originated from Baisha Slope, west Liang Wang Mountain, northwest Songming county. It winds from south Huangshiyuan into Guandu district Xiaohe town. Panlong River originates from Songhua dam and ends in Dianchi Lake. In the master plan of Kunming city (2011 - 2020), Panlong River is planned as "a main river to meet the basic flood control and drainage of the city; a gorgeous landscape link that highlights the charm of the city and inherits the river water culture; an important ecological corridor to maintain the ecological safety of urban landscape". Panlong River winds through villages, suburbs and cities. Both sides of the river are rich in natural and human resources.

2.2. Data

Landscape hydrology evaluation is the basis of water ecological restoration planning. In the early planning stage, the study group sampled and evaluated the hydrological data of Panlong River, and AHP and distance index were applied to evaluate the landscape environment of Panlong River. From the source of Songhua Dam in Panlong River to the entrance of Dian Lake, the study group collected and analyzed the water samples and evaluated the surrounding landscape environment. The total number of collection points was 84. Evaluation factors include water quality, plant coverage, water fluidity, flood control effect, public space quality, region, landscape accessibility, greening quality, surrounding building quality, etc. The water quality, plant coverage, flood control effect can query the objective data. The other indicators are determined by expert scoring. The

observation points of the upper, middle and lower sections of Panlong River were recorded by the study group. In this paper, 40 landscape architecture undergraduates and postgraduates were invited to evaluate the water landscape, and 60 local residents and tourists were randomly interviewed to evaluate the observation points. There were 100 participants in this study, 98 of whom completed the questionnaire and submitted the results. The age range of effective participants in the study was 16 to 67 years, with a ratio of 1: 1.16 for men and women.

The reasons for the selection of the personnel involved in the investigation: 1) the participation of relevant professionals is conducive to improving the rationality of the evaluation results. Landscape architecture

2.3. Planning Procedure

2.3.1 Survey

Field investigation and data collection are the basis of water landscape planning. The depth and breadth of the investigation directly affect the follow-up evaluation of river landscape elements, the progress and development of landscape planning. The main contents of the survey include water ecological environment, socio-economic environment, landscape quality and so on. The water ecological environment aspect mainly includes water quality, vegetation coverage and water fluidity. Socio - economic mainly include flood control effect, public space quality, regional cultural characteristics. The aesthetic aspect mainly includes traffic accessibility, afforestation

students have certain space perception ability and professional quality. By participating in the basic investigation of river landscape, they can objectively evaluate the water landscape. 2) The local residents and tourists feel more intuitive water landscape, reflecting the real needs of users and participants. To sum up, this paper chooses the method of landscape evaluation by combining professionals with residents and tourists in the site, which provides favorable support for water ecological restoration planning. Analytic hierarchy process weight set questionnaire by the relevant professional professors and engineers to score. The effective part is 15 parts. The evaluation matrix was constructed with 15 valid questionnaires.

quality, surrounding building quality, etc. In the process of field investigation, it should be combined with the river landscape situation and development direction and characteristics to adjust the survey content.

2.3.2 Evaluation Index System

In order to select the key river water restoration areas according to the river water situation, the study group needs to carry out river ecological restoration layout planning. Urban river landscape has three important characteristics: ecological environment, social economy and aesthetics. River landscape evaluation can be divided into three layers: target layer, criterion layer and index layer. The study group should establish a set of evaluation index system: river landscape evaluation as the target layer; ecological

environment index, socio-economic and aesthetic indicators as the standard layer; water quality, plant coverage, water fluidity, flood control effect, public space, regional cultural characteristics, traffic accessibility, greening and surrounding buildings as the index layer. The evaluation index system is shown in table 1.

Table 1 Evaluation Index System of River Landscape

<i>Target layer</i>	Crite rion layer	Index layer
F river landsc ape evaluat ion	F ₁ ecological environm ent	F ₁₁ water quality
		F ₁₂ Vegetation coverage
		F ₁₃ Water fluidity
	F ₂ socio - economic	F ₂₁ Flood control effect
		F ₂₂ Public space
		F ₂₃ Regional cultural characteristics
	F ₃ aesthetic value	F ₃₁ Traffic accessibility
		F ₃₂ afforestation
		F ₃₃ Surrounding building

2.3.3 Evaluation

This paper uses AHP to determine the weight of the index system and evaluate the index of single river course.

The indexes of each layer in the index system can be compared with the indexes of the previous layer in turn, and finally the judgment matrix is established. For the criterion layer, the importance of ecological environment, economic society and aesthetic value is $f_1: F_2: F_3 = 6.3: 2.3: 1.4$. In the eco-environmental criterion layer, the importance of water quality index is slightly greater than that of plant coverage rate and water fluidity index $F_{11}: F_{12}: f_{13} = 4: 3: 3$ in the socio-economic criterion layer, public space and flood control effect index is greater than that of historical and cultural protection index $f_{21}: f_{22}: f_{23} = 4: 5: 1$. In the aesthetic criterion layer, afforestation, landscape accessibility and the importance of surrounding building indicators are relatively equal $f_{31}: f_{32}: f_{33} = 3.5: 3.7: 2.9$. According to these, the judgment matrix can be established on the premise of consistency check. The calculated weights are shown in the following table:

Table 2. Index Weight for River Landscape

Target layer	Criterion layer	Criterion layer weight	Index layer	Index layer weight
River landscape evaluation	Ecological environment	0.63	Water quality	0.2525
			Vegetable coverage	0.1892
			Water fluidity	0.1892
	community economy	0.23	Flood control effect	0.1012
			Public space	0.1449
			Historical and cultural protection	0.0529
	Aesthetics	0.14	Landscape accessibility	0.0491
			afforestation	0.0513
			Surrounding building	0.0406

Taking Panlong River as an example, the landscape environment of the upper, middle and lower reaches of Panlong River was evaluated by using AHP and distance index method. A questionnaire was created according to the AHP method. The weight setting questionnaire was graded by landscape professors. The effective part is 15 parts. [7] An evaluation matrix was created using 15 valid questionnaires. Because the AHP is used, it is necessary to check the

consistency of the calculation results. Through the test and calculation, 15 valid experts questionnaire through consistency test calculation, the result is $Cr < 0.1$. Therefore, the judgment matrix finally meets the requirements of consistency test, and the obtained weights conform to the scientific law. To sum up, the evaluation index system of Panlong River landscape with weight is as shown in table 3:

Table 3. The Score of Panlong River Landscape Evaluation

Target layer	Criterion layer	weight	Index layer	Standard value	Upper distance score	Median distance score	Lower segment distance score	
Landscape evaluation of Panlong River	Ecological environment	0.63	Water quality	0.6	0.6	0.4	0.4	
			vegetable coverage	0.8	1	0.8	0.6	
			Water fluidity	1	0.8	0.8	1	
	community economy	0.23	Flood control effect	1	1	1	1	
			Public space	1	0.1	0.7	0.4	
			Regional characteristics	1	0.1	0.3	0.2	
			Landscape accessibility	1	0.4	0.6	0.6	
	Aesthetics	0.14	afforestation	1	0.4	0.7	0.6	
			Surrounding building	1	0.4	0.4	0.3	
	Total					0.75	0.68	0.49

Secondly, In order to eliminate the problem that the dimension of each evaluation index in the evaluation index system is inconsistent and cannot be directly compared, the standardization treatment is carried out on each index in the index system.

The standard value range after the evaluation index standardization is Water quality, plant coverage, water fluidity, flood control effect, public space, regional cultural characteristics, traffic accessibility,

afforestation and surrounding buildings and other index layer ideal value is determined as follows:

(1) Water quality indicators. Urban river water quality target is the third level of water, so its ideal value is third level. By obtaining the river water quality monitoring data, if it meets the third level standard, then it is 1, otherwise it's 0.^[8]

(2) Plant coverage indicators. A plant coverage rate of 80 % is ideal. The ratio of

the coverage rate of the river plant to the ideal value is the standard value.

(3) Water fluidity. The flow velocity of water body is fast, smooth, and the change is not single, so it is an ideal state. Scores are determined by expert scoring.^[9]

(4) Flood control standards. If the flood control standard can reach 50 years, then it is ideal.

(5) Public space. The ideal state is to have a variety of green space park, and public space can fully integrate the humanities and natural ecological landscape. Scores are determined by expert scoring.

(6) Historic buildings. The ideal state is to preserve historical buildings well and to highlight regional characteristics. The score is determined by expert scoring.

(7) Accessibility. Ideal state is that the traffic is convenient with three-dimensional multiple lanes and sidewalks.

(8) Afforestation. The ideal state is to establish a tree - shrub - vegetation complex plant community, as well as reasonable and beautiful type of trees and flowers. Scores are determined by expert scoring.

(9) Surrounding buildings. The ideal state is the building along the coast and river scale coordination, height is appropriate, facade effect is good. Scores are determined by expert scoring.

Thirdly, distance index and analytic hierarchy process is used to evaluate.^[9] The distance scores are within the range of [0,1]. When the distance score approaches 0, the system evaluation is not ideal. When the distance index score approaches 1, the system evaluation is ideal. The corresponding relationship between distance score and river landscape evaluation is: less than 0 ~ 0.25 for

poor, 0.25 ~ 0.5 for general, 0.5 ~ 0.75 for good, more than 0.75 for good.

Lastly, by distance index method, experts grade the specific evaluation factors in each index layer and calculate the results.

3. Results

Taking the water restoration planning of Panlong River as an example, 25 undergraduate students majoring in landscape architecture in senior year were invited as survey objects, and the specific evaluation factors in each index layer in the upper segment of Panlong River were scored, and the calculation results were obtained by distance index method. The distance indices are in the [0,1] range. The corresponding relationship between distance index and landscape evaluation of Panlong River is as follows: less than 0 ~ 0.25 for poor, 0.25 ~ 0.5 for general, 0.5 ~ 0.75 for good, and more than 0.75 for excellent.

The upper, middle and lower sections of Panlong River are evaluated. The upper part of Panlong River begins at Songhua dam and reaches the access point of water diversion and drinking water. It is about 2.21 km long and its average width is about 30m. The construction density around the upper reaches of Panlong River is small, and the nature of land is mainly unused. Therefore, the human activities in this section have little impact on Panlong River. The natural landscape of this section is rich, the hydrophilicity and accessibility of the embankment are high, and the balance of water quality and ecosystem is the greatest among the three parts.

Through calculation, the distance index score of the upper segment of Panlong River

is 0.94, which is excellent. Socio - economic and aesthetic indicators score of 0.45 and 0.44, respectively, generally. The overall greening is original with a high sealing degree and a dull space. Water quality is up to class ii water standard and the water flow rate is fast. Landscape activities on both sides of the facilities are not unified whose use efficiency is low. In terms of landscape quality, revetment form is single without motor vehicle lanes on the east coast. There are no bike lanes or system of traffic on both sides of the east and west. The middle section of Panlong River begins at the second north ring road to the second south ring road, with a length of 6960 meters and an average width of 30 meters. The surrounding land mainly is for residential, commercial, educational use. It flows through the most prosperous central area of Kunming, and is also the area where historical and cultural resources are concentrated. A bronze cow sculpture with long history also stands on the edge of the river.

The distance index of ecological environment in the middle part of Panlong River was 0.72, which was excellent. The scores of socio-economic and aesthetic indicators were 0.68 and 0.55, respectively, which was general. The afforestation rate of the middle riverside is higher with trees growing well. The urban space is lack of organic connection with the river. There are a certain amount of public service facilities, and there is insufficient display space for historical context inheritance. Revetment form here is single but the rail style varies. This section of the traffic flow is large and chaotic. On both sides of the riverside road, the transportation of people and car is mixed. There is no link between walking road and

waterfront space. Panlong River's low section begins at the south around the city high-speed to Dianchi Lake with a width of 15m. Panlong River's lower section is relatively desolate with bungalows on both sides. This section of the river is polluted and has poor water quality due to pollutants discharged by the surrounding residents. The lower part of Panlong River has flowed out of the center urban area of Kunming city, and the width of the river channel has become more and more narrow. The afforestation effect on both sides is poor.

Each index layer factor in the lower section of Panlong River is evaluated and a conclusion is drawn. The distance index score of the lower reaches of Panlong River is 0.53, which is good. The socio-economic and aesthetic index scores were respectively 0.42 and 0.51, which were general and good. The lower section of the riverside environment quality is poor, the surrounding afforestation rate is high with a lack of public service facilities. Since it's close to the downstream, its water quality is poor with much sediment pollution. The distance index score is low, and the surrounding landscape features are unified but lack of diversity. In general, the upper part of Panlong River is better than the middle and lower parts in ecological environment. From social and economic aspects, Panlong River has less public facilities and a lack of public space in upper and lower parts, which is complete in middle parts. In the aspect of comprehensive evaluation index, landscape environment of the upper and middle reaches of Panlong River gradually decreased.

Previous to planning and layout, the key water restoration areas are screened by AHP, and the areas to be restored (river bend,

population gathering area, industrial polluted area, etc.) are determined according to the comprehensive score. In the process of planning, the index layer should be analyzed to put forward the ecological restoration strategy according to the importance level of ecological restoration classification. Taking Panlong River as an example, because its comprehensive score is gradually reduced from the upper to the lower, the study group can set up aerobic landscape in the key improvement area of water quality, using elevation difference. In the area with low vegetation coverage, purification plants can be selected, and landscape planning and water quality improvement can be combined to carry out the restoration of plant landscape ecology.

4. Conclusion and Discussion

In the process of urbanization, the research on the combination of river landscape construction and water landscape restoration is of great significance, but the previous research lacks quantitative guidance on hydrological indicators such as water quality, water fluidity, and flood control effect and so on. In this paper, the urban river water resources index is introduced to provide quantitative support for river landscape planning, which improves the scientificity and rationality of planning and design.^[10] But in the concrete implementation process, we should pay attention to the following aspects: first, in the selection of evaluation indicators, this paper takes Panlong River as an example to test the water quality, water fluidity and other indicators. However, in the planning of different projects, designers can choose

different index layer factors according to the actual situation and data acquisition situation, in order to improve the rationality of the planning.^[11] Second, in the process of professional landscape evaluation, picture data is used more often in landscape quality evaluation except for the objective indicators of water resources. Picture data has the advantages of easy collection and convenient display, and disadvantage of the difference with the actual space feeling. Therefore, in the process of evaluation, researchers should adopt the method of field investigation and evaluation or VR image as far as possible to represent the real scene.

Acknowledgments

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The Landscape Renewal Strategy in Suburban Hilly Areas

Based on “Zero External Water Input”

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Abstract:

The suburban hilly areas is a vulnerable area between the city and the mountain body, which contains a large amount of land that is under non-intensive use conditions. It is also a key factor in limiting the urban expansion and building a sustainable ‘outer circle’ for the Eco-city. However, the sprawl of the city has put the suburban hilly areas at risk of disorderly development. The green space in the suburb of shallow mountainous area not only extends the Green Infrastructure of the city, but also can link up the ecosystem inside and outside the city to meet the increasing recreational demand. This particular mode should be different from urban landscape renewal and closed forest project, it is supposed to make full use of shallow mountain resources, improve ecological status. According to the functional characteristics of its natural resources protection, land rational use and entertainment and leisure experience, it puts forward the objectives of resource intensive, ecological service value maximization and cultural continuity.

This paper puts forward the landscape renewal idea of "Zero External Water Input".The process of this mode can be summarized in the following five steps:

1. Water collection;
2. Allocation of water resources;
3. Technology of waterscape;
4. Ecological native plants;
5. Reasonable continuation of cultural memory.

This paper takes Shijiazhuang Mountain Front Park in Hebei Province as an example, practices and explains the renewal strategy proposed by the author. It responds to the development trend of self-sufficient biological city from the perspective of landscape architecture, explores a new way to build Green Infrastructure in suburban hilly areas.

Keywords: Suburban Hilly Areas, Water, Renewal Strategie, Regeneration, LID, Green Infrastructure

1.Introduction

1.1 Conceptual Definition

1.1.1 Suburban Hilly Areas

In this paper, Suburban Hilly Areas is considered to be consistent with Suburban Hilly Areas. A shallow mountain area is a part of a mountain area, which has a certain elevation and slope fluctuation relative to the plain. The landform of Shallow Mountain Areas is dominated by low mountain, hilly land, platform, foothills plain and alluvial fan. Meanwhile, it is the buffer area between artificial construction and mountain natural habitat. ^[1]

The shallow mountain area is a special part of the mountain area, which is different from the concept of “deep mountain area” and “high mountain area”. To be more specific, the defining factors relate to altitude, relative height difference, human disturbance and so on. ^[2] The shallow mountain area is the transition zone between the mountain area and the plain. It is a region with certain development value and has already endured certain development pressure or is likely to be affected by urbanization. At the same time, it is also a vital part of the urban ecosystem.

1.1.2 Piedmont Plain City and Suburban Hilly Areas

It is easy to form the urban agglomeration in the mountain front plain because it holds abundant natural resources and the dense water system composed of mountain catchment water. Usually, the urban space of the piedmont is in the form of plane or band, and there is a distance between the construction area and the mountain body. Due to the impediments played by the surrounding mountains in the process of urban development, the suburban space is banded or dendritic, the green space is wedge-shaped, and the boundary with the city is blurred.

1.2 Necessity of Landscape Renewal in the Suburban Hilly Areas

1.2.1 Characteristics of the Suburban Hilly Areas

(1)The Complexity of Resources

First, the natural and cultural resources are very rich in the suburban hilly areas. They are located at the junction of the plain and the mountain, as a result, the ecosystem shows mixed features. The topography of the region is rich, and the low mountains, hills, terraces, foothills plains and alluvial fans are good habitats for plants and animals. The annual temperature, rainfall, evaporation and other natural indicators are also relatively moderate. Meanwhile, the height difference

and slope bring about certain vertical difference, which makes its geographical space type more diverse. Besides, the shallow mountain area has long been affected by human behavior, which means it holds valuable cultural heritage resources.

Secondly, the scarcity of water resource. The geographical characteristics of the suburban hilly areas determine that the catchment of the mountain body in this position will flow naturally along the slope. The deep and narrow gullies formed by the confluence of the mountain body are mostly formed by erosion of the earth's surface, which makes it hard to form the catchment water. Therefore, water resource is the main constraint in the development of shallow mountain areas.

(2) The Transitivity of Space and Function

The transition is the most typical feature of the suburban hilly areas, which is reflected in both space and function. From the spatial point of view, it is not only a transitional zone between urban built-up areas and ecological conservation areas, but also a transition region between agricultural farming areas and natural vegetation areas. From the perspective of function, it connects the city center with the rural hinterland and drives the urbanization of mountain area.

(3) The Dynamics of Regional Development:

The scope of suburban hilly areas is constantly changing, the expansion of urban scale directly leads to the buffer surface

between built-up areas and ecological conservation areas constantly advancing to the mountain. The suburban hilly areas is greatly affected by the development of the piedmont plain city.

1.2.2 Necessity of Regeneration in Suburban Hilly Areas

Corresponding to its characteristics, there are three problems in the landscape development of suburban hilly areas:

(1) Neglecting the ecological environment condition, insufficient consideration of resource conservation.

(2) Excessive urbanization, the protection of ecosystem and ecological performance are ignored.

(3) Failure to conduct a thorough survey on the needs of the users, insufficient understanding of the needs and functions of the site.

From the perspective of landscape architecture, in order to continue the Green Infrastructure of the city and link up the ecosystem inside and outside the city, it is very necessary to study the suitable landscape renewal strategy for the suburban hilly areas.

1.3 Objectives for Landscape Renewal in suburban hilly areas

This particular mode should be different from urban landscape renewal and closed forest project, it is supposed to make full use of shallow mountain resources, improve

ecological status. According to the functional characteristics of its natural resources protection, land rational use and entertainment and leisure experience, it puts forward the objectives of resource intensive, ecological service value maximization and cultural continuity.

This paper puts forward the landscape renewal idea of "Zero External Water Input".

2. Overview of the Case

This paper illustrates the process and approach to achieve the goal with a practical case. The project, called Mountain Front Park, is located in Shijiazhuang, China. Shijiazhuang is a typical piedmont plain city, which is located in the middle of the east edge of the second largest geomorphologic ladder in eastern China. There are a variety of mountain types on the west side of the city. The project site extends from the east side of Piedmont Avenue to the west side of the channel, and extends north and south to the boundary of the village. The total designed area is 50.1 hectares. (fig.1)

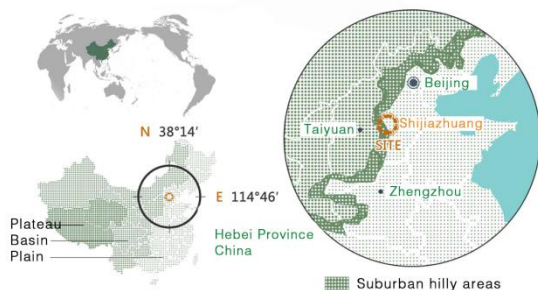


Fig. 1. Site location (Drawn by author)

The site is basically agricultural land, and the existing large area terraced fields constitute the basal texture of the site; Stone is a common material in the site, there is a legacy of stone construction (fig.2); Three gullies traverse the site, which constitute the basic resource structure of the site and can be utilized.

(fig.2)

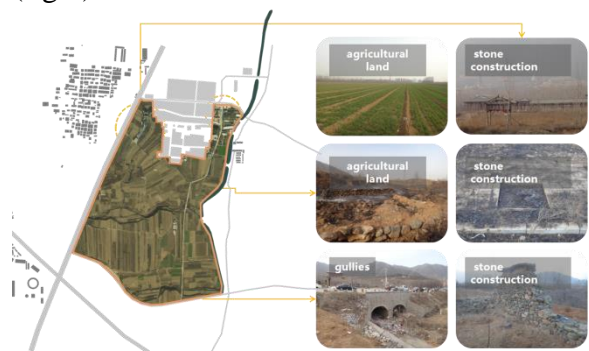




Fig.2 Site status maps(Drawn by author)

Through modeling and GIS analysis, the natural base conditions of the site are analyzed, and the following conclusions can be drawn: The site itself has 27m height difference, and the whole is a complex single slope. Three typical seasonal stable gullies pass through the site, and the runoff is

larger in the rainy season. Through the GIS analysis of the site (including solar radiation analysis), it is clear that the climate condition is conducive to the formation of rich park landscape; More than 80% of the site has a good foundation for construction, but some steep slopes have formed a limit.

3 Research Approaches and Results

3.1 Water Collection

In order to achieve the goal of zero input of external water resources, the first step is to calculate the amount of site Rain Water can accumulate and determine the collection method. The west side is bounded by the surrounding mountain ridgelines, the eastern boundary is the red line of the site, and the village is the border of the south and north, with a total drainage basin area of 5.6 million square meters.(fig.3)

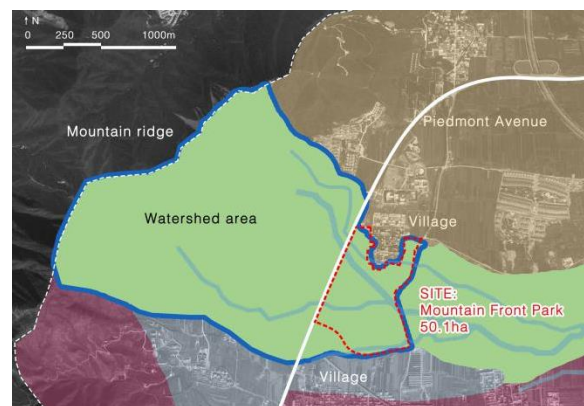


Fig.3 Watershed area map(Drawn by author)

Different colors represent different watershed areas, and the blue frame is the rainwater collection range.

Through GIS software, the surface runoff in the basin area was analyzed and the maximum, minimum and average precipitation of Shijiazhuang in the last 50 years was found in Shijiazhuang hydrogeological condition analysis. The net flow coefficient of park green space and rainfall data are obtained from the practical

hydrological manual of Hebei province^[3],China. The above data can be used to calculate the total amount of surface runoff ,which is 31.88 million cubic meters.(fig.4)

Watershed area / m ²	Precipitation / m (mean, maximum, minimum)	Runoff coefficient (park green space)	Water sequestration in blocks / m ²
3849250.0041	0.5522	0.15	318833.3778
3849250.0041	0.9599	0.15	554234.2618
3849250.0041	0.2408	0.15	139034.9101

Fig.4 Calculation table of watershed catchment in site (by author)

Based on site status and geographical environment of Shijiazhuang, Surface runoff is collected in Low Impact Development way.

Rain water garden is set up at the source of the gully to intercept rainwater. In order to reduce process water consumption,organic impermeable material is used to rebuild gully.

The waterscape sets in the existing terrain depression.Simultaneously, underground storage facilities are set at the lowest place of the site,to maximize the collection of Rain Water resources in the basin..(fig.5)

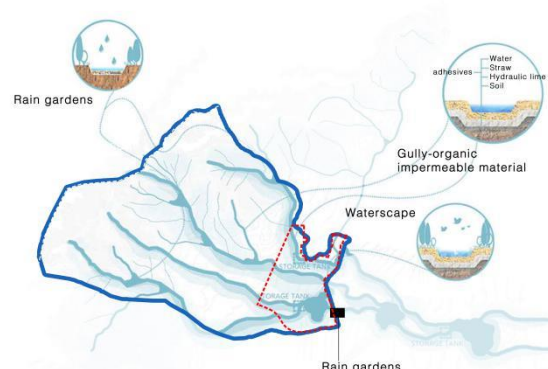


Fig.5 Water Collection system (Drawn by author)

3.2 Allocation of Water

The second step is to determine the distribution of rain water collected. The landscape renewal should meet the needs of ecology and landscape recreation at the same time.

According to the principle of maximizing ecosystem service value, by introducing the concept of ecosystem service value per unit area, this paper compares the value of wetland ecosystem with that of forest ecosystem, and then distributes rain water reasonably.

Among them, forest ecosystem includes forest land, shrub land, unformed forest land, heavy cutting land and nursery.^[4] Wetlands are natural or artificial, permanent or temporary marshes, wet plains, peat bogs, or water areas, whether the water is still or flowing, fresh or salt. Further more, the water depth should not exceed six meters at low tide.^[5]

We focus on the ecosystem service value of forest ecosystem and wetland ecosystem. By comparing the value of 1 cubic meter of water itself with the value of 1 cubic meter of water used to irrigate plants, the value of 1 cubic meter of water itself is 3.4476 yuan and 1 cubic meter of water used to irrigate plants is 6.3702 yuan.^[6] Value of forest ecosystem > value of wetland ecosystem. **Therefore, in the design process, the least amount of water should be used to create the waterscape, , the rest more of the water is used for plant maintenance.**

The waterscape construction technology we use should base on the current situation (existing potholes, depressions, gullies), so that the surface runoff can go from high to low, fill each catchment area in turn. It calculates design water and evaporate water to restore the waterscape and water system with minimal impact. According to the accumulation of long-term observation data obtained in the “Water Surface Evaporation Scale Effect and Its Relationship with Meteorological Elements”^[6], the evaporation amount is inversely proportional to the area, that is, the law that the evaporation amount decreases with increasing area. Therefore, only four large water surfaces are arranged in the whole garden.^[7] (fig.6) The amount of water that can be stored in water is 54300 cubic meters, plus the amount of water used to fill the water, the total water consumption is 85300 cubic meters.

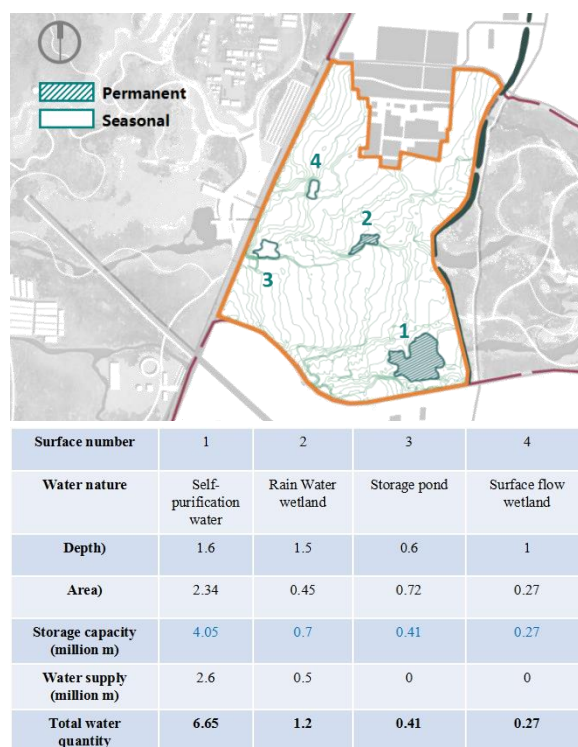


Fig.6 Four large water (Drawn by author)

After subtracting water consumption from total water storage, it can be determined that the remaining 233500 cubic meters of water can be used for plant maintenance.(fig.7)

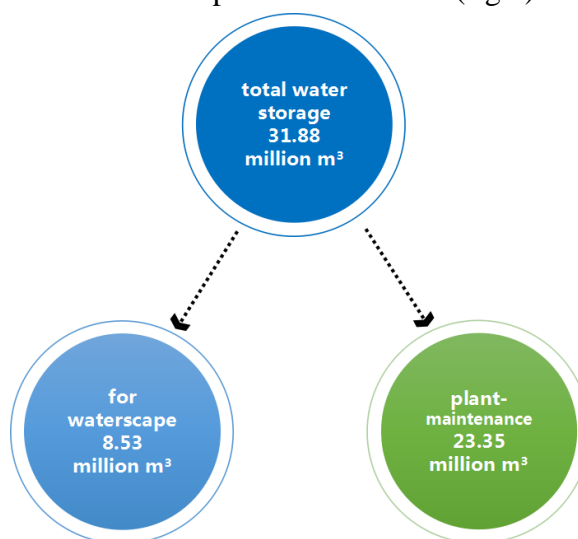


Fig.7 (Drawn by author)

3.3 Technology of Waterscape

3.3.1 Selection of waterlines: Based on the need of connecting water systems and increasing the abundance of waterscape, considering the elevation of the site and the current situation of water catchment, three waterlines are selected to link the water points with the three gullies in the site.(fig.8)

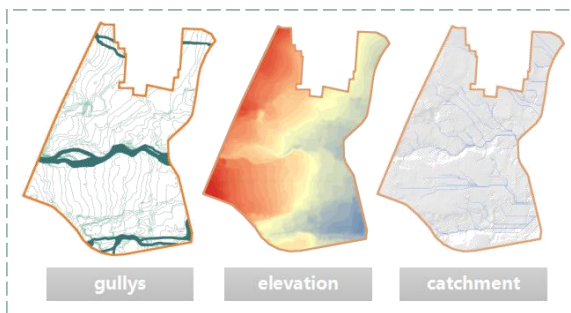


Fig.8 Selection of waterlines(Drawn by author)

3.3.2 Composition of water networks: The selected water points, waterlines and current gullies form a water network that highlights the characteristics of site resources.

3.3.3 Accounting rain water's demand for slow discharge:

The rainy season and dry season of Shijiazhuang are distinct, and the rainfall in the rainy season reaches more than 70% of the annual rainfall, and there are often heavy rains in summer.

The site is located in the middle of the largest catchment area in the planning park, and receives a large amount of rain water. Meanwhile, the site is located on the east side of Piedmont Avenue, which is the largest surface of runoff, so it is very necessary to manage the rain and flood during the rainstorm period.

At present, the total amount of water collected in the design site is 54300 m³.

The latest heavy rain in Shijiazhuang is used as a reference for calculation (happen in 2012, once in five years).^[8]

$$P=5$$

$$r_{t,P} = 2497.652(1+0.862 \lg P) / (t+12.61)^{0.781}$$

$r_{t,P}$ —When the recurrence period is P and the rainfall duration is t, the rainfall intensity is L / (s·hm²);

$$r_{t,P} = 12.21L / (s \cdot \text{hm}^2)$$

It is calculated that the rainfall of this intensity is 105mm, $r_{t,P} = 12.21L / (s \cdot \text{hm}^2)$.

$$Q = CA \cdot r_{t,p}$$

Q- design runoff L / s;

C-runoff coefficient

A- Water catchment area

The total net flow is: $Q_{\text{total}} = Q \cdot T$

Conclusion: If the heavy rainstorm last for

24 hours (once in five years), it may result in a runoff of 60600 m³
 60600m³>54300m³

Heavy rain will exceed total site storage capacity. To regulate the water storage and slow the emission rate, the site also needs to set up the immersible area that can be submerged under the condition of heavy rain, and the amount of rainfall that can be accumulated is: 6.06-5.43=0.82 (10000 thousands of cubic meters)

Combined with topographic and catchment factors, the immersible area is selected at the junction of water system or lower depression, the average water depth of submerged area is 0.3 m, the total area is 3.1 ha, and the maximum water volume can be adjusted to 8200 m³ under heavy rain.(fig.9)

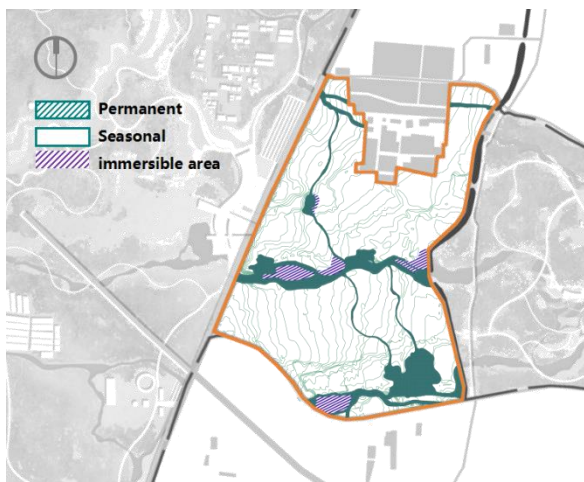


Fig.9 Water system layout(Drawn by author)

The designed runoff paths are: the rain flood source from the western mountain body is purified by storage ponds, surface flow wetlands and storm water wetlands. Partly of the purified water may flow into

the self-purification water body and other may be discharged along the stream. It can basically meet the requirements of rain water storage during the rainstorm period, and form the seasonal dynamic water system landscape.

3.4 Ecology Native Plants

3.4.1 Plant irrigation water requirements are equal to plant water consumption minus effective rainfall. Annually effective rainfall can be calculated by annual historical rainfall. The average effective rainfall coefficient RF is 53. [9] The annually effective rainfall of the site is 5522*53/100 = 292.67mm. Plants that can survive by using natural precipitation are classified as "self-supplying plants", and plants that require additional irrigation become "irrigated plants" that cannot be satisfied with natural precipitation. The site uses local self-supply plants on a large scale to form a keynote landscape with nostalgic memories. At important nodes, 379300 cubic meters of water are used to conserve irrigated plants.(fig.10)

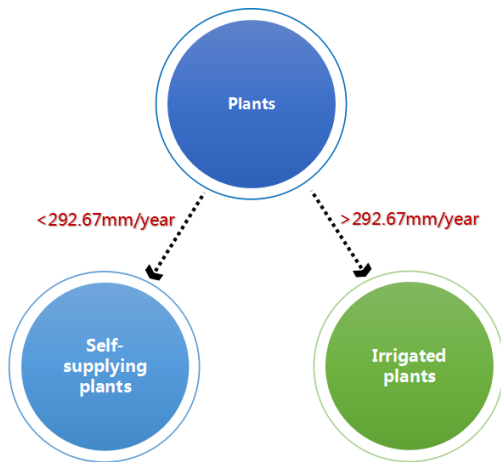


Fig.10 (Drawn by author)

Referring to the water consumption of common garden plants in Hebei Province, we can see that the average water consumption of 1 m² irrigated plants is about 266.06mm per year, so it can be estimated that the irrigated plant area can be controlled within 142900 square meters in the whole garden. These irrigated plants are often used to embellish important landscape nodes to form delicate landscape effects.

3.4.2 Plant Arrangements based on Habitat

According to the formed landscape system, plant habitats in the site can be clearly divided into terrestrial habitats, short-term immersible habitats, wet habitats and aquatic habitats.^[10](fig.11)

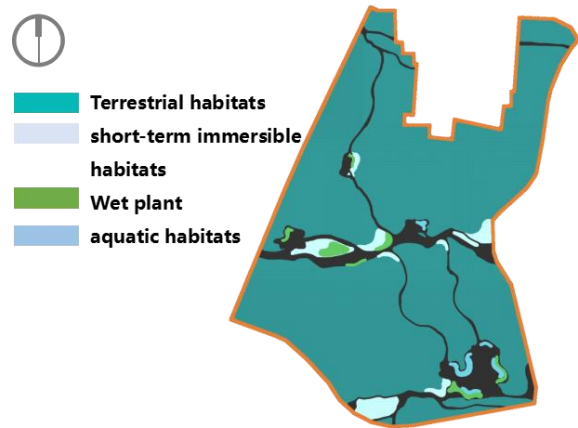


Fig.11 Plant Habitat (Drawn by author)

3.5 Reasonable continuation of the site context

Changes in the nature of land use: The conversion of the site from cultivated land to country park will result in a change in the nature of the site. Considering the position of the site, as well as the excessive water consumption of crops, the farmland will be completely reserved in the field. Considering the factors such as convenient irrigation and reducing pollution, the reserved farmland area is determined as the area nearby the water source.

The designing concept for the site texture is ‘complete reservation’ and ‘extraction of features’. The ‘complete reservation’ method means retaining its integrity, preserving the morphology and function of farmland intact.^[11]The ‘extraction of features’ method means drawing the wisdom of terraced fields to apply it to the site, which creates a harmonious shape composed of curves and fold lines that fit the contour lines.

Functional requirements: Through the derivation and collision of three keywords: ‘agriculture’, ‘arts’ and ‘countryside’, the demand for the function of the country park was selected by the questionnaire, and the functional partition of the site was determined as: natural art experience area, countryside landscape recreation area, peaceful forest recreational zone and agriculture sightseeing area.(fig.12)

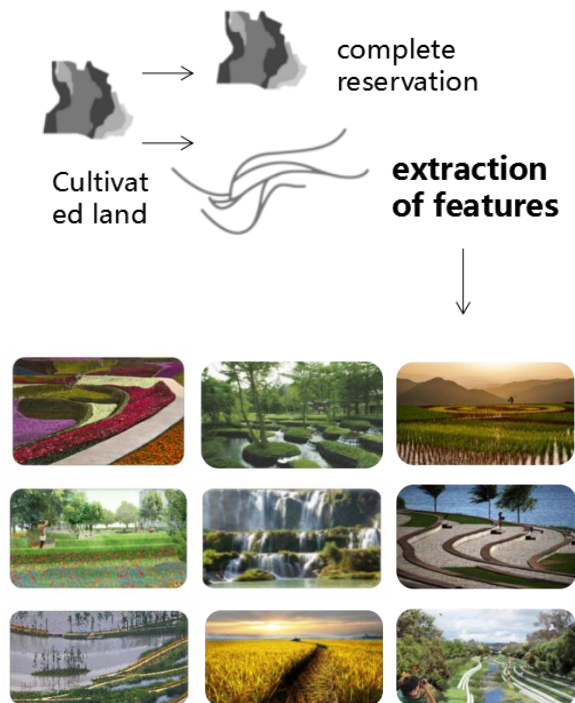


Fig.12 (Drawn by author)

4. Design Achievement

In general, under the guidance of the concept of "Zero External Water Input", this paper tries to promote a landscape

regeneration model for the shallow mountains area.

The final design results of the Mountain Front Park (fig.13)are as follows: Taking water as the main landscape elements, it contains four wetlands, three streams, three waterfalls, two islands and three water terrace landscape. According to the analysis and research, the site is divided into four parts: Wind Valley (natural art experience area), Leisure Area (countryside landscape recreation area), “Returning to My Farm” area (agriculture sightseeing area) and Peaceful Forest Recreational Zone (forest recreation area).(fig.14)

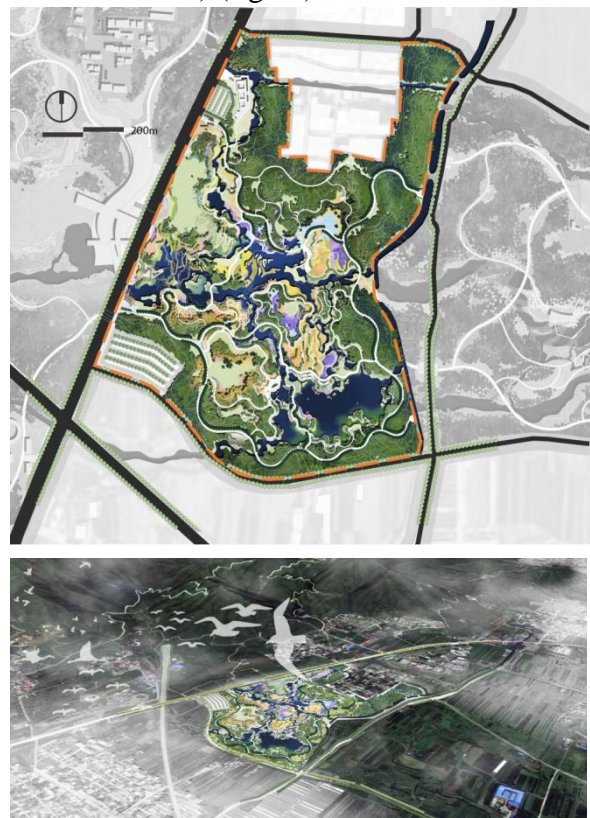


Fig.13 Plan and aerial view(Drawn by author)

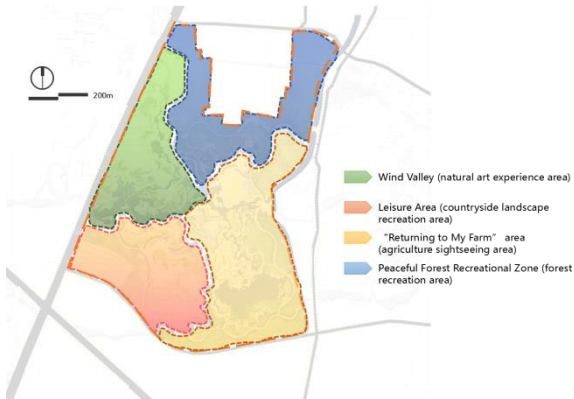


Fig.14 Zoning and landscape renderings (Drawn by author)



5 Thinking and Discussion

5.1 Innovation Points

This paper focus on the relationship between the shallow mountain area and the city, it puts forward the characteristics of the present situation of the suburb shallow mountain area and the landscape renewal target. Based on the concept of "Zero External Water Input", this paper puts forward a new strategy of landscape renewal in the suburb shallow mountain areas, which can solve the problem of resource shortage from the source. Moreover, it raises a thought about how to benefit the ecological and landscape factors of suburb shallow mountain areas under the rapid expansion of cities. It is a new respond to the biophilic city from the landscape architecture perspective.

5.2 Research Limits Future Development

The generalizability of this research is subject to certain limitations. For instance, this method is based on a case, which requires more practical projects to verify and enhance its reliability. Moreover, considerably more work will need to be done to determine the estimation of water consumption of native plants, as the current statistical data on plant water consumption are too small and the regional differences are notable. Meanwhile, further research should be undertaken to explore how to determine the irrigated plant planting area, which would help us to establish a greater degree of accuracy on this matter.

Acknowledgments

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From “Gray” to “Green”— Intelligent Transformation of Urban Road Infrastructure

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Abstract

With the rapid development of the city, the gray infrastructure, including urban road, mainly serving for municipal function, occupies a large part of the urban space, which loses vitality and makes the living environment worse. In this context, how to reuse the gray infrastructure becomes a big problem to be solved. Taking the transformation of Beijing Marathon Track in 2008 as an example, the paper aims to explore the opportunity to embrace the road system as a part of urban public space and turn "gray" into multi-functional "green", by the means of intelligent Interactive Device.

With the end of the marathon race in 2008, this route was almost entirely as a transport infrastructure in the city or region and lost public space vitality. The nature and size of land make it difficult to be activated and reconstructed. Based on the research and evaluation of the surrounding building scale, the nature of the buildings, green space, green space usage, physical flow of people and so on, the article explored potential space on the site and formed several "circles", which means non-motorized system. The public can choose their daily trip from it. What's more, there will be many "points" which provide space for exercise and communication.

The change from "gray" to "green" is approached through the installation of intelligent interactive devices along the road, including perceived vibration pedal, water storage tank and energy conversion equipment. Through collecting vibration energy generated by pedestrians, automobile, and underground trains, the electrical energy converted from the vibration energy will be used for road lighting, green belt irrigation, active facilities supplying and so on. At the same time, the relevant data can be sent back to users through mobile applications, in order to encourage public participation in sports.

In this paper, we try to use a kind of minimum intervention——Intelligent Interactive Device, integrating the single function of municipal engineering into a more comprehensive urban public system, and enhancing the diversity and multifunction of the city. By proposing the "intelligent infrastructure", this article aims to set a base for further development of urban open space system-the integration of inner-city road system, outdoor walking network and ecological framework.

Key words: gray infrastructure, green infrastructure, urban public space, interactive devices, smart city

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1. Introduction

1.1. Landscape as Infrastructure

Urban Infrastructure, socio-technical systems of facilities and services that are essential to the basic functioning of cities and regions. In the early days of social development led by the industrial revolution and socio-economic development, urban infrastructure was often defined as a network of roads, bridges, railways, and other public facilities necessary to ensure the basic operation of the industrialized economy. However, with the development of landscape urbanism theory, "Landscape as Infrastructure" is increasingly accepted by people. At the same time, green infrastructure, which protects and maintains the balance of natural ecological processes, natural resources, and urban resiliency, has also increasingly implied in city development. In the urban conditions, the open space system formed by the natural resources green space system will not only function aesthetically, meeting citizens' entertainment needs but also becomes functioning ecologically.

1.2. Intelligent Infrastructure Systems

In this paper, green infrastructure will be redefined beyond its physical design meanings and ecological functions — but also refer to urban intervention that alleviates traffic congestion, promotes energy conservation and emission reduction, and a more walkable lifestyle. The proposal takes the least intervention — smart interactive devices but promotes sustainability in an efficient way. The

extension of this definition means that "Landscape as Infrastructure" not only refers to a physical design of landscape features or facilities but also can refer to a virtual and subtle change in lifestyle that promotes by the green infrastructure system itself. In this high-technology era, taking advantages of the power of media and interactive devices provides landscape architects new perspectives and roles to work with. entity that works together to contribute to the city. The interactive device system presented in this paper visualizes the conversion of kinetic energy to electrical energy, and at the same time, it is also a visualization of the strategy of smartly transforming the gray infrastructure into a green infrastructure. Breakthrough the traditional understanding of the green infrastructure, with intelligent means, the language of the landscape, re-interpretation of the urban greenway.

2. A Case Study — Beijing 2008 Marathon Circuit Renovation

2.1. Background Study

With the rapid development, traffic congestion and excess energy emission has become a severe issue in China. Road infrastructure connects various urban fabrics in modern cities. However, due to the long-term lack of comprehensive consideration of the natural environment, social ecology, and aesthetics, the traditional way of planing and design roadway systems cannot meet the requirements of urban development anymore.

This article takes the renovation of the Beijing 2008 Marathon track as an example. With the end of the Beijing Olympic Games, this route exists almost entirely as a transport

infrastructure within a city or a region. There is a large limitation on the nature and size of the land on both sides. Without the conditions for large-scale reconstruction and development, people's travel and leisure are squeezed into the gray space. The purpose of this paper is to explore how to integrate road grey infrastructure into urban public spaces through smart landscape approaches, achieve synergies with the green infrastructure, maximize the potential for space use and capacity, and become the driving force for urban regeneration and sustainable development.

2.2. Urban Open Space Analysis based on Beijing 2008 Marathon Route

2.2.1 Existing Conditions and Problems Analysis

1. Stormwater Management

Acknowledged from the survey results, the site of the original competition route is located in or adjacent to the Yishui section. The drainage system of these areas is not perfect, and there is no suitable green space nearby to absorb the water, rain, flood, heavy rain, flooding, this problem It has caused many inconveniences and even threats to the safety of people walking and driving on rainy days. Therefore, the transformation of the grey infrastructure that contains water and stagnant water into a green infrastructure with hydrophobic water will be a key point in the use of the track.

2. Pedestrian Circulation&Green Network

The race route passes through the central urban area, important high-tech zones, and cultural and educational districts. It is the most densely populated area in Beijing. The traffic congestion along the roads with a

large number of traffic flows and poor planning is extremely common. Congestion brings a lot of tail gas and noise pollution, resulting in pedestrians walking on the road, non-motorized travel experience is poor, some people reduce outdoor activities, some people join the motor vehicle travel to intensify congestion.

At the same time, along the track, historic parks such as the Summer Palace, as well as community parks, are also along the route. These urban green spaces scattered in the green space system have not been fully utilized, either from the perspective of civic activities or from the perspective of urban ecology. As a result of the green space system analysis map, the use of marathon tracks to promote smart walking and bicycle travel will greatly reduce the pressure on traffic congestion in the downtown area of Beijing and enable the sports spirit conveyed by the original marathon to be promoted in daily life. Enhance public awareness and recognition of the marathon competition, make the green space system more perfect, and the infrastructure functions become more effective.

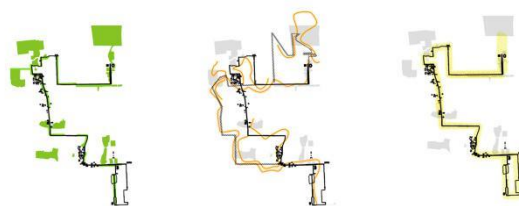


Figure 2.2.1-3 (From Left to Right) Urban Green Space Analysis; 2008 Beijing Olympic Games Marathon Route renovation potential analysis; Lighting Feature and Street Amenity Analysis

3. Urban Identity

The starting point of the 2008 Beijing Marathon course starts from the eastern side of Tiananmen Square, passing through the

Changan Street, Yuyuantan Park, the Summer Palace, the Forbidden City and other iconic historical and cultural centers, as well as the CCTV TV Tower, the World Trade Plaza, the Bird's Nest, the Water Cube and the Olympic North. New landmarks such as stadiums are an urban linear space that carries the long history and culture of Beijing and the vitality and sportsmanship of the new era. However, the current road landscape construction is the same, and does not reflect the urban characteristics. Therefore, how to restate history through landscapes and reshape urban features will also become the most important aspect of landscape design and promotion.



Figure 2.2.4 Urban Identities Illustration Collage

2.2.2 Renovation Potential Analysis

The area along the race track can be divided into five major areas with different characteristics according to the surrounding building properties, building size, green area, green space usage, and potential functions of green areas: historical and cultural sites, high-tech industry start-up areas, college culture and education areas, Commercial area, Olympic venue area. According to the different characteristics of each area, landscape design should also be focused on local conditions. Finally, in combination with other marathon tracks and the potential space on the site, multiple “rings” are formed. These “rings” are sports track and jogging system, and the public can select

daily exercise routes according to their needs. Secondly, multiple points are set on the route to combine the green space or the venue to provide space for exercise and communication.

2.3. The transition from "gray" to "green"

The transition from “gray” to “green” on the site is applied by the installation of intelligent interactive devices along the roadway, including pedals that senses vibration; stormwater tanks that direct and harvests rain water; and devices that promotes clean energy. By collecting the energy generated by the urban road infrastructure, and utilize it in lightening the street lamps, irrigating street vegetation, and supporting street amenities, citizens will easily aware of their involvement in this invisible transition. As a result, more and more people will be participating in the activities, and promoting the green lifestyle gradually.

Firstly, installing energy collection devices along the sidewalks, driveways, and subways, harvesting vibration energy generated by pedestrians, vehicles, and subways (Figure 2.3.1), and then convert the energy into electrical energy, also storing it in the devices for future use. (Figure 2.3.2).



Figure 2.3.1 Energy Harvesting Device



Figure 2.3.2 Source of Energy Harvesting

The stored energy is utilized in two aspects. On one hand, it can be used to irrigate green spaces and help alleviate stormwater flood issues. According to the Marathon route surrounding area open space analysis(see section 2.2), it is easy and beneficial to harvest rain water in the rainy season. When it comes to the large rainwater event in rainy season(June-September), the excess rainwater on the roadway and sidewalks will flow into the sediment forebay collection box, to be cleaned and then stored in the tank. When it comes to the small rain event in normal season, water in the storage tank is pumped out and sprayed through the sprinkler device, irrigating the green belt around the road (Figure 2.3.3), also supporting some on street water features which will adjust micro-climate in dense urban conditions.

Secondly, taking advantage of the renovation, the green spaces along the roadway can be redesigned as recessed lawn area or bio-retention pond, etc. The process of rainwater collection and reuse in urban roads combined with the park green space system can become a unique landscape of the city.

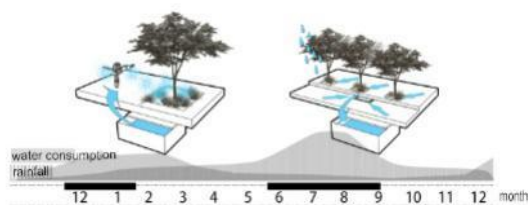


Figure 2.3.3 Collecting Rainwater and Irrigation

At the same time, the stored energy can also be used for the activities of citizens in the open space along the route. People can interact with the devices by easily stepping on them, and observing the energy

transformation processes through the devices. In certain areas, by pedaling the trigger device, playful public open space is formed to stimulate people's interest in the activity. Convert energy into electricity to provide billboards, street lights, etc. on both sides of the sidewalk, saving energy (Figure 2.3.4).



Figure 2.3.4 Diversifying Public Event Space

Finally, various data is uploaded to personal social account through the Internet, with which personal travel and sports data can be updated simultaneously.

The installation of such micro-facilities will achieve the goal of transform gray transportation facilities into intellegent green infrastructure that people can interact with. At the same time, combine with the urban open space to better exert ecological, social, and economic effects (Figure 2.3.5).



Figure 2.3.5 Application Mode Schematic

2.4. Landscape Design Approach

In the Chinese industry standard “Planning and Designing of Urban Roads”, the urban road greenbelt is defined as the land that can be green within the scope of

roads and plazas, including road green belt, traffic island green space, square green space and parking. Green field. Therefore, this paper plans to select three representative venues for the marathon track, which are green roads, traffic islands and square green spaces, and carry out specific examples of landscape design analysis.

The first site was selected in the road green belt on both sides of the road (Figure 2.4.1). When rain flows through undulating terrain, it slows down the flow and sparse more time for infiltration. At the same time, after the rain passes through the first permeation unit of the inlet, it is initially filtered out of the larger litter, when the amount of rainwater in the pond exceeds the design. At depth, rainwater overflows from the first permeation unit into the second permeation unit, and so on. When the last permeation unit is saturated, excess rainwater will flow into the underground water storage facility. At this point, the water flowing into the water storage facility has undergone preliminary filtration and purification of the plant roots, which can be used for irrigation and landscape water use. When a large-scale rainfall occurs and the rainwater that enters the underground water storage facility from the storm water inlet still cannot be absorbed, the rainwater will be directly discharged into the urban underground rainwater pipe network system.

After the tests of the model, the road green belt can reduce 80% of the runoff of the storm water once in 25 years. Integrate the functions of rainwater management and utilization into street greening and combine

landscape elements to create urban streetscapes with local characteristics.



Figure 2.4.1 sectional perspective of road

The second site is chosen in the three-dimensional transportation system (Figure 2.4.2). The number of pedestrians and vehicles in the traffic lanes are all relatively large. The continuous vibration can provide energy for the site. 1st floor for passengers traffic 2nd floor for a person who in lack of exercise, with runways, seats and green climbing plants hung over the 2nd floor.



Figure 2.4.2 sectional perspective of 3D circular

The third site is selected in the square green space on both sides of the road (Figure 2.4.3). The paving and green space in the plaza can stay in the rain and infiltrate the rainwater. The reservoir in the site can also collect rainfall through the collected roads. Energy, on the one hand, can increase air humidity through spraying when the city is relatively dry, creating a good urban microclimate. On the other hand, it can be used as dry spray square to form an interesting street corner park.

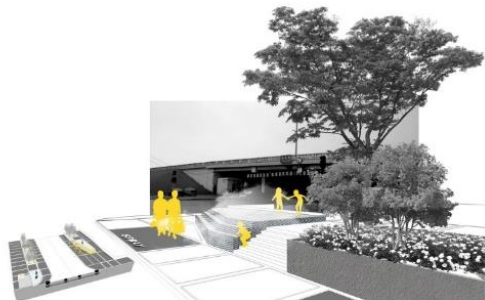


Figure 2.4.3 view of street park and mist spray

2.5. Benefits Analysis

1. The original track areas are all high-density and high-congestion roads in Beijing. However, this paper proposes to convert the gray infrastructure wading and reuse into green infrastructure, and collect and purify the rainwater by placing water collection tanks in the inner city area. Irrigation road trees, plants on the green road, so as to create a green environment of urban roads. The use of rainwater is resource-based during the different phases of urban rainfall. It also alleviated the problem of water accumulation caused by poor water flow through the urban pipe network in heavy rain weather in Beijing.

2. Based on the track, build a chronic system of urban green travel. With intelligent interactive devices as the media, the company will attract people's attention and participation by means of visualizing energy and increasing interest, so as to achieve energy conservation and emission reduction, ease traffic congestion, link multiple green areas along the route, and tap the green potential space. Integrate the

infrastructure on the scale of the human, connect the original single gray infrastructure through pedestrian traffic, rejuvenate and create an open green innovation environment.

3. Based on the establishment of a green and chronic system, residential areas and commercial areas along the race track will also be injected with new vitality. The gathering of people contributes to the agglomeration of cultural connotations in residential areas; for the business district, it means that the promotion of consumption drives the regional economy.

4. The ultimate goal of this design is to promote green travel and achieve energy conservation and emission reduction as well as the use of clean energy. As a highly industrialized and highly mechanized city, Beijing still has a very high use of fossil energy. In the process of improving the level of intelligence, cities can only achieve constant and efficient exchange of information, energy and materials in an open and innovative environment, and then realize the flow and agglomeration of innovative entities. The smart city green innovation ecosystem The dissipative structure can achieve orderly operation. In the proposal of this article, the public will be introduced to the thinking of science and energy conversion, and at the same time, the public will be made aware of the practical significance of using clean energy in a visual way. This move has long-term significance for the development of the city.

3. Conclusion

This paper attempts to integrate a single-function municipal project into a more comprehensive urban public system with a minimum intervention—the intelligent interactive device—in a limited urban space, creating urban complexity and multi-function. Through such smart infrastructure construction, it provides a reference for the development of an integrated urban open space system and the integration of inner-city transportation networks, outdoor walking networks, and ecological networks.

However, in practice, how to effectively transform the gray infrastructure into green infrastructure still has many difficulties and problems. Take this article as an example to make some suggestions.

1. Integrating with Microscopic Green Infrastructure

In today's rapid economic development, the areas that are in urgent need of transformation are often urban areas with a high degree of construction. It is difficult to have a lot of room to build green spaces, and only to see the green in the seams to improve the existing urban environment on a microscopic scale. However, in large cities, frequent rain and flood disasters, it is difficult to completely solve urban water problems by simply relying on micro-scale green infrastructure. All kinds of microscopic green infrastructures only slow down flood peaks and retain part of the rainwater. Rainwater that exceeds their capacity needs to pass through the urban pipeline. The network to deal with, how to coordinate the micro-scale green

infrastructure and other urban infrastructure is a consideration.

2. Post-maintenance issues

The good operation of the micro-scale green infrastructure requires continuous maintenance and regular testing and evaluation to ensure its normal operation. On the one hand, continuous maintenance and management can summarize the experience in design and improve the insufficiency of design. On the other hand, it can adapt to the continuously evolving usage requirements and improve accordingly. Some current infrastructure construction "reconstruction of light pipe", follow-up investment, inadequate management and maintenance, making the project greatly reduced the effect. Only by paying attention to late-stage maintenance and management can we ensure that we can continue to function well after completion.

3. Public participation

Public participation is also a very important aspect. In urban areas with a higher degree of construction, it is difficult to have a large amount of space to build green spaces. People's travel and leisure are squeezed into the gray space. It is necessary to build green infrastructure, provide citizens with public space for activities, and mobilize the enthusiasm of the public. At the same time, they need to solicit the views and suggestions of the site users to design a micro-green infrastructure that is convenient and easy to use. However, the current level of public participation in China is relatively low, including the lack of willingness of the residents themselves to participate and the related policy procedures are not perfect. It is necessary to strengthen the construction in this area.

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The Identification and Building Pattern Research of Urban Greenway Network Based on Space Potential

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Abstract

With the proceeding of urbanization in China, especially in megacities such as Beijing, urban land use patterns were confronted with problems such as geographic imbalance, space fragmentation, inconvenient slow traffic and low environmental quality. In a matter of speaking, as a multifunctional public space network deep into city, the construction of urban greenway network, which can effectively improve the traffic condition, raise the residential quality and promote slow traffic lifestyle, is an important means of urban stock space optimization. The present research of urban greenway in built-up areas was relatively insufficient, especially in the study on the one key factor-----the potential of urban land conversion in network identification. From what we have mentioned, this paper is aimed at the characteristic of this kind of greenways that is closely connected with urban life and is easily constrained by urban land use and residents demand. In the new data environment, multiple heterogeneous spatial information is used to intentionally explore the means of urban greenway network identification with the mature land suitability assessment process based on GIS spatial analysis(the evaluation of urban land use potential) . An empirical research is also conducted in Beijing Haidian district, exploring an effective way for the development of compact and intensive city in the future of China.

Keywords: Urban greenway; spatial network; green infrastructure; landscape urbanism

1. Introduction

Since the reform and opening-up, Chinese cities have experienced unprecedented rapid development and expansion. With the increase of urban area and population, a variety of urban lands are developing rapidly and the internal spaces are rapidly reducing. And what's worse is that the surrounding lands have been severely encroached and the degree of land fragmentation is increasing. At the same time, the pattern of urban land development also has a geographical imbalance[1]. Residents' daily life, works, cultures and recreational spaces have been placed in different places without any connection, which forms the urban lifestyle that relies heavily on motor vehicles[2]. As a matter of fact, the convenience of slow traffic is inhibited and the transport infrastructure is overwhelmed. More serious is that the related pollution causes the constant deterioration of the environment[3]. All of these are considered to be one of the major causes of urban crisis. Many cities are facing a series of serious problems, such as protecting environment, culture and improving residents' quality of life, while realizing the demand of continuous and balanced development of land.

The greenway is a "green infrastructure" that connects people to the site while building an open space network. In addition, it provides a new development model for urban renewal and sustainable use of land[4]. With the development of the concept of the greenway, it has developed into a kind of complex network with functions of ecological improvement, cultural protection, entertainment and green

travel from the original linear plant area only used for protection[5]. Meanwhile, it can promote the further optimization of urban spatial structure, which is of great significance in the process of compact and refined development in Chinese cities.

Urban greenway network, which is closely related to residents' life in urban area, can effectively improve urban traffic condition and improve residents' quality of life. Simultaneously, it promotes a city lifestyle led by slow behavior and as the main way to optimize the spatial structure of urban land storage[6].

However, Chinese greenway has encountered many difficulties in its promotion. Firstly, for the built-up areas of a compact city like Beijing, incremental lands are insufficient, short of lands need to be optimized and the land that can be used to build urban greenway is seriously insufficient. More importantly, government departments are more willing to invest money, land and other resources to build a wider road to provide more vehicles to ease urban congestion. Unfortunately, after a long construction, traffic jams in compact cities such as Beijing have not been solved. Secondly, academic research has lagged behind the development of practice and cannot respond to the problems encountered in the development of urban greenway in real life. At present, the potential assessment of urban land use in integration, transformation and borrowing is seriously insufficient. More scholars devote their energies to the methods of route selection of greenway.

Most of these methods are mainly based on the suitability analysis of greenway ecological function, cultural function and recreational function. All of these reflect that the focus of China greenway planning and construction are still focusing on the regional level and the outskirts of the city, and there is a serious shortage of attention to the urban greenway in the built-up area[7].

Therefore, it is very urgent to pay much more attention to the urban greenway in the built-up area. At present, there are several driving keys make the idea of developing urban greenway based on space potential become reality. On the one hand, under the background of the apparent inadequacy of incremental land, the land use efficiency of city is greatly improved with the progress of technology, which makes the optimization of the stock land have broad development foreground. On the other hand, the huge pressure from transportation, energy and environment requires us to develop the chronic transportation network with the main characteristics of green behavior, especially the shared bicycles, one of the new four inventions in China, is developing rapidly, with a cumulative amount of over 10 million vehicles. Many of these shared bicycles exist in dense urban areas, and many of them still have to share the driveway with the motor vehicles. Fortunately, urban greenway can provide a safe and green travel environment.

Combined with the actual situation of China, exploring a set of technology framework of urban greenway network identification and construction which may base on the urban space development potentiality, leisure, ecology, cultural

service function and the citizen social life demand is very important practical significance and promising.

2. Method

The following methods are used in the research process.

2.1. Literature, case reading and induction

By using relevant books, academic journals and network resources, we systematically classify the excellent urban greenway design examples at home and abroad. At the same time, the related construction ideas and the innovation space utilization patterns are summarized. Then on the basis of the current classification standards of urban land use, the potential land resources of greenway in built-up area are excavated. Moreover, it puts forward the refinement land classification, which is beneficial to the identification and development of urban greenway based on spatial potential.

2.2. Analytic hierarchy process (AHP) for land suitability analysis

For the potential land resources of greenway in built-up area, the evaluation factors are screened from the function level of ecology, culture, leisure and social service, and then the analytic results are obtained by using AHP. Furthermore, the spatial suitability map of Haidian District is drawn, which is based on geographic information system.

2.3. Field research and empirical research

A detailed field survey is conducted in haidian district of Beijing. Besides, the relevant upper planning and basic data are obtained, and then the spatial characteristics of the built-up area are systematically summarized and analyzed. On the basis of the space suitability map for drawing, partial empirical research is conducted. In addition, according to its spatial characteristics, a differential greenway construction model is proposed.

3. Result

By using the above research methods and combined with relevant information, we get the following results.

3.1. The main type of urban greenway and the mode of innovation space utilization

Through the reading of relevant literature, we found that, in the course of greenway classification, scholars usually divide it on the basis of the function, the scale and the main resource type. What's more, these classification experiences are instructive for the classification of urban greenway based on spatial potential[8].

However, we believe that there are still some drawbacks in this classification. First, now the urban greenway is carrying more diverse functions, and a single function to classify the kind of method is inaccurate; Second, the urban Green Road is mainly located in the urban built-up area, the scale is similar; Thirdly, the type of urban greenway is classified by the main resource type, and the coincidence degree is high,

which makes it difficult to classify accurately; Last but not the least, such classification method is not conducive to the storage space optimization of urban concentration areas and the promotion and construction of urban greenway.

Through sorting and summarizing, we have found that there are currently three kinds of construction ideas, namely integration, transformation and borrowing, for how to build urban greenway based on space potential. Dividing urban greenway with different construction concepts can accurately reflect the specific tactics of releasing space potential under the guidance of corresponding concepts. In addition, it is advantageous to carry out the statistical analysis of resources in the course of actual construction by identifying the types of urban land to be relied upon. At the same time, it provides convenience for finding similar urban land and excavating the potential of space and provides development space for the popularization and practice of urban greenway. Therefore, we believe that there are basic and objective conditions for classifying research in these two points which include the concept of urban greenway construction and the type of urban land relied on.

1. Divided by different construction concepts

1.1. Integration

In recent years, the development of landscape ecology and green infrastructure ideas has provided theoretical support for the development of greenway. In particular, with the deepening of research in the fields of ecological network structure and ecological connectivity theory, scholars

have come to an agreement on the basic cognition of urban greenway. That is to say, the greenway has the characteristics of linearity and connectivity. It not only has the function of a biological corridor, but also carries the functions of connecting broken natural spaces, integrating history, culture, ecology, social resources, and building a complete greenway network. However, due to the fact that most urban greenways are located in urban built-up areas, they usually cannot provide sufficient land resources to meet the needs of greenway construction. Therefore, the development of urban greenway should not only make full use of the existing greenways and greenbelt resources, but also actively expand its regional scope to form the overall effect and release the space potential. This is the idea of "integration", such as east coast greenway construction in America and so on.

1.2.Transformation

At present, the concept of "urban regeneration" has been adopted by people. More and more people have realized that "urban regeneration " is a more prudent, sensible and harmonious development than simply "pushing and rebuilding". This process takes a series of smarter and more diverse renewal approaches, such as protection, repair, reuse, and redevelopment[9]. It is more suitable for the development of compact cities in China. For urban greenway, it can effectively promote the storage space optimization of compact city and release the space potential by actively striving for the land allocated for green space in planning as reserve. Especially, it is necessary to transform the abandoned land and land facilities in the former city to develop urban greenway. This

is the idea of "integration", such as high line park in New York and so on.

1.3.Borrowing

For the built area of the city, the restriction of land ownership of present situation makes the planning and implementation of green space system more difficult[10]. Under such pressure, "borrowing" and other new construction ideas emerged. It refers to the use of the land compound urban greenway function on the premise of no change in land ownership or property rights. For example, the Singapore Park Bureau in the greenway land requisition project "borrow" land that does not belong to the Park Bureau. The land ownership of the latter has not changed, but the Park Bureau invests in the construction of greenway and is responsible for maintenance and management[11].

2.Divided by different types of urban land relied on

Based on the idea of "integration", "transformation" and "borrowing", we conclude that we can carry out detailed classification in five aspects: planning land reservation, current ecological land integration (green land, mountain forest, wetland, etc.), other types of land use function transformation, regeneration of abandoned land facilities and upgrading of compound urban greenway functional land.

In order to facilitate the understanding with other practitioners, explore the potential of space beyond the green space and effectively promote the construction of urban greenway in China, we use the *Code for classification of land use and planning standards for development land* (GB50173-2011) as the basis for classification. In order

to be able to put forward a set of refined land classification that has localization characteristics, which is conducive to tapping space potential, and covers all urban lands completely by the detailed study of urban greenway at home and abroad. The results of classification are as follows:

Form. 1. Land classification based on different types of urban land(Appendix)

3.2.Precise land classification based on space potential

We use the current *Code for classification of land use and planning standards for development land* (GB50173-2011) as the basis for classification. It can cover current examples of excellent urban greenway design at home and abroad, but there are still deficiencies. However, through the above form, we find that not all land covered by the listed urban land types can build urban greenway. Some types of urban land still need to continue to refine the classification. Only in this way can we select and identify the land with spatial potential from the imprecise type of urban land.

Under the constraints of technology and environmental benefits, we no longer list land types with no spatial potential.

1.Planning land reservation

At present, water classification is mostly inefficient use of land and has the characteristics of linearity and connectivity. With the current technical conditions, except for a small amount of land, most of the land can be regarded as the land with spatial potential to develop urban greenway.

Form. 2. Precise land classification of planning land reservation(Appendix)

2.Current ecological land integration

Code for classification of land use and planning standards for development land(GB50173-2011) requires: "Nature reserve, scenic spot and forest park are classified as ‘water area’ (E1), ‘agroforestry land’ (E2) or ‘other non-development land’ (E3) according to the actual use of land.” However, for the convenience of statistics, these types of land are unified into "other non-development land(E9)".

Form. 3. Precise land classification of current ecological land integration(Appendix)

3.Other types of land use function transformation

In the process of urban development, because of the need for planning and construction, many types of land have changed. In addition, many of these lands are gradually becoming idle lands on account of the loss of vitality. However, urban greenway can find new development potential from these modificatory types of land.

Form. 4. Precise land classification of other types of land use function transformation(Appendix)

4.The regeneration of unused land facilities

These abandoned land facilities are the inevitable products of urban development, which are widely distributed in cities. We can combine the original features and develop the urban greenway while solving

its problems. By this means, it not only improves the urban environment, but also adds urban public function to these abandoned land facilities.

Form. 5. Precise land classification of the regeneration of unused land facilities(Appendix)

4.The promotion of compound greenway function land

At present, there is such a part of the land in the city, which can be developed into urban greenway without changing its main function and the types of land. It not only improves the urban environment, but also optimizes the allocation of urban resources.

Form. 6. Precise land classification of the promotion of compound greenway function land(Appendix)

3.3.The method of Land suitability assessment

At present, the planning and construction of urban greenway in China is still in the exploratory stage. More scholars pay their attention to the planning method of Greenway line selection. For example, w. Mille [12]and a. Conine[13] provide the basis for the selection of greenway through quantitative analysis of site suitability[14]. However, these planning methods only do suitability analysis from the functional aspects of ecology, culture and recreation. At the same time, they pay more attention to the regional level and the outskirts of the city. As a result, the association with the urban built-up area is weak.

Therefore, with the help of the current greenway route planning method, it is

difficult for us to effectively evaluate the potential of urban land in the development of urban greenway in built-up area. according to the present research shortcoming, we believe that an effective and applicable land suitability evaluation method needs to be established. Moreover, the social life service function level and the evaluation factors selected from it are included into the suitability evaluation system. The above problems can be avoided by re-focusing and examining the important functions of urban greenway, such as daily transportation.

The study is based on the analytic hierarchy process. Meanwhile, combined with expert scoring method, we determine the weight coefficient of all levels of objectives, and then relevant professional scholars are invited to score. Finally, the target evaluation index is calculated to comprehensively evaluate the potential of developing urban greenway in the corresponding built-up area.

1.Setting up the hierarchical structure model

After studying, we selected 8 evaluation factors from the function level of ecology, culture, leisure and social life service. The following form shows the hierarchical structure model of the development of urban greenway potential evaluation in built-up area.

Form. 7. The hierarchical structure model

2.Reach the weight of each coefficient

To determine the weight of each factor at all levels, the scale of Santy is introduced to get a quantified judgment matrix when

compare the evaluation indexes with each other, and then reach the weight of each coefficient (W_i) by calculating. Finally, the calculated consistency is under 0.1, indicating that it has a satisfactory consistency, which can be accepted.

3. Obtain the evaluation index of the calculated target

We will invite relevant experts to score. First we need to get all index layer scores which can be obtained from index layer corresponding evaluation score (P_i) multiplied by the weight coefficient (W_i), then add all the index layer scores to get the final index layer score. And then we will get the evaluation index of the target to evaluate the land use and develop urban green road space potential.

4. Discussion

The results what we have been discussed are guiding our empirical study in Haidian District, Beijing. By refining the land classification standard, we can find out the space potential of developing urban greenway from the current land. At the same time, according to the evaluation of land suitability, we can quantitatively analyze the land with space potential. Therefore, we think that our research has some research value and can provide guidance for the following urban green route selection and put forward the development suggestion for the existing urban greenway.

5. Conclusion

Under the technical and ideological conditions at that time, Charles Eliot intended to commandeer the land, such as wetlands, steep slopes and rugged mountains, for which it was difficult to exploit, and set up an open space system in Boston. The greatness of Eliot's thoughts is that he looked for an available space in the crack of the city and turned it into a useful place[15].

At present, the technological conditions and the thoughts of land utilization have undergone profound changes and unwieldy lands are becoming less and less for mankind. However, be that as it may, we believe that Eliot's thought is not outdated, but the way we look for space potential needs to be constantly updated. And our research is updating the way to explore the potential of space, in order to build a better compact city.

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Appendix

Form. 1. Land classification based on different types of urban land (Appendix)

Classification basis	Construction idea	The source of urban land use	The type of urban land use						Related cases				
			E Non-development land	E1 Waters	E11 Natural waters			E12 Reservoir		E13 Pond and Ditch	E9 The other not-development land		
1	Integration	Planning land reservation	E Non-development land	E1 Waters	E11 Natural waters			E12 Reservoir	E13 Pond and Ditch	E9 The other not-development land	Gwangju Urban River Greenway		
		Current ecological land integration			H Development land	H1 Urban and rural settlement land	H11 Urban Development land	G Green space and square	G1 The park green space		G2 Green area for environmental protection	Hardberger Park	
2	Transformation	Other types of land use function transformation	H Development land	H1 Urban and rural settlement land				H11 Urban Development land	R Residential	R2 The second category of residential	R3 The third category of residential	Urban Greenway in Manhattan	
					M Industrial	M1 The first category of industrial	M2 The second category of industrial		Qian'an Sanlihe Greenway				
						S Road, street and transportation	S2 Urban rail transit land		High Line Park in New York				
					U Municipal Utilities	U3 Safety facility land	U32 Flood control facility land		Qian'an Sanlihe Greenway				
		Reuse of unused land facilities			H2 Regional traffic facility land	H21 Railway land			H41 Military land	East Coast Greenway in the United States, Nansen Park			
						H22 Highway land							
						H23 Port land							
						H24 Airport land							
						H25 Pipeline land							
		3			Borrowing	The advance of compound greenway function land	H1 Urban and rural settlement land		H11 Urban development land	A Administration and public services	A3 Education and scientific research land.	A31 University land	Greenway in Tongji University, China
S Road, street and transportation	S1 Urban road land		Greenway of Three Hills and Five Gardens, Beijing										

Form. 2. Precise land classification of planning land reservation(Appendix)

Urban land relied on	Type of urban land relied on			Precise classification	
Planning and coordinating land reservation	E Non-development land	E1 Water area	E11 Natural water area	River	
				Lake	
				Intertidal zone	
	E13 Pond and Ditch	E13 Pond and Ditch	Pond		
			Ditch	Diversion channel	
				Irrigation channel	
				Drainage channel	

Form. 3. Precise land classification of current ecological land integration(Appendix)

Urban land relied on	Type of urban land relied on					Precise classification		
Current ecological land integration	E Non-Development land	E9 Other Non-Development land					Wetland	
							Saline-alkali land	
							Nature reserve	
							Scenic spot	
							Forest park	
	H Development land	H1 Urban and rural settlement land	H11 Urban development land	G Green space and square	G1 Green space and square	Comprehensive park		
						Community park		
						Topic park		
						Zonal park		
					Roadside green space			
					Sanitary isolation belt			
					Road protective green space			
					Windbreaks			

Form. 4. Precise land classification of other types of land use function transformation(Appendix)

Urban land relied on	Type of urban land relied on					Precise classification
Other types of land use function conversion	H Development land	H1 Urban and rural settlement land	H11 Urban development land	R Residential	R2 The second category of residential	Ancillary road land
					R3 The third category of residential	Dangerous building
						Shantytown
				M Industrial	M1 The first category of industrial	Low efficiency and unutilized land
						Land of planning to be removed
					M2 The second category of industrial	Low efficiency and unutilized land
						Land of planning to be removed
					M3 The third category of industrial	Low efficiency and unutilized land
						Land of planning to be removed
						Land of planning to be removed

Form. 5. Precise land classification of the regeneration of unused land facilities(Appendix)

Urban land relied on	Type of urban land relied on					Precise classification			
The regeneration of waste unused land facilities	H Development land	H1 Urban and rural settlement land	H11 Urban development land	S Road, street and transportation	S2 Urban rail transit land	Low efficiency and unutilized land			
						U Municipal Utilities	U3 Safety facility land	U32 Flood control facility land	Low efficiency and unutilized land
				H2 Regional traffic facility land	H21 Railway land			Land of planning to be removed	
					H22 Highway land			Land of planning to be removed	
					H23 Port land			Land of planning to be removed	
					H24 Airport land			Land of planning to be removed	
					H25 Pipeline land			Land of planning to be removed	
				H4 Special land	H41 Military land			Land of planning to be removed	

Form. 6. Precise land classification of the promotion of compound greenway function land(Appendix)

Urban land relied on	Type of urban land relied on						Precise classification			
The promotion of compound greenway function land	H Development land	H1 Urban and rural settlement land	H11 Urban development land	A Administration and public services	A3 Education and scientific research land.	A31 University land	Road land			
										Green space
							S Road, street and transportation	S1 Urban road land		The main road
							The branch road			

Form. 7. The hierarchical structure model(Appendix)

Target layer(G)	Rule layer	Index layer(C _i)	Weight coefficient(W _i)	Evaluation score(P _i)	Factor interpretation
The evaluation of developing urban greenway potential (G)	Ecological function	Soft and hard ratio (C ₁)	W ₁	P ₁	The ratio of surface area and green space to hard pavement.
		Biodiversity (C ₂)	W ₂	P ₂	The number of animal and plant species.
	Cultural function	Historical preservation value (C ₃)	W ₃	P ₃	The richness and importance of the cultural landscape.
		Conservation value (C ₄)	W ₄	P ₄	The richness and importance of natural landscape.
	Recreational function	Infrastructure level (C ₅)	W ₅	P ₅	Whether the park, the table, chair, and the sanitation facilities are perfect
		Richness of recreational resources (C ₆)	W ₆	P ₆	The type, quantity and importance of recreational resources
	Social service function	Traffic convenience(C ₇)	W ₇	P ₇	The convenient of external transportation convergence
		Peripheral population density (C ₈)	W ₈	P ₈	The density of the distribution of the surrounding population

Construction of Biophili city: Taking Freiburg, Germany as an example.

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Abstract

Biophili city is the trend and mainstream direction of urban development. It is the requirement of adapting to the era development, building a harmonious society and implementing circular economy. According to the view of ecology and ecological ethics, all the development of human economic society should transform from ‘centralism of human interest’ into ‘centralism of ecological interest’, from ‘priority of human interests’ to ‘priority of ecological interests’. The past urban planning mode with the human interests as the main body and the environment as the object of human rights should also be transformed, and need to establish the ‘ecological first’ urban development view. With the rapid development of the world economy, the high urbanization in the world has caused a series of negative impacts on the natural environment we live in. Therefore, the city planning construction and management scientifically and reasonably could make the city under the state of a virtuous cycle of sustainable development. It is an urgent need in today's urban planning development basic task. Famous ecological city Freiburg in Germany, for example, the paper studied its further study green ecological planning and construction management measures, to learn from it in urban ecological planning and construction management good measures and methods.

Keywords: Biophili city, Freiburg

1. General Information

Freiburg is the city of Baden-Württemberg, the capital of the Freiburg district, with an area of 153km² and a population of about 200,000. The city of Freiburg is located in the western part of black forest in Germany. Freiburg boasts pleasant scenery, and is especially abundant in sunshine. It is regarded as the warmest and sunniest city in Germany [1].

The city was once badly bombed during world war ii and rebuilt after the war while making full use of the city's sunshine

2. Ecological Measures

2.1. Restore the natural landscape.

Freiburg pays special attention to social and cultural factors in urban environmental protection. The most important principle of landscape planning is to restore the natural landscape. First of all, all the hardened ground (except for the roads) was completely removed in the city and replaced by various kinds of permeable ground (including the permeable bricks, gravel, groove brick, gravel, organic debris, etc.). This transformation has brought great improvements to Freiburg's environment in many ways. Secondly, urban residents in Freiburg had come up with many ideas in order to improve their hygiene, environmental quality and living comfort level to a very high level, such as the courtyard self-help greening, vertical greening, balcony greening, roof greening

resource conditions and implementing the sustainable development policy of renewable energy. Starting in the 1970s, Freiburg began to build eco-cities. In 1986, Freiburg became one of the first cities in Germany to set up the E.P.A. In 1992, Freiburg was awarded the 'green capital' of Germany for building smog and ozone warning systems, as well as the achievements in environmental public transportation. Although Freiburg is a small city, but it has been recognized as one of the best ecological

and so on. These methods have helped the city back to green, and effectively helped the strong solar radiation city reduce the heat island effect. Thirdly, the rivers in Freiburg were made to simulate the natural river, which could keep the transition structure between river and land. The principle of maintaining natural vegetation for protecting the environment of the shore could also improve the water quality as well as the natural beauty of the river with less maintenance costs.

2.2. Using new energy

The development of economic in Freiburg follows the laws of ecology. It combines the clean production, comprehensive utilization of resources, ecological design and sustainable consumption together, in order to reduce and recycle the urban waste. Maintaining the natural ecological balance could also resulted from waste reduction, resource recycling and safe disposal in the end.

In 1986, the city council of Freiburg decided to use solar energy instead of nuclear power, and set up the city Environmental Protection Bureau at the same time, which made Freiburg become one of the earliest cities in Germany [2]. The weather in Freiburg is warm and sunny all year round, with sunny days and an average annual sunshine of more than 1,800 hours. Citizens were aware of the importance of harnessing solar energy for climate protection, economic development and urban prosperity. Not only in football fields, city hall, exhibition halls, schools, churches, houses, or the surface of the high-rise buildings, they even installed solar cell device above the abandoned dirt. This constitutes to a special landscape in Freiburg.

Germans have a good habit of classifying and disposing of rubbish. In Freiburg, has reached its acme. Garbage classification is required to be done from the beginning of the household, and each resident learns how to classify the garbage accurately. Handing over part of the classification work to the residents could greatly reduce the difficulty and complexity of the waste disposal work. The smart Freiburg people know how to turn waste into treasure by scientific treatment. 80% of the city's paper is made from recycled paper. The unrecyclable waste can be burned while the heat generated by the incineration can be used for heating. The heat generated by waste fermentation can also generate electricity. Garbage is no longer a stinking thing, but instead, could be used as inexhaustible resource, which could bring economic and social benefits to the city. Freiburg not only attaches great importance to garbage collection, but also

values the importance of garbage reduction. To reduce the amount of garbage, residents should try to reduce the production of garbage. Germany has very advanced social education, so the quality and ideological level of their people is high. Even without penalties, citizens in Freiburg, known for their 'environmental protection', have high levels of self-consciousness. However, the government has adopted a number of incentives to control the amount of rubbish at its source. For example, the use of environmental protection baby diapers can be subsidized; the residents who do not throw garbage can reduce the waste treatment fee; and subsidies the residents who make the garbage compost and so on. The average number of waste dumped by Freiburg residents was significantly lower than the state and national levels. Citizens in order to make an effort to stop global warming are actively involved in the activity 'lose weight for carbon dioxide'. They develop their own carbon dioxide 'lose weight' plan while comparing with others' emissions. It can be seen that environmentally-friendly low-carbon construction has been integrated into the details of civic life, rather than just shout slogans.

2.3. Promote energy-saving buildings.

Solar community and its ancillary commercial facilities were designed by the famous solar architect Rolf Dischi. The solar community in Freiburg were built in 2004, with an area of 15574 m² and 59 apartments. As the pioneer for energy saving, there are a large number of

ecological tourists come here to visit his design every year. For example, the famous Heliotrope is a good case.

The city showed the development and utilization of renewable energy. But using solar energy as a conventional energy, we still have a long way to go. Although solar panels are widely used, only 1% of the city's power is provided by the solar energy in the use of renewable energy.

At the same time, reduce building energy consumption is also a main aspect of building energy efficiency. The new district has the perfect heating system. The residential houses are mainly low energy consumption and solar energy. In order to ensure the construction of low energy consumption, every house builders must sign on in a low energy consumption building contract to guarantee the houses they make are low energy consumption buildings. Additionally, government support and encourage residents to install solar facilities. At the same time, the law stipulates that the social housing must be Passive House. It is called a passive house because passive construction should meet the need for comfortable life environment without external energy consumption for heating and cooling. Buildings need to adjust themselves. In fact, it is impossible that the buildings could adjust without external energy at all currently, but the energy consumption standards are very strict.

Used for building ontology and indoor air heating and cooling energy consumption for each year of building energy consumption Which includes the energy consumption of

the residents Including heating and cooling, domestic hot water and electricity for more than a certain family life can only be used for the renewable energy efficiency standards from current energy consumption standard of German law Price is still lower. Energies of heating and cooling the buildings are 15KWh/m² per year. The total energy consumption is 120 KWh/m² which includes the energy consumption of the residents, heating and cooling, domestic hot water and electricity. The rest could only be using the renewable energy. That is a quarter lower than the current German law requires.

3. Referential Significance

3.1. *Combination of management policies and incentive policies.*

The development and construction of the city cannot be successful without the guidance of urban planning. The high quality urban planning is the basic guarantee for the healthy development of urban construction. The city is a place for people to live, work, study and entertain. The basic tenor of urban development and construction is to serve the people. Therefore, the good urban planning requires public participation.

The public participation in German urban planning has a very strong legal basis, extensive social foundation and effective institutional guarantee. The public participation system in German urban planning and construction has been effectively and effectively implemented. Through public participation, the urban residents' willingness and ideas can be fully integrated in future city renovation. The city

could serve the people better, and at the same time, it can also set up strong ownership of the city residents, thus they would be more voluntary to protect the ecological environment of the city.

3.2. Mobilize the public participation

Every July, Freiburg hosts the ‘city pageant’, in which the government invites industry experts and urban citizens to participate actively. The pageant is a chance to brainstorm the strategies of future urban development. In addition to the support of high and new science and technology, various financial security measures and ecological compensation have generated good incentives and guidance for cities, governments, enterprises and even individuals. In the ecological construction of Freiburg, the city council had played a good leading role of innovation. It integrated the development of urban ecological technology effectively into the planning and construction. Combined with the active public participation in urban planning and the fine tradition of construction, the sustainable development of Freiburg could be pushed forward well. Other countries should learn from Freiburg and combine with the feature of their country’s national conditions and project optimization. It could lay a good foundation of theory and experience for the domestic development of green ecological city.

3.3. The combination of planning concepts and technologies.

The urban water management in Freiburg is mainly embodied in four aspects: sewage treatment, rainwater utilization, water-saving device and river technology. Freiburg has a complete set of modern sewage treatment system, which provides a richer choice for the utilization of urban water resources. During the construction of the new district, it paid attention to the concept of low impact development for discharging, recycling and utilization of rainwater. In addition, in order to motivate residents' initiative to protect and utilize water resources well, the city has also adopted a method of charging sewage and rainwater separately. The method could encourage residents to use water-saving devices extensively.

In the aspect of river technology utilization, the relationship between energy development and river ecological protection was deeply considered in the construction of modern hydropower station [3]. Freiburg paid much attention on the characteristics of the city itself with the selection of ecological technologies.

Aristotle once said, people come to cities to live, and people live in cities to live better. However, with the rapid development of the world's highly urbanized economy, it has also contributed to the ecological environment problems such as global warming, the deterioration of natural environment and the explosion of energy consumption. It has become an important issue of global sustainable development in the 21st century to utilize the green

ecological technology scientifically and rationally. The ecological city construction of Freiburg brings us a lot of experience: first, always give priority to ecological interests, let the environment return to nature; Second, choose the unexpected problem to start with in order to obtain the biggest effect with the smallest input; Third, stimulate the pride of residents and the spirit of ownership in order to expand the biophili city construction to a further extend.

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The Construction of Botanical Gardens in Tokyo Metropolis in Japan from the Perspective of Green Infrastructure

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Abstract

Green infrastructure (GI), which is constructed by the central hub and link corridor, is proposed to build a green space system with interrelated and organic unity, and steadily play the ecological value of green space in the city. The botanical garden, as an important part of the urban green space system, is one of the key points in GI central hub construction. With the urban development and social evolution, as a facility for plant collection, cultivation and exhibition activities, botanical garden's landscape, social and economic value is more significant.

Tokyo, as the capital of Japan, is the origin of the Japanese botanical garden. From the Koishikawa Botanical Garden, Tokyo has built 15 botanical gardens of different sizes and types, accounting for 1/8 of the total number of botanical gardens in Japan (115 places). From the perspective of GI, Tokyo botanical gardens, as GI central hub, play important ecological value, and the construction effect is also very prominent, mainly reflected in three aspects, the overall planning and system development process, the function expression and facility construction, and the plant application and plant landscape.

Tokyo botanical garden system (TBGS) has long time history and wide space distribution. After Koishikawa Botanical Garden has been established in 1638, TBGS has begun a history of 380 years, including five period of Edo, Meiji, Taisho, Showa and Heisei. During this period, despite of the war, earthquakes and other irresistible factors, the overall style is well preserved. Also, TBGS is widely distributed in the Tokyo area and the tama area, with Tokyo as the center of the 50km service radius, to meet different users' traffic demand.

TBGS has diverse types and abundant facilities. There are Shinjuku Gyoen National Garden, Harumi Island Triton Square, Hoshi University Medicinal Plant Garden, Koishikawa Botanical Garden, that are the representative of comprehensive national and public botanical gardens, the botanical gardens operated by a company or a person, medicinal plant special gardens and university affiliated botanical gardens, respectively. With the continuous improvement of the botanical garden construction, the facilities in the garden, such as buildings, transportation, and signs are also more abundant.

TBGS has diverse plant species, rich plant landscape and obvious plant types. The number of plants preserved in each botanical garden is not less than 500 species, also there are more than 4000 species in the Koishikawa Botanical Garden and the Jindai Botanical Gardens. The four seasons plant landscape in TBGS, such as Sakura in spring, *Hydrangea macrophylla* in summer, acer and chrysanthemum in autumn, *Prunus mume* in winter and rose in four seasons, enrich the wonderful green space. Also, different plant types, such as ornamental plants, medicinal plants, economic plants and cultivated plants are applied in different kinds of botanical gardens.

Through the above three aspects, it can be seen that TBGS, as an important carrier of GI central hub, has three main characteristics, ecological sustainability and permeability, function perfection and comprehensiveness, landscape diversity, and has a good enlightenment to the current botanical garden as well as the GI construction.

Keywords: landscape architecture; green infrastructure; botanical garden; Tokyo metropolis

1. Introduction

Green infrastructure (GI), which is constructed by the central hub and link corridor, is proposed to build a green space system with interrelated and organic unity, and steadily play the ecological value of green space in the city [1]. The botanical garden, as an important part of the urban green space system, is one of the key points in GI central hub construction. With the urban development and social evolution, as a facility for plant collection, cultivation and exhibition activities, botanical garden's landscape, social and economic value is more significant.

Tokyo, as the capital of Japan, is the origin of the Japanese botanical garden. From the Koishikawa Botanical Garden, Tokyo has built 15 botanical gardens of different sizes and types, accounting for 1/8 of the total number of botanical gardens in Japan (115 places) [2]. From the perspective of GI, Tokyo botanical gardens, as GI central hub, play important ecological value, and the construction effect is also very prominent, mainly reflected in three aspects, the overall planning and system development process, the function expression and facility construction, and the plant application and landscape.

2. The overall planning and system development process of Tokyo botanical garden system

Tokyo botanical garden system (TBGS) has long time history and wide space distribution. After Koishikawa Botanical Garden (KBG) has been established in 1638, TBGS has begun a history of 380 years, including five period of Edo, Meiji, Taisho, Showa and Heisei [3]. During this period, despite of the war, earthquakes and other irresistible factors, the overall style is well preserved. Also, TBGS is widely distributed in the Tokyo area and the tama area, with Tokyo as the center of the 50km service radius, to meet different users' traffic demand.

2.1. Edo period (1603-1867)

The original of Japan botanical garden is the KBG which was built in the Edo shogunate period. This garden is the Edo shogunate facility, which was subordinated to the state organ. In this period, some herbal works, such as the Chinese 'Compendium of Materia Medica' and the Holland 'Herb Record' was introduced into Japan. Meanwhile, the number of shoguns who were interested in medicinal plants

gradually increased. Also, the increasing needs for the plant breeding and plant site resulted in the appearance of planting function in the garden. The owner of the garden not only planted herbs picked from Japan in the garden, but also introduced herbs and logs picked from China and Korea. This development made the garden become a place for the public health care and medicinal research. At the same time, Japanese sweet potatoes were experimented here and then popularized in the whole region of Kanto of Japan. In the middle of the Edo period, the Kyōhō Reforms appeared, and made the garden take the function of free medical service. After more than ten years, the cold summer and pest caused famine in Edo, and the sweet potatoes taken as the relief food were the first time cultivated in the garden.

2.2. Meiji period (1868-1912)

In 1868, Japan entered the Meiji period after the Meiji reform. Besides the KBG, the Shinjuku Gyoen National Garden (SGNG) opened, and the administration rights of botanical gardens were transferred to the court with the land rights to the state. With the extensive learning of western European technology, Japan introduced various tropical and subtropical horticultural plants and wild plants from Europe and America, and began to plant these plants in the two botanical gardens. The two gardens also began to build greenhouse in this period. The Meiji period is the industrial revolution stage, in which a lot of cultural products from the western country were input into Japan. At the same time, western industrial technology and various varieties of fruits, vegetables and flowers began to flow into Japan. The greenhouse construction not only provided conditions for the study of cultivated plants, but also provides the

premise for the development and exploration of Japanese botany.

2.3. Taisho period (1912-1926)

In 1923, the great Kanto earthquake occurred and the KBG was used as a refuge for a part of the victims that made the function of the botanical garden extended. In 1918, the SGNG become the venue of viewing Sakura. In 1921, the predecessor of the Tama Forest Science Garden (TFSG), Royal Forest and Field Bureau, was built, as well as the official building. In this period, some publications related to the urban planning, such as ‘Research on the modern city’ and ‘Research on free urban space’ began to appear some discussion about the botanical gardens. In 1919, the ‘Urban planning law’ was promulgated. Parks and gardens have gradually become the urban planning facilities and been under the legal protection. It could be said that the development of botanical gardens in this period gradually established under the guidance of urban planning, and synchronized with the urban development.

2.4. Showa period (1926-1989)

From 1939 to 1945, Japan was involved in the Second World War, because of which, the facilities in KBG, such as the greenhouse, the gate, the meeting place and the classroom building was destroyed, as well as the pavilion in SGNG and the official buildings and laboratory in TFSG. At the same time, the Jindai green space, as the facility of Tokyo, began to become the air defense base and the place for teenager exercise and food production in the war. In 1941, the Hoshi University Medicinal Plant Garden (HUMPG) established with the opening of the Hoshi University, however, the land waste was very serious for being used as barracks. After the war, all the

botanical gardens began to carry out a large area of repair work. In this period, some botanical gardens were newly built, such as the Medicinal Plant Garden of the school of pharmacy in Showa University (MPG-SU), the Medicinal Plant Garden of Tokyo University of Pharmacy and Life Sciences (MPG-TU), the Itabashi Akatsuka Botanical Garden (IABG), and the Yumenoshima Tropical Greenhouse Dome (YTGD).

2.5. Heisei period (From 1989)

From 1989, Japan has entered into the stable Heisei period, the greenhouse of KBG was finished in 1993, the SGNG belonged to the environment department in 2001, the TFSG was open to the public from 1992 and has been developed as the largest research agency related to the forest, forestry and timber, the Jindai Botanical Gardens (JBG) opened aquatic botanical garden in 1997, the HUMPG increased practical function and began to enhance the facilities in the garden such as the entrance gate. During this period, six new botanical gardens set up, respectively for the Medicinal Plant Garden in Showa Pharmaceutical University (MPG-SPU), the Itabashi Botanical Gardens (IBG), the Medicinal Plant Garden (MPG), the Harumi Island Triton Square (HITS), the Shibuya City Botanical Garden FUREAI (SCBG-FUREAI), and the Institute for Sustainable Agro-ecosystem Services of the graduate school of Agricultural and Life Sciences in the University of Tokyo (ISAS-TU)

To sum up, the scale and scope of botanical gardens have been increasing with time, and the network system has been gradually expanded. As the core of GI, the botanical gardens in Tokyo effectively connected with the urban traffic belt and green belt. The combination of point and line could fully play an important role of

ecological radiation of urban green space. Meanwhile, as most of the botanical gardens have been located in the metropolitan area of Tokyo, and less of them on the edge of the urban fringe, these gardens meet the needs of all kinds of people from the perspective of spatial distribution.

3. The function expression and facility construction of Tokyo botanical garden system

TBGS has diverse types and abundant facilities. There are Shinjuku Gyoen National Garden, Harumi Island Triton Square, Hoshi University Medicinal Plant Garden, Koishikawa Botanical Garden, that are the representative of comprehensive national and public botanical gardens, the botanical gardens operated by a company or a person, medicinal plant special gardens and university affiliated botanical gardens, respectively. With the continuous improvement of the botanical garden construction, the facilities in the garden, such as buildings, transportation and signs are also more abundant.

The university affiliated botanical garden is mainly used as a place for students and teachers to research and teach, as well as a park for opening to the public. The KBG and ISAS-TU are both of this type, and have important functions of scientific research and education. For example, in 1877, the KBG, as a botanical garden affiliated to University of Tokyo, in which professor Yatabe Ryoshi and Ito Keisuke began the study of botany. In 1897, the botanical classroom was set up to become a place for botanical cultivation teaching in Japan and to play the function of the research and education center. The Japanese Institute of Botany (JIOB) and the bachelor's Association were also established in this

garden in 1882 and 1886 respectively (Fig.1).

The comprehensive national and public botanical garden always has plenty of ornamental and rare plants. Some are aquatic or forestry botanical gardens which collect characteristic plants, the others are huge scale botanical gardens which were built with museums, and there are also some botanical gardens to popularize plant knowledge or provide rest places for surrounding residents. The SGNG, TFSG, JBG, IABG, YTGD and SCBG-FUREAI are all of this type and have close connection with the public. In these botanical gardens, there both have public and ornamental plants area, and the combination of pleasure and cognition is the obvious feature of this type.

The botanical garden operated by a company or a person often has a large collection and centralized display of some kind of plants according to the company's own characteristic, such as displaying some orchid, bamboo or alpine plants as well as displaying with insects and animal rearing. This botanical garden is suitable for people who are interested in ornamental plants or plant species relationship. The HITS belongs to this type, and has been used as urban space for protecting the season colors. In this garden, stuffs have been arranged to introduce the rich plant changes in different seasons and develop investigation and adjustment schedule of the garden's condition in different stages, aiming to help the public set up their awareness of protecting and cultivating plants. This garden has also become an urban green space near the sea for integrating the urban function of basic necessities of life.

The medicinal plant special garden not only collects plants as pharmaceutical raw material at home and abroad, but also collects and cultivates some aromatic compounds, dyes and poisonous plants for

study. As the garden is often subordinated to university, most of the facilities in garden are not open to the public. The HUMPG, MPG-SU, MPG-TU, MPG-SPU, and MPG are all of this type. This type of botanical garden mainly has three aspects of function, that are the medicinal plants collecting, cultivating, researching and displaying, the practical activities for teachers, students and pharmacists, and the popularization and inspiration of knowledge about medicinal plants to public.

From perspective of development process, botanical garden in Edo period had obvious medicinal function and always planted a lot of rare plants. In Meiji period, the modern botanical gardens came to appear and began to develop scientific and research institution attached to university. Also, along with the botany development, facilities such as greenhouse, plant cultivation and experiment grounds began to build, and the botanical garden's function of social education, public relaxation and health care began to appear. Even though the function and facility development of botanical garden was slow in Taisho period, every aspect entered the stage of rapid development in Showa period. Although the war had great influence on various botanical gardens, it also made the gardens undertake more functions. In Heisei period, facilities of TBGS continued to improve, and four types of botanical gardens developed mature along with the various functions of botanical gardens. Because of the opening to public, gardens have also created more and more facilities for practical activities, and the progress of botany also has promoted the botanical gardens to pay more attention to the function of scientific education and research.

In 2006, the JIOB established the national plant diversity protection botanical garden system according to the climate, location

and characteristic of botanical gardens. This system clearly shows the order of plant protection, the collection and preservation method of plants and seeds, and the plant education and inspiration to public (fig.2) [4]. The KBG, SGNG, and JBG are all in this system and has made great contribution to the natural environment protection career.

To sum up, different from the general GI, botanical gardens of different types have various functions. At the same time, as there have kinds of facilities in gardens, including appreciation type, practical type and functional type, the botanical gardens have become the places for people activities centralized in. The perfect service facilities in gardens have also made sure to meet people's needs. It could be said that botanical gardens have enhanced the richness and diversity of the overall GI system function.

4. The plant application and landscape of Tokyo botanical garden system

TBGS has diverse plant species, rich plant landscape and obvious plant types. The number of plants preserved in each botanical garden is not less than 500 species, also there are more than 4000 species in the KBG and JBG. In addition, in the SGNG, there have been more than 270 kinds of trees, and about 2700 kinds of plants in the greenhouse, among which about 140 kinds of plants have been recorded as the endangered species. In the ISAS-TU, there have been about 250 kinds of ornamental lotus, 200 kinds of foliage plants and 30 kinds of orchid. In the TFSG, there have been 500 kinds of woody plants and 600 cultivated Sakura system [2].

Different plant types are applied in different kinds of botanical gardens, such as ornamental plants in comprehensive national and public botanical gardens, medicinal

plants in medicinal plant special gardens, economic plants in botanical gardens operated by a company or a person and cultivated plants in university affiliated botanical gardens. Taking the JBG which belongs to the comprehensive national and public botanical garden as an example, there have been different kinds of rose, rhododendron, plum and Sakura in the garden. The MPG of the medicinal plant special garden has mainly collected the original plant medicine for the Japanese medicinal administration. The HITS of botanical garden operated by a company or a person has developed different flowers exhibition according to the season changes (fig.3). The KBG of university affiliated botanical garden has been widely collected different kinds of plants, and arranged them in order according to the new Engler System for easy visit.

The four season plant landscape in TBGS, such as Sakura in spring, Hydrangea macrophylla in summer, acer and chrysanthemum in autumn, Prunus mume in winter and rose in four seasons, enrich the wonderful green space. For example, there have been about 65 kinds and 1100 Sakura in the SGNG, thus resulting in different flowering period (fig.4). People will have long time to appreciate different flower colors, such as about 400 'Somei Yoshino' blooming from late March to early April, about 20 kinds of 300 double cherry blossoms from early April to late April [5]. The sunken garden in the JBG planted roses which have bloomed twice in one year, among which 409 kinds of 5200 roses bloom in the late May in spring and about 300 kinds of more than 5000 roses bloom in the middle October in autumn (fig.5) [6]. Even though the flowers are very small, the color are very bright.

To sum up, various plants is the obvious characteristic of botanical garden which is

different from the general green space. The plants not only enhance the species diversity but also ensure the stability of community structure, thus helping release the ecological function of the botanical garden taken as the core of GI. At the same time, the various shape of plants help create different plant landscape space and sightseeing experiences for users through diverse configuration methods, which further complements the landscape function of GI.

5. Conclusion

Through the above three aspects, it can be seen that TBGS, as an important carrier of GI central hub, has three main characteristics, ecological sustainability and permeability, function perfection and comprehensiveness and landscape diversity. The TBGS have been playing important role in many fields, such as plants diversity study, alive plants exhibition, social education, plants resource development, plants system preservation and public recreation. As the important part of Japanese urban green space, the botanical gardens have been the main carrier of Japanese GI and have a good enlightenment to the current botanical garden construction as well as the GI construction.

Acknowledgments

Figure 1 is cited from <http://haofu.blog.so-net.ne.jp/2013-12-05>.

Figure 3 is cited from <http://www.toa.co.uk/article/tokyos-harumi-island-triton-square/>. Figure 4 is cited from <http://season-dictionary.com/outdoor/83/>.

Figure 5 is cited from <https://www.tokyo-park.or.jp/park/format/index045.html>.

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Appendix



Fig. 1. The Tokyo University comprehensive research museum in the Koishikawa Botanical Garden

Location	Theme	Property		
		■	▲	◆
Hokkaido	Botanic Garden Hokkaido University	✓	✓	
	Galaxy Gardens	✓		
Tohoku	Botanical Gardens, Tohoku University	✓	✓	
Kanto	Musashi-Kyuryo National Government Park	✓	✓	
	Tsukuba Botanical Garden	✓	✓	
	Shinjuku Gyoen National Garden, Ministry of the Environment	✓	✓	✓
	Botanical Gardens, Graduate School of Science, the University of Tokyo	✓		
	Nikko Botanical Garden	✓	✓	
	Tokyo Metropolitan Jindai Botanical Park	✓		
	Medicinal Plant Garden, Kitasato University		✓	
Chubu	Niigata Prefectural Botanical Garden	✓	✓	
	Botanic Gardens of Toyama	✓	✓	
	Nagoya Higashiyama Botanical Garden	✓		
	Anjo industry culture park den park		✓	
Kinki	Botanical Garden, Osaka City University	✓		
	Mount Rokko National Park	✓		
	Kyoto Botanical Garden	✓	✓	
	Takeda Garden for Medicinal Plant Conservation, Kyoto		✓	
	Mizanomori Water Botanical Garden		✓	
	Sakuya Konohana Kan		✓	
Chugoku	SETSUDAI Medicinal Plant Garden		✓	
Chugoku	The Hiroshima Botanical Garden	✓	✓	
Shikoku	The Kochi Prefectural Botanical Garden	✓	✓	
Kyushu	Medicinal Plant Botanical Garden in Graduate School of Pharmaceutical Sciences	✓		
	Fukuoka City Botanical Garden	✓		
	Kujukushima Zoo & Botanical Garden	✓		
	Tropical & Subtropical Arboretum of Okinawa Shurijo Castle Park	✓	✓	

■ Regional wild and endangered plants preservation place
 ▲ Predominant plants collection and preservation place
 ◆ Seeds long term preservation and using place

Fig. 2. The national plant diversity protection botanical garden system



Fig. 3. The flowers exhibition in the Harumi Island Triton Square



Fig. 4. The Sakura in the Shinjuku Gyoen National Garden



Fig. 5. The Rose garden in the Jindai Botanical Gardens Garden

Biophilia in Human Settlements Construction in Ancient China - A Case Study of the Northwestern Suburbs of Beijing

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Abstract

Famous historic gardens of China such as the Summer Palace are usually interpreted from the perspective of culture and art. In this paper, however, the northwestern suburbs of Beijing where the Summer Palace is located are demonstrated to be a complete human settlements system. While handling the relations between human beings and nature, they represent distinct biophilic characteristics. In the meantime, both macroscopic regional planning and microscopic garden design by ancient Chinese have fully verified authenticity of the *Biophilia Hypothesis*. The application of ancient experience to modern urban construction and the unique role of landscape architecture are discussed at the end of the paper.

Keywords: biophilia; ancient Beijing; human settlement; planning & design; case study

1. Backgrounds

Chinese people have pursued the concept of “harmony between man and nature” during human settlements construction since ancient times, which is mainly because they have a profound understanding of the harmonious and unified relations between man and nature. In other words, people can survive and develop sustainably only by conforming to the objective laws of nature when production and life cannot be separated from nature. It is in this context that China’s agricultural civilization came into being and the unique cultural structure - Chinese gardens - emerged. As an important demonstration of ancient civilizations,

Beijing and its northwestern suburbs are particularly noteworthy.

Northwestern suburbs of Beijing, which is a rare combination of natural mountain forests and plain wetlands in northern China, mainly refer to Haidian District – a region that is historically distinct from other areas in Beijing. They have served as an important water source and scenic spot since ancient times. For example, the region served as a water source and scenic spot for nobles in the Jin Dynasty (1115-1234), and a dwelling place for royal aristocrats, political center of the empire, crucial water source and rice production area in the Qing Dynasty (1644-1911). This paper attempts to explore changing laws and driving factors of the entire region from regional and dynamic perspectives.

2. General Introduction

The northwestern suburbs of Beijing reached an unprecedented peak after 128 years (1684 to 1811) of construction by four emperors (Kangxi, Yongzheng, Qianlong and Jiaqing) in the Qing Dynasty, thereby being rated as a model for the construction of human settlements in ancient China. According to statistics, the northwestern suburbs of Beijing covered a total area of more than 85 square kilometers, which far outweighs the ancient city (66.2 square kilometers). In addition to five imperial gardens that occupied an area of 9.7 square kilometers, there were lots of mountains, waters, small and medium-sized gardens, villages, farmlands, temples and barracks (Fig. 1). In other words, the northwestern suburbs of Beijing contained all infrastructures necessary for high-quality production and life. Gardens, as one of the core components, not only provided comfortable accommodation for a large number of upper class people, but also carried rich history and culture. All these took place in the suburbs rather than highly populated cities, which amply demonstrates the extraordinary yearning and dependence of ancient Chinese on nature, and effectively demonstrates the instinctive love of human beings for nature according to the *Biophilia Hypothesis*.

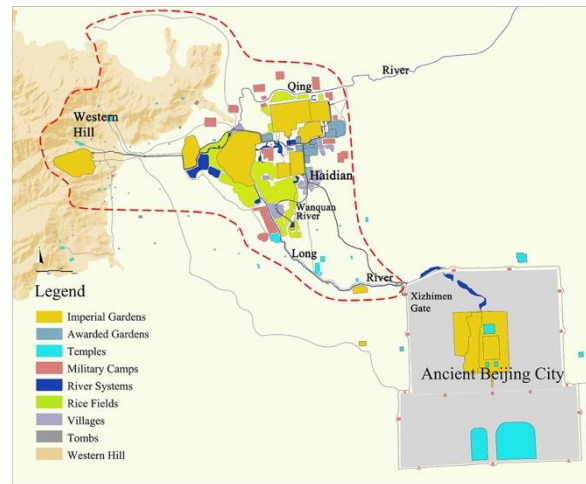


Fig. 1. The layout of ancient Beijing city and its northwestern suburbs in 1860s
 Source: Redrawn according to reference [1]

3. Macroscopic and Microscopic Biophilia

3.1. Macroscopic Biophilia

Judging from the regional perspective, ancient Chinese made full use of the superior natural conditions and resources in the northwestern suburbs of Beijing to build a biophilic system that was jointly supported by artificial and natural forces. A fully functional, comfortable and pleasant living environment was formed on the basis of giving priority to water distribution and agricultural production (Fig. 2, attached in appendix).

3.1.1. Rise of Water Conservancy and Agricultural Infrastructure

Due to the unique geological structures and climatic conditions, the northwestern suburbs of Beijing have enjoyed abundant groundwater resources and natural precipitation [2]. The ancients not only overcame the unfavorable topographic

factors and built the Long River that transported water to the southeast, but also reclaimed land from lakes on a large scale to produce rice. In the meantime, peasant-oriented agricultural settlements and gardens centered on nobles and literati emerged and reached a certain scale early in the Ming Dynasty (1368-1644) ^[3]. According to historical records, areas between the Long River and the West Lake (Kunming Lake) and the Jade Spring Hill served as public tour destinations and lots of ancient poems indicated the strong yearning of urban residents for nature. Although the publicity disappeared for the privileges of Manchu rulers, water conservancy and agriculture reached unprecedented development in the Qing Dynasty (1644-1911). They were greatly promoted by national projects such as water source development and reservoir construction in Emperor Qianlong's period, significantly boosting social and economic development. It was in this context that the Kunming Lake Reservoir was built. (Fig. 3)

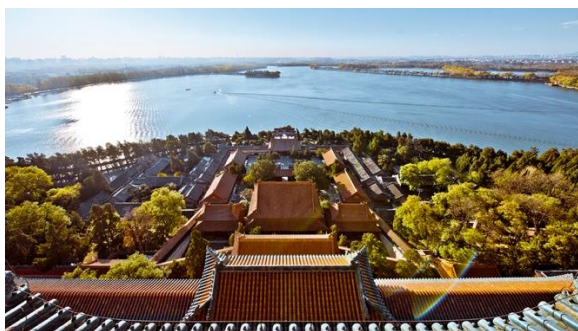


Fig. 3 Kunming Lake in the Summer Palace
 Source: Taken by author

3.1.2. Scientific Site Selection

Ancient Chinese developed the habit of living in the highlands and farming in the lowlands in long-term agricultural practices.

The name of “Haidian” originally referred to lakes in the northwestern suburbs of Beijing and later became a settlement name. According to the topographic analysis, Haidian, the agricultural settlement, was located on the plateau in the east of the waters, which is mainly attributed to the following reasons: the high altitude protected the settlement from flooding. In addition, it was close to the farmland on the west, thereby enjoying convenient traffic ^[4]. However, gardens in the Ming Dynasty were located in low-lying areas to draw water into gardens, despite the threat of flooding, which was the reason why the eastern dyke of Kunming Lake played an important role. Rivers built with natural and artificial forces enabled Wanquan River on the south and Kunming Lake on the west to supply water simultaneously. The river water and lake water flew through the garden, got fully utilized and merged into natural rivers, which reflected the strong control and application of water by ancient people.

3.1.3. Clustered Development of Gardens

Gardens of the Ming and Qing dynasties differed in nature. Qinghua Garden and Shao Garden in the Ming Dynasty belonged to country villas while gardens in the Qing Dynasty consisted of politically powerful and grand-scale imperial gardens. Emperor Kangxi, the second emperor to rule over all of China, built the first imperial palace Changchun Garden on the site of Qinghua Garden, and two temporary imperial palaces on the site of the Fragrant Hill and the Jade Spring Hill respectively. He awarded lands around Changchun Garden to nobles to facilitate their living and working gardens. The historic change directly laid the

foundation for the development of the “Three Hills and Five Gardens” into the political center of the Qing Dynasty and the contiguous development of gardens. With the prosperity of national economy and culture, gardens in this region had peaked in both scale and art. They maintained garden communities in the east and famous mountain scenic spots in the west ^[5] before the destruction by Anglo-French invaders in 1860. Therefore, garden construction in the Qing Dynasty precisely reflected people’s needs for higher-quality nature and significantly improved the ecological environment.

3.2. Microscopic Biophilia

This paper selects GARDENS as the research objects. Although the various imperial gardens and awarded gardens distinctly differed from each other in scales and characteristics, they mostly reconstructed the relations between man and nature by mimicking and humanizing nature, which reflects strong biophilia – clearly verified in the construction of gardens.

3.2.1. Construction of Artificial Landscapes

Ancient Chinese attached great importance to the construction of living environments and tended to create ideal landscape patterns through earthwork. Based on the few constraints, strong plasticity and large effective use area of flatlands, landscape architects fully practiced this notion in low-lying areas in the eastern region. They simulated various kinds of natural landscapes by virtue of the original soil, waters and rocks. Although the mountains were not high and the waters were not deep, the exquisite space art

provided a wealth of touring experience and visual experience. As one of the masterpieces, Yuanming Garden (the Old Summer Palace, with an area of 355 hectares) had more than 150 themed scenic spots, thereby being known as the Garden of Gardens (Fig. 4-5). The garden boundaries, which were composed of low mountains and stone walls, enhanced their beauty with plants and enabled people to look into the distance in specific positions. The West Mountain in the distance, Jade Spring Hill and Longevity Hill nearby, dense rice fields and hardworking peasants on the plains constituted a layered and poetic picture.

It was on these bases that architecture with different functions (enormous and regular palace architecture, small and flexible residential and recreational architecture, and mysterious religious architecture) were designed and built. In addition, all these buildings were closely related to the external landscapes. Therefore, gardens should not only satisfy people’s demands for comfortable and spacious residential and recreational space, but also meet the needs of getting close to nature. These excellent gardens have presented optimal solutions after unremitting exploration of the ancients.

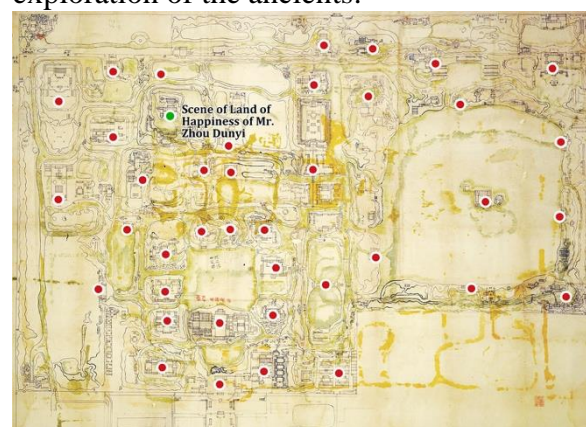


Fig. 4 The distribution of *Forty-scenes* in Yuanming Garden
 Source: Redrawn according to reference [6]



Fig.5 Scene of *Land of Happiness of Mr. Zhou Dunyi* in Yuanming Garden painted in 1744
 Source: National Library of France

3.2.2. Creation of Animal and Plant Landscapes

Mountains and waters are not the only thing of this artificial biologic system while humans, animals and plants are the real protagonists. As the *Biophilia Hypothesis* advocates, the cross-species affection of humans for plants is a product of evolution. The creation of animal and plant landscapes in highly artificial places like gardens is also an art. Landscape architects shall select plants (including horticultural species that need to be carefully managed) in accordance with the habitats and themes, so as to create a natural atmosphere. For example, ancient Chinese planted pines, peaches, apricots,

bamboos and lotuses, and raised rare birds, fish and beasts (waterfowl, deer, crane, koi, etc.) in imperial gardens, so that people living in these gardens could maintain a reverence for life. Both plant changes with season and animal sounds were sources of spiritual enjoyment. Although everything was artificially controlled, the scene presented was harmonious. In other words, the gardens, which are artificial, are comparable to natural wonders (Fig. 6).



Fig.6 The Garden of Harmonious Interests of the Summer Palace
 Source: Taken by author

3.2.3. Implantation of Culture and Religion

The various natural elements have been endowed with humanistic and symbolic meanings under the influence of traditional Chinese culture over the past few thousand years, which is referred to as “humanized nature”. In other words, natural things are interpreted from the perspective of human beings. Therefore, the creation of gardens is actually the reverse process of cognizing nature and culture is one of the most important driving factors. The austere garden landscapes tend to have deep cultural connotations such as traditional political and philosophical ideas and classic literary

works, which is the reason why gardens were historically exclusive to scholar-bureaucrats. In such a specific space, everything (climate changes, sun, moon, mountains and water, plants) can trigger thinking and emotional changes (Fig. 7).

In addition to these controllable factors, biophilia is manifested as religious beliefs and close relations with the uncontrollable nature. For example, precipitation directly affected crop yields in the farming age, making the dragon king (the dispenser of rain) highly respected. Emperors not only gave honorary titles to the dragon king, but also held sacrifice ceremonies regularly to pray for abundant precipitation [7]. Dragon king temples can be found in many imperial gardens, including Yuanming Garden, the Summer Palace and Jingming Garden. In addition, land god in charge of local security, flower goddess in charge of plant growth and gods in charge of climate were honored in different degrees, leading to a mysterious religious culture.

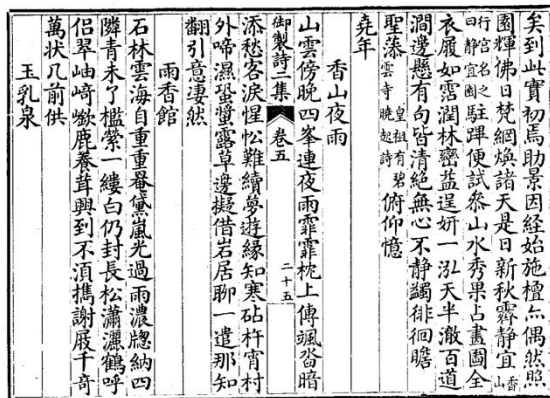


Fig.7 Royal Scenic Poems written by Emperor Qianlong (1711-1799)
 Source: Reference [8]

3.3. Conclusion

According to the above argument, the construction of human settlements in the northwestern suburbs of Beijing has demonstrated biophilia in many respects and experienced four stages: depending on nature (canals digging and farmland irrigation), yearning for nature (picnic places yearned by urban residents), recreating nature (rise and prosperity of gardens) and realizing nature (penetration of landscape culture into literati' minds). Nature has been an eternal topic over the thousands of years of development, which is quite touching.

4. Discussion

Biophilia is not a brand new concept, but a concept that has been amply demonstrated in ancient China, especially in the northwestern suburbs of Beijing. In the meantime, there is some reason to believe that this is not the only case. However, it is still difficult to effectively translate such characteristics in agricultural civilization in the context of industrial civilization and ecological civilization, which is also an important foundation for landscape architecture to gain a foothold in the human settlements science system. Therefore, it is necessary to have a firm grasp of changes and inheritances: changing the productivity, the ability to transform nature and people's lifestyles while inheriting the yearning for nature and the expression of feelings through nature. Only when the core of inheritances is grasped shall landscape architects reasonably express, guard and sustain the long repressed biophilia of people by virtue of design and guidance

when dealing with the relations between cities and nature.

Acknowledgments

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Appendix

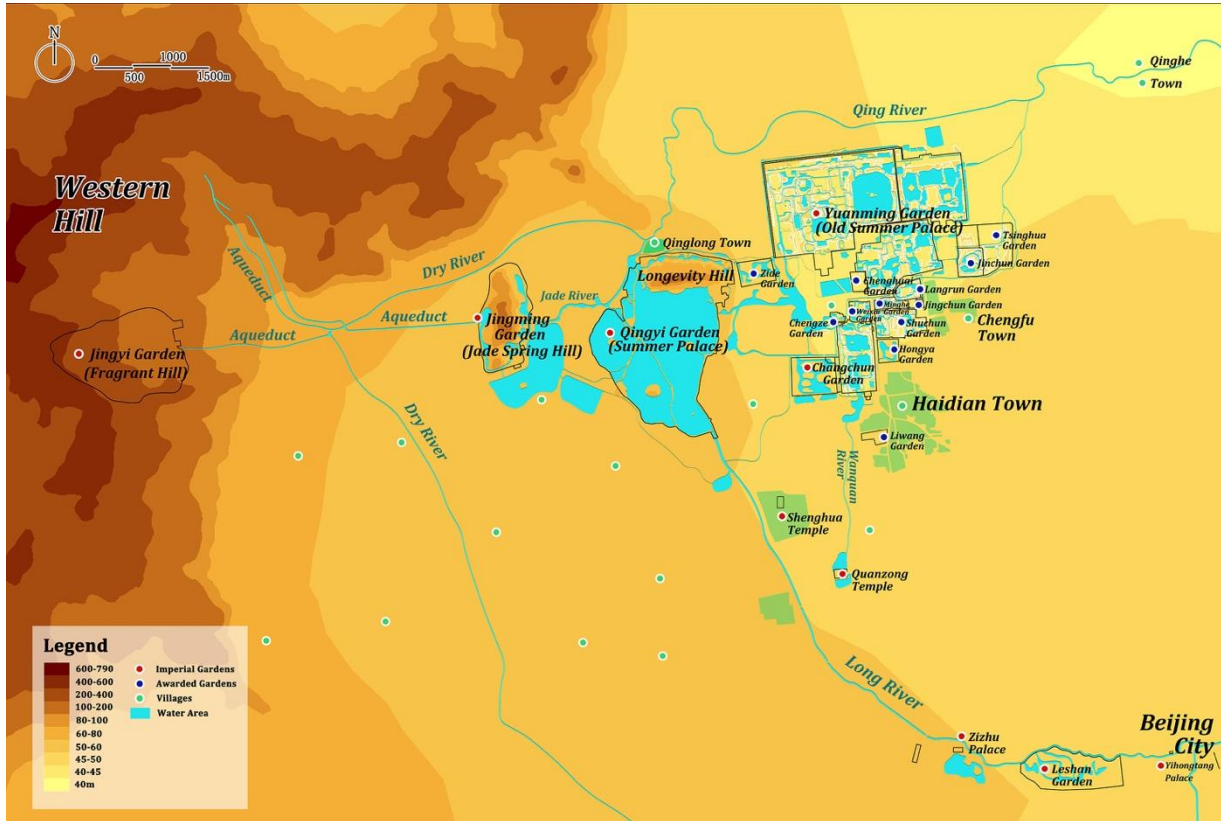


Fig. 2 The distribution of landform, water area and settlements in the northwestern suburbs of Beijing in 1860s
 Source: Drawn by author

Conserving urban bird habitats In Beijing By Planning of green infrastructure network

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Abstract

Due to the pressure of urbanization, urban animal habitats are losing at an alarming rate in Beijing. Birds are often used seen as symbolic species in biodiversity research to test the complexity and stability of city ecosystems because of their key position in the food chain and their strong environmental sensitivity. Therefore, the protection of urban bird habitats is particularly important. Beijing is a stop point on the bird migratory route from of "East Asia to Australia". With urban areas gradually replacing natural habitats, the meeting rate and diversity of birds in Beijing have been decreasing. GI (Green Infrastructure) is an interconnected network with natural areas and open spaces. It preserves the value and function of natural ecosystems, maintains landscape connectivity and reduces habitat fragmentation, which thus it plays an important role in the habitat conservation. This paper firstly describes how the green infrastructure, as a life support platform, provides birds the life supportive services such as food, water sources, nesting grounds and flight corridors for birds,. And then explains how the green infrastructure it affects the survival and reproduction of birds by environmental factors. Taking the Beijing city as an example, the paper secondly subsequently explores the way to build an urban bird habitat system with the planning of green infrastructure network. Based on RS and GIS platforms, researchers extracted basic elements of urban green infrastructures, identified habitats and classified them. On the basis of acreage and position information of patches, ecological corridors and habitat islands. According to the result above, current GI elements can be recognized with function importance and be planned hierarchically to protect the bird diversity. simultaneously, target species are clearly defined for every core areas of various habitats, and those broken islands are connected to improve the network system. Finally, this paper put forward an ideal model for the construction of GI network in Beijing from the angle of bird habitat protection. In addition, it proposes some suggestions on the current construction of urban green space.

Keywords: Green Infrastructure, Avian habitats, Biodiversity

1. Urban birds habitats status

Due to the rapid expansion of cities, China is one of the countries where the destruction of habitats and loss of

biodiversity are extremely serious. With the reduction of vegetation, pollution, population density and pressure from

climate change, animal habitats in cities are disappearing from our side at an alarming rate. As the main area where humans live, a large number of natural areas in cities have been converted into construction land. The original habitat of plants and animals was invaded, species migration corridors were cut off, and habitats were seriously islanded. All of the above reasons have made the city a hard-hit area where species richness has declined.

Urban green space is the main habitat for birds. As the only living part of urban infrastructure construction, green space provides food, water, breeding grounds and hidden conditions for birds, which has a decisive influence on the survival and

2. Green infrastructures and bird habitats

Green infrastructure is a network of interconnected natural areas and open spaces. It preserves the value and function of natural ecosystems, maintains the connectivity of landscapes, and effectively reduces the fragmentation of habitats. Because of the function of protecting biological habitats, Green infrastructure plays an important role in biodiversity conservation.

As the life support platform for urban birds, the green infrastructure provides food, water, nesting sites, flight corridors,

3. Urban bird habitats conservation based on the green infrastructure network - Beijing case

The study site in this paper is a stop point on the "East Asia-Australia" migratory route of the birds. With the gradual replacement of natural habitats for urban construction land, the bird encounter rate and diversity in Beijing are gradually reduced. Even once the city was referred to as a "no-birds capital". Some bird species with strong adaptability to the artificial

Biophilic Cities reproduction of urban birds. However, urban green areas are mostly designed according to people's use. They are mostly affected by other types of construction lands, so habitat qualities need to be improved. Main problem of urban habitats are as follows.(1) The total amount of habitat is insufficient.(2) The type of habitat is single and it is difficult to meet the diversity of birds.(3)Lack of reasonable layout planning and zoning which lead to the lower utilization of birds(4) Landscape fragmentation(5) The vegetation cover level is simpler than natural forests. (6) Excessive artificial surface, human interference intensity.

and other life supply services. It also exerts a tremendous influence on the survival and reproduction of birds through these influence factors. Analysing the relationship between urban greenland structure and birds, studying ways of optimal allocation of urban greenland structure and building methods of bird habitat will provide important scientific basis and play an important guiding role in urban ecological environment construction and bird diversity protection.

environment have become dominant species, which are not conducive to the improvement of urban biodiversity. This research takes Beijing as an example to explore ways to build a network of urban bird habitats and to protect urban bird habitats based on the idea of building a green infrastructure network.

3.1 Target species selection

It is not realistic to create habitats for each type of bird in the city. It is feasible to follow the natural characteristics of all types of green space to plan and create suitable habitats for different bird populations. Therefore, it is necessary to select appropriate target species to analyse and evaluate the value of various birds to humans.

Protected objects in Conservation Biology may include endangered species, threatened species, endemic species, flagship species, umbrella species, focal species, key species, and indicator species. In the special environmental conditions of urban green space, the following types of birds deserve attention by landscape architects. (1) Flagship species that have special charisma and can serve as public relations tools to protect specific regions, such as those large birds that are easily visible from space, or small birds with bright colours, or birds with unique or pleasing sounds. (2) Occasional species in urban areas, which are very attractive to urban residents who have a bird watching habit. For ordinary people, these birds also increase their chances of experiencing more abundant biological forms. (3) Focal species. Through the restoration, protection and management of the habitats needed for these bird communities, people can achieve

the goal of protecting most species and even the overall biodiversity. (4) Common species. They adapt to the urban environment and are relatively stable in terms of quantity. They are "emotional ambassadors" that link the emotional connection between humans and other creatures.

This research is based on the current conditions of habitats in urban green space. With reference to the principle of bio-protection, the following species are selected as representative species for each type of habitats. According to the environmental sensitivity and requirements on the environmental quality of target species, researchers selected indicator species, focal species, common species that are respectively represent the birds 'demand for green infrastructure at three different levels of high, medium and low.

Different birds are selective to their habitat. For example, if the floating birds mainly inhabit the open water and catch small fish and shrimp in the water, the wading birds mainly live in the shallow water areas or the banks of the wetlands. The climbing birds, songbird, and land birds live mainly in forested habitats. Raptors have a large habitat scale which can cover the whole urban area. Therefore, they are not included in specific habitat discussions.

	INDICATOR SPECIES	COMMON SPECIES	FOCAL SPECIES
AQUATIC HABITAT	Mergus squamatus	Anas platyrhynchos	Anas platyrhynchos
SHALLOW WATER HABITAT	Ciconia nigra	Nycticorax nycticorax	Ardea alba
FOREST HABITAT	Athene noctua	Pica pica	Phasianus colchicus

Table 1 The selection of target species

TARGET SPECIES	SUITABLE HABITAT CHARACTERISTICS	PROTECTION LEVEL
Mergus squamatus	It Inhabits streams, valleys, meadows, ponds, and grasslands in broad-leaved or coniferous mixed forests.	National first level
Ciconia nigra	It Inhabits swamps, ponds, lakes, river banks, and estuaries.	National first level
Athene noctua	It Inhabits the hills, forest margins, and plain forests. It also appears in the woods near fields, deserts, and villages.	National second level
Nycticorax nycticorax	Habitats and activities in streams, ponds, rivers, swamps and paddy fields in plains and lowland hills. Nocturnal.	Non-dangerous species
Anas platyrhynchos	It inhabits aquatic bodies rich in lakes, rivers, ponds, swamps and other waters; in winter and during migration it also appears in open lakes, reservoirs, rivers, sandbars, and marshes and grasslands near the coast.	Non-dangerous species
Pica pica	It Inhabits mountain area, plains, farmland, suburbs, and cities.	Non-dangerous species
Ardea alba	It inhabits rivers, lakes, paddy fields, seashores, estuaries and swamps in open plains and hilly areas.	National “Sanyou” Protection projects
Phasianus colchicus	It Inhabits shrubs, bamboo bushes, or grasses in the middle and low hills.	National “Sanyou” Protection projects

Table 2 the Suitable Habitat Characteristics Of Target Species

3.2 green infrastructure network construction

3.2.1 data sources

This study mainly used the Landsat Landsat 8 OLI_TIRS satellite remote sensing data in Beijing in summer 2017 (mainly using the NIR, R and G bands). The researchers used ENVI5.3 to fuse different bands, subset and sharpening the image. Through the above operations, the full-scale false color image of Beijing was obtained, which has enhanced the spectral characteristics of plants. Image accuracy is 15M. At the same time, Beijing’s latest land use change survey results on the scale of

1:10,000 were used as supplementary data. Through E-cognition, we implemented a classification operation, and Beijing land use type map (Figure 1) and NDVI variation map (Figure 2) were extracted. Among them, forest land (natural forest land, artificial forest land), farmland, shrub-grassland, water area, and shallow water area can all satisfy bird inhabitation activity to a certain extent. These area can be used as a component of the green infrastructure.

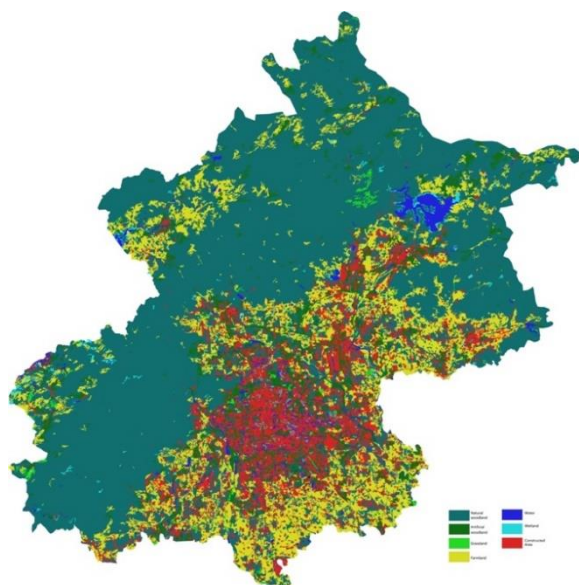


Figure 1 The Classification of Land use

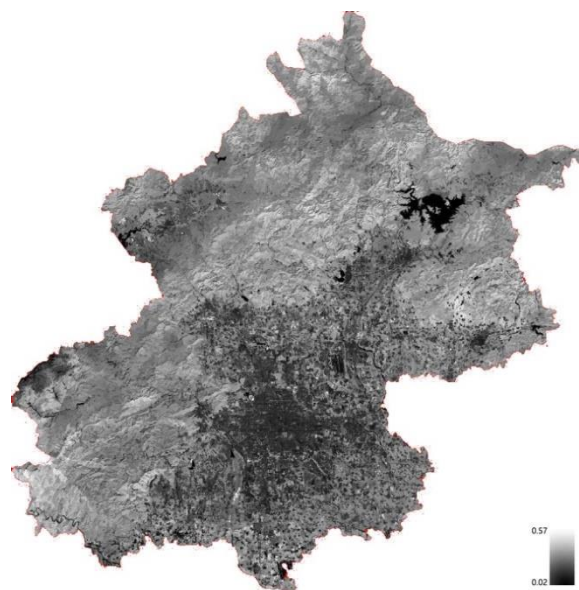


Figure 2 The Distribution of NDVI Indexes

3.2.2 Habitat suitability evaluation

3.2.2.1 Suitability Evaluation Index System

The core purpose of green infrastructure is to protect biodiversity and guide natural ecology. In the green infrastructure construction based on the protection of specific species, the extraction of various network elements based on the suitability of species habitats is very important. The study summarized the characteristics of the habitats of three types of typical habitats—forest habitats, near-water habitats, and aquatic habitats. The results are summarized in Table 2. The evaluation of habitat suitability of 9 representative birds in the Beijing area was also conducted.

The construction of the bird suitability evaluation matrix is mainly to establish the corresponding relationship between habitat impact factors and suitability index and the contribution value of the total suitability index of the target species of each impact factor. According to the comprehensive analysis of expert experience and knowledge, it is possible to establish the different degrees of importance of various

habitat factors in the suitability analysis and assign different weight values to each factor. The determination and allocation of weight values is a very critical step in suitability analysis. The scientificity, objectivity, and authenticity of this process play a decisive role in the evaluation results. The weighting process of this study uses the method of factors 'relative importance.

In the suitability analysis of bird habitats in Beijing, the researchers selected the land use, vegetation coverage (using the NDVI index), and the human disturbance as the first-class evaluation factor. The distribution of weight values is shown in Table 3. For the birds living in forest habitats, their requirements for vegetation coverage are high, and the density and species of the vegetation have a great impact on their nesting and foraging. Therefore, compared with aquatic birds and wading birds that depend on aquatic habitats, the NDVI index has a more pronounced impact on them. In addition, for common birds in

cities, their adaptability to human disturbance is strong, so the interference intensity has little effect on these birds. In the establishment of the evaluation matrix about second-class factors, the urban land use condition is divided into six categories: natural forest land, urban green land, water area, shallow water area, farmland, and constructed land. The NDVI indexes are evenly divided into three levels. The specific classification of human interference

Biophilic Cities intensity is determined by the distance from the specific habitat location to the central urban area. Among these target birds, birds that rely on aquatic habitats have a larger radius of activity and a larger field of vision, so their demand for plant coverage are moderate. In contrast, birds living in woodland habitats require higher vegetation densities to meet their requirements for nesting and avoiding natural enemies.

	<i>Mergus squamatus</i>	<i>Ciconia nigra</i>	<i>Athene noctua</i>	<i>Nycticorax nycticorax</i>	<i>Anas platyrhynchos</i>	<i>Pica pica</i>	<i>Ardea alba</i>	<i>Phasianus colchicus</i>
Land cover	0.45	0.5	0.5	0.5	0.5	0.7	0.7	0.5
NDVI	0.35	0.3	0.3	0.3	0.4	0.25	0.1	0.3
Interference intensity	0.2	0.2	0.2	0.2	0.1	0.05	0.2	0.2

Table 3 The Factor Weights for Bird Habitat Suitability

	<i>Mergus squamatus</i>	<i>Ciconia nigra</i>	<i>Ciconia nigra</i>	<i>Nycticorax nycticorax</i>	<i>Anas platyrhynchos</i>	<i>Pica pica</i>	<i>Ardea alba</i>	<i>Phasianus colchicus</i>	
LAND COVER	Natural woodland	6	6	10	6	8	10	8	10
	Urban Green Space	4	4	4	6	8	10	4	4
	Farmland	2	2	6	8	4	10	2	6
	shrub-grassland	2	2	4	6	6	10	4	8
	water area	10	8	0	8	10	0	8	0
	shallow water area	8	10	2	10	8	2	10	2
	Built-up area	0	0	0	2	0	4	0	0
NDVI	0.02~0.20	3	3	3	3	3	3	3	3
	0.21~0.39	9	9	6	9	9	6	9	6
	0.40~0.57	6	6	9	6	6	9	6	9
	> 6000M	10	10	10	10	10	10	10	10
DISTANCE FROM BUILT-UP AREA	4500M~6000M	4	4	4	10	10	10	5	8

1500M	2	2	2	10	9	10	3	4
~ 3000M								
0~ 1500M	1	1	1	6	5	10	1	1

Table 4 Quantitative Factors Evaluation table of The Suitability analysis

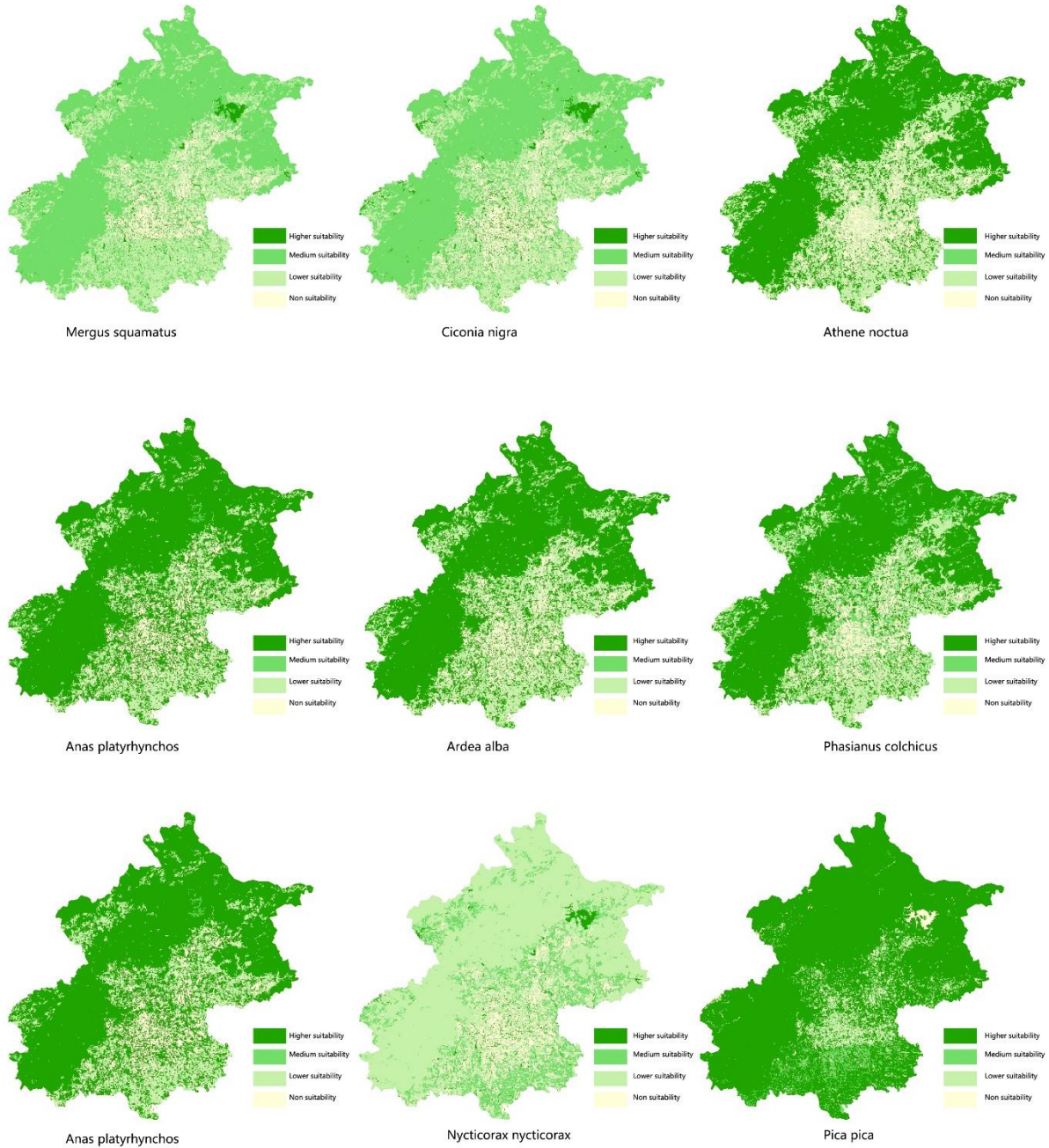


Figure 3 Habitat Suitability Analysis of Target Birds

3.2.2.2 Bird habitats suitability evaluation

The bird habitat suitability analysis method of this study effectively combines mathematical models with remote sensing and GIS technologies. The spatial quantification of the habitat impact factor data is based on the homogenous polygon unit extracted by the object-oriented image segmentation technology. Each polygon evaluation unit is composed of multiple remote sensing pixels. The suitability of birds reflects the comfort of the bird's survival and reproduction in the environment. The influence of each factors on the habitat does not exist in isolation. In different combinations, their influence is different, but they restrict and complement

suitability index in this study, the researchers used linear functional relationships to describe habitat suitability and impact factors. The formula is:

$$HSI_i = \sum_{n=1}^m (A_{ni} B_{ni}) \quad i=1,2,\dots,x$$

In the formula, HSI_i is the value of the habitat suitability index of the i types of birds. A_{ni} ($n=1, 2,3,\dots,m$) represent the contribution rate or weight of the number n factor to the number i bird group. B_{ni} ($n=1,2,\dots,m$) is the suitability value of the number n factor to the number i bird species. m is the number of influencing factors involved in the analysis. x is the number of birds that participated in

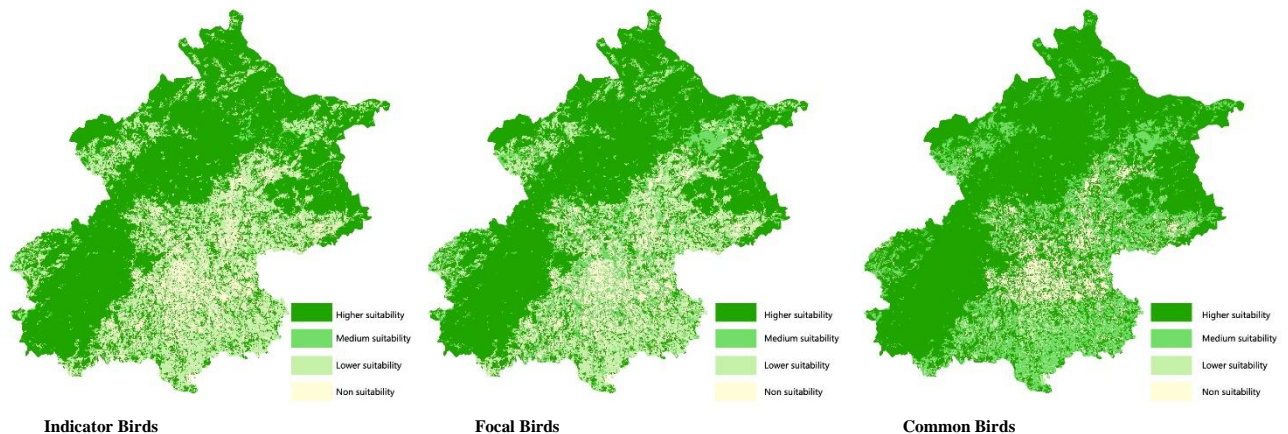


Figure 4 Habitat suitability analysis of target Species

each other. In the calculation of the bird habitat evaluation unit, and calculating suitability values for individual evaluation units based on suitability analysis models and habitat geography spatial quantification values. The high value results in the analysis unit correspond to the good bird living environment, and the low values correspond to the poor living environment of the birds with poor habitat suitability. In this study, the calculation results are also divided into four levels in accordance with the evaluation grade index, that is, the habitat evaluation of birds is divided into four categories: high-suitable area, moderate-

the analysis. suitable area, low-suitable area, and unsuitable area. With the support of the GIS platform, suitability analysis figures of 9 target bird groups was obtained. The results are shown below in Figure 3.

During the process of comprehensive suitability assessment of the three groups of target species, ---indicator species, focal species, and common species---we can assume that the those birds communities are threatened in the same degree. Therefore, we use the same weights in complex overlay calculations. Through the data recalculation, three sets of bird comprehensive suitability evaluation maps

were obtained. And the results are shown below in Figure 4.

From the comparison results, it can be found that the suitable areas for birds of the three groups differ greatly. The indicator species groups have the least range of suitability due to their high environmental sensitivity, high requirements on habitat

quality, and vulnerability to human activities. The focal species represents the degree of adaptation of most types of birds, and common birds' activities area cover most of the city

3.2.2 Green Infrastructure Network Composition

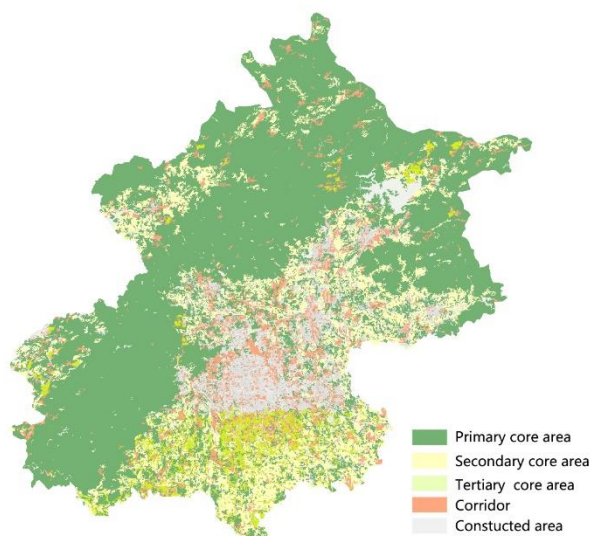
3.2.2.1 Elements Extraction

The study used the assessment of habitat suitability with the three groups as a base map to extract the elements of the green infrastructure network. According to Forman's "concentration and decentralization combined" landscape ecological landscape pattern, The overall landscape optimal layout model includes: some large natural vegetation patches to conserve water resources and maintain the

survival of key species; There are wide enough and a certain number of corridors for species diffusion and energy flows; Small natural vegetation patches serve as temporary habitats or shelters. Based on this, the study uses morphological principles to segment the base map, identify existing green infrastructure elements, and identify potential ecological corridors. The contents of each element are as follows.

NETWORK ELEMENTS	LANDSCAPE ECOLOGY FUNCTION
CO R E A R E A	Large-scale natural patches are the "source" of many ecological processes, providing habitat or migration destinations for wildlife. In urban areas, the core area usually corresponds to large parks, nature reserves, scenic spots, etc. in urban areas.
ECO L O G I C A L I S L A N D	The isolated small patches, which are equivalent to the "ecological hopping island" in the ecological network. It can provide scattered island species, or the flow of matter and energy, and play an intermediary role in the ecological network.
BU F F E R	The transition zone between the core area and the peripheral cities is to protect the ecological process and natural succession of the core area, and reduce the impact of the outside landscape. It has a marginal effect. In the urban environment, the main area is the intersection of green landscape and the outside world, such as the forest belt outside the park.
CO N N E C T I N G CO R R I D O R	The corridor connecting the adjacent core area is a channel for species dispersal and energy exchange between patches in the adjacent core area.

Table 5 Basic Elements of the GI network



3.2.2.2 Hierarchical planning

(1) Hierarchical planning of core areas

The organic integration of the core area and connecting corridors is essential to provide ecological functions and improve the landscape connectivity. We classified the importance of the green infrastructure network centre by distinguishing the suitability of the three groups of target species, identifying the patch area and the landscape structure inside the patch. Classification criteria include (1) plaque area (2) plaque quality (3) suitability of target birds in each group.

Core areas in first-level group, which are composed of higher avian suitability area and peripheral buffers, can meet the habitat requirements of important indicator species. These areas are large in area and have high connectivity and biodiversity. Core areas in first-level group are consist of moderate suitability area and buffer area . At least, they can meet the adaptability of the focal species. Although the area and connectivity of them are smaller than that of the first-level network centre, they also have the function of maintaining urban biodiversity and other ecological environments. However, such areas are mostly surrounded by urban constructed land, so these area in second-level has high ecological sensitivity and poor system stability, and are easily affected by external disturbances. Core area in the third-level group consists of island patches and low habitat suitability area. They can meet the demand of common bird habitats, and can serve as as an “eco-hopping island” for species migration, material and energy flow channels. And they play a role in media and links in the green infrastructure network.

(2) Hierarchical planning of corridors

The principle of the corridor grading is similar to that of the core area. The

reference indicators mainly include (1) the corridor width (2) the corridor connection degree (3) the core area level of the corridor connection. The first-level corridors are used to connect to the first-level cores, which helps the flow and exchange of energy between large-scale green space patches. The Two-level corridors, used to connect the first-level cores and the second-level cores, or contact different second-level network centres. Such corridors are mainly based on branches, combined with urban river riparian zones and urban secondary roads for greening, which helps to strengthen the interrelationship between patches in different grades of core areas. Three-level connection corridors, used to contact three-level network centres, can reduce the fragmentation of the landscape and increase the overall continuity of the green infrastructure network.

4. Conclusion

According to the related superposition and calculation, the results of urban green space infrastructure planning based on bird protection are shown in Figure 5. The results showed that the green infrastructure can set up three intensity ranges of high, medium and low levels for birds. The indicated

species with higher ecological environment requirements can perch in the primary core area, and the focal species representing most bird habitats can live in a wider space for inhabiting, as well as common birds. However, there are more bird species in suitable woodland types in Beijing, but less

suitable for water birds. Due to the lack of shallow water areas, the existing river channels shrink the living space of wading birds. In the green infrastructure, we should appropriately increase the buffer area of water and construction land and the degree of connectivity between corridors.

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Research on Water Saving Urban Forest Plant Planning in Beijing Based on Plant Water Requirements

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Abstract

With the rapid process of urbanization, the urban natural ecological environment is replacing by reinforced concrete successively. With the concept of eco-friendly construction becoming deeply into human mind, the urban ecological construction has been paid more and more attention. Under the background of retreating the non-capital city function of Beijing and improving the city living environment, the urban forest construction in Beijing has been developed step by step. The urban forest is based on the spirit of eco-friendly city construction in the aspects of improving the urban ecological environment, promoting the harmony between human and nature, and maintaining the balance of urban ecosystem. The combination of urban forest construction and urban ecological construction is also an important way to express the characteristics of natural ecological landscape in the city. Among them, water-saving urban forest construction is the important method to build low-maintenance, self-recycling natural ecological system. This paper is taking the water-saving city's forest plants strategy planning as the entry point, then taking the urban forest construction of Hengjiezi in Beijing as an example, according to the rain Water resources collected within the urban forest construction scope to calculate the effective rainfall which could be used by the plants. In order to realize the self-balance and self-maintenance of irrigation water for urban forest plants, the calculated effective rainfall can be combined with the average annual water demand of plant growth, the selective use of water in urban forest plant planning is carried out. A plant landscape planning method based on the calculation of plant water consumption is put forward through the micro level, and the content, connotation and steps of the method are further explained. This paper expounds how to calculate plant water consumption to provide quantitative support for the determination of planting area and vegetation type, and makes a strategy study on plant selection and community allocation of urban forest in Beijing. This paper discusses the combination of urban forest and natural ecological environment, establishes a new eco-friendly model of water-saving urban forest, and tries to provide new ideas for urban forest plant planning in Beijing.

Keywords: Plant Water Requirements; Urban Forest; Plant Planning; Ecological Friendliness

1. Introduction

The rapid urban development has caused great damage to the natural ecological environment in the city. Although some achievements have been made during the urban greening construction in China, the problem of wasting resources is common in this process, while the optimal allocation and efficient utilization of resources have not been realized. ^[1]China has a large population, and its per capita water resource is only 28% of the world's average per capita level. In this situation, the water consumption of green space, especially the amount of water consumed by plant irrigation, has been increasing with the construction of green spaces year by year, and the construction of water-saving green spaces has become the inevitable requirement for urban ecological development.

In the context of relieving Beijing's non-capital functions, setting aside vacant land and adding green space, urban forest is gradually emphasized due to its high ecological value. Since China's per capita urban forest area is greatly below the world average, urban forest plays an important role in improving urban ecological environment, promoting harmonious coexistence between human and nature, and maintaining the balance of urban ecological system, which greatly correspond the spirit of ecological civilization construction. In this way, the restoration of urban natural ecological environment is of great importance.

2. A review of water-saving landscape and urban forest research

2.1. *A review of water-saving landscape research*

Water-saving landscape is a crucial aspect of resource-efficient landscape construction. It is to allocate and recycle resources rationally, save water resources to the maximum extent, and improve the utilization rate of water resources. It intends to achieve the maximum ecological benefit with the least amount of water and minimum interference pattern. Although many studies has been working on the issue of the water-saving landscape at present, most of them focus on the maintenance management of water-saving technology, such as reclaimed water recycle, permeable pavement material and ecological revetment design, which intend to save landscape water consumption. Although there are some concerns about plants in these studies, most of them are from the perspective of the development model of traditional garden, while the issue of great water consumption of irrigation plants in the garden water is often neglected.

2.2. *Review of urban forest plant landscape research*

Since the 1960s, scholars have begun to study urban forest and defined urban forest from various perspectives. At present, though the concept of urban forest is not uniformed, it contains the same argument: the urban forest is mainly composed of trees, including the configuration and layout of the plant community. And urban forest has its important ecological significance, which plays an important role in promoting social

economic development, urban ecosystem health as well as the infrastructural service for urban residents.

Nowadays, the researches on forest plant community is mainly from the macro perspectives, which evaluate urban forest landscape pattern, ecological service value and aesthetic value, as well as investigate and evaluate current urban forest plant community. The planting configuration of urban forest, as an important approach to promote the restoration of urban natural ecological environment, should be different from that of traditional city parks and advocate the construction mode of low-maintenance and self-recycling.

2.3. Existing problems

As the only living organism in the green space, plant carries its important ecological functions and also behaves as an important carrier and manifestation of landscape. As an artificial ecosystem, a stable artificial community is more conducive to realize the virtuous cycle of urban forest internal organization system. The construction of artificial plant community should be based on the concept of natural landscape, local landscape, protective landscape and other related theories.^[2] Among the discussion of urban forest, the research on the selection of water-saving plants and the strategy of community collocation is very scarce. Therefore, based on the water consumption of plants, this paper studies the issue of how to carry out low-input, self-sustaining and high-efficiency water-saving construction in the case of water shortage, at the same time, conducts strategic research on urban

forest plant planning to improve the ecological service function of urban forest.

3. Research on water-saving urban forest plant planning based on the calculation of water consumption

3.1. Research object

The design area is located in the southern in Beijing, close to the Fifth Ring Road with the total area of 43.6ha. It has the typical monsoon climate of medium latitudes, zonal vegetation type belongs to warm temperate deciduous broad-leaved forest and has warm coniferous forest distribution. The annual average precipitation in Beijing is 638.8mm.^[3] Water shortage has become a prominent contradiction for the green space construction in Beijing. It is imperative to rationalize the utilization of rainwater resources to construct the water-saving goal and provide more ideas for urban forest construction. Corresponding to Beijing's development model which is leaving blank space and increase green space, the establishment of urban forest in this area not only creates good ecological benefits, but also serves as the elastic threshold of urban expansion, so as to provide more possibilities for the future urban development.

3.2. Research contents and methods

3.2.1. The calculation of water consumption utilized by plant irrigation

After the study of current situation and basic materials, the site is analyzed with the elevation and rainwater collection with Geographic Information System (GIS),

according to its annual precipitation in this area. (Fig. 1) Referring to the runoff coefficient, the total amount of rainwater collected in the site is 112950m³. Combined with the principle of low impact development, according to the total amount of rainwater collected from the site, the amount of water required for the current potting pit is 78750 m³, the total amount of water available for plant irrigation is calculated as 34200m³.

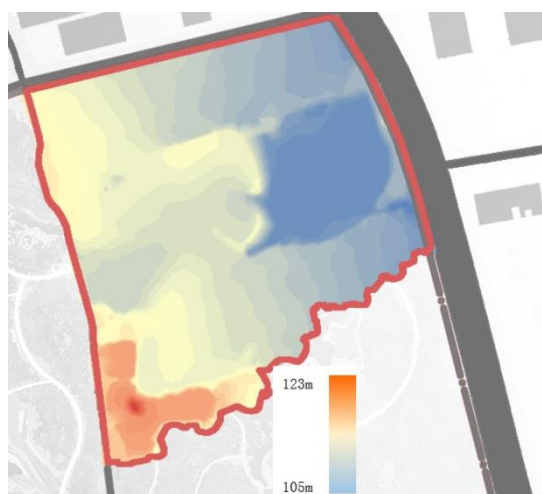


Fig. 1. Elevation analysis.

3.2.2. Classification of plant irrigation types

According to the rainfall in Beijing, the rainfall utilized effectively by plants, which is called effective rainfall, should be at the first priority. According to the effective rainfall coefficient, the effective rainfall as the critical value, it is believed that when the water requirement of plants growth is less than the effective rainfall, plants could meet their own growth and development needs through rainfall, and no artificial irrigation is required, which are defined as self-supporting plants. While the water demand is greater than the effective rainfall and the

plants could not satisfy its growth and survive under the condition of natural rainfall, the artificial irrigation is needed to maintain its good growth status in this situation, these plants are defined as irrigation plants.

Summarizing the previous research results on plant water consumption, with the effective rainfall as the critical value, plants, which consume less water per year than the average annual rainfall, include trees, shrubs, herbs, such as *Pinus tabulaeformis* Carr, *Robinia pseudoacacia* L, *Sabina procumbens* (Sieb.ex Endl.) Iwata et Kusata , *Euonymus japonicas* Thunb, *Miscanthus sinensis* Anderss.

3.2.3. Calculation on planting area of irrigated plants

In the urban forest construction, we need to follow the principle of water-saving and choose self-supporting, reduce water consumption. In this way, it could ensure the diversity of plant species, strengthen the plant community of ecological benefit, give full play to its ecological function at the same time, and also utilize irrigation type plants with high efficiency. According to the amount of rainwater for irrigation and average water demand of water-saving irrigation plant communities, it could be calculated that the largest amount of irrigation plants should be planted under certain circumstance of the irrigation water consumption.

Previous researches have studied the water consumption patterns of the existing plants in Beijing. For the purpose of water-saving, the area ratio of trees, shrubs and

herbs which are suitable for the allocation of green spaces in Beijing is (10:11:17), which is consisted with the green space of 100m², the tree layer of 50m², the shrub layer of 55m², and the herb layer of 85m².^[4] Considering plant species and density, microclimate, plant collocation model, as well as factors such as species richness, combined with the water consumption of plants, the above conditions are used to match the plant community. Weighted calculation of water consumption among different communities and averaged the data, the average water demand per 1m² of plants is 266.06mm/ year in the configuration mode of the water-saving type.

It could be seen from the data above that, with the 34200 m³total amount of irrigation water for plants, the planting area of irrigation plants on the site is 12.875 ha. (Fig. 2)

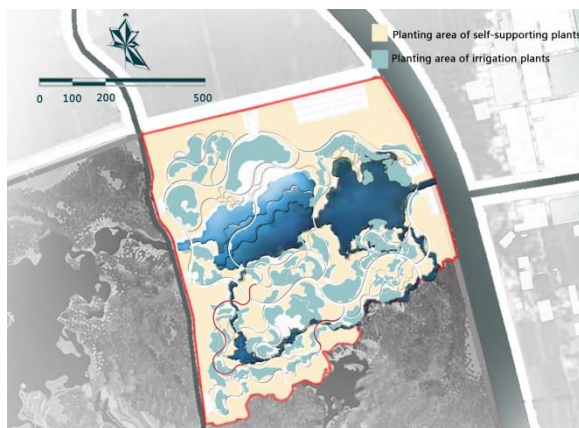


Fig. 2. Planting area of self-supporting plants and irrigation plants

3.3. Planting strategy

According to the landscape demand and the analysis of the basic natural conditions, self-supported plant communities and irrigated plant communities are constructed. Simultaneously, the distribution of points, groups, belts, and sheet among the plant communities is formed. Based on the landscape demands in different regions, we should build the tree-shrub-herb communities, shrub-herb communities and herb communities, as well as increase the diversity of landscape types, and enhance landscape effects. (Fig. 3)

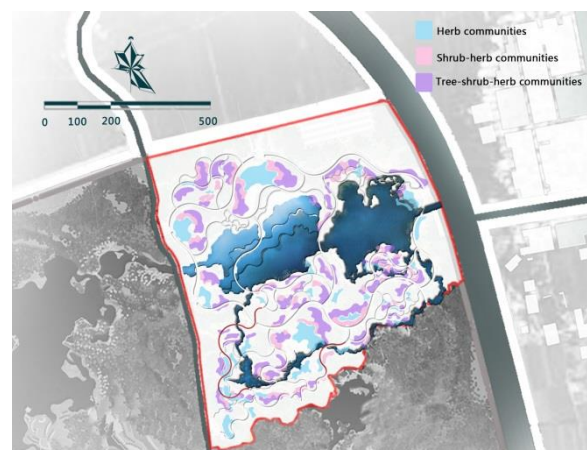


Fig. 3. Different types of plant communities

During the construction of self-supporting plant communities, combined with the characteristics of urban forest to build a natural ecological base based on self-supporting native plants, with the thematic plant landscape like rock gardens and xeric botanical gardens as embellishment, self-supporting plants are fully displayed. For example, planting self-supporting plants such as *Miscanthus sinensis* Anderss in the rock garden, and planting various types of

self-supporting plants in xerex botanical garden demonstrate the landscape and also play a role in popular science. The low-maintenance and self-recycling characteristics of the self-supporting plants also bring about the possibility of low-interference management, as well as play a role in promoting the ecological succession of plant communities.

In the construction of irrigated plant communities, regarding the water saving as a premise, use ornamental species, with self-supporting plants as much as possible to form plant communities. Improve plant species diversity and plant landscape richness. At the same time, considering the seasonality of plants, the landscape elements of different spatial levels are enriched. Focus on building important landscape nodes and make efficient use of the limited water resources. For example, the use of *Ailanthus altissima* (Mill.) Swingle and *Koelreuteria paniculata* Laxm, which have a relatively low water consumption among irrigated plants, can be the supplements of upper-level plants, while combining with self-supporting plants, like *Pinus tabulaeformis* Carr, *Platyclusus orientalis* (L.) Franco, etc. Also, the shrubs were designed as embellishments with the low water consumption plants, such as *Hibiscus syriacus* L, *Lagerstroemia indica* L and Floribunda Roses, which could form mesmerizing plant communities in all seasons.

Self-supporting plants and irrigated plants are combined to create a landscape of rustic charm. A natural base is created with self-supporting plants, and the irrigated plants

are used as embellishments. The natural and playful landscape will be constructed with a water-saving urban forest, in order to create a landscape forest and an ecological forest. Choose self-supporting herbs with ornamental characters, such as *Duchesnea indica* (Andr.) Focke, *Oxalis corymbosa* DC, to form the landscape with wildflowers as ground materials. Add irrigated plants with ornamental flowers at important landscape spots, such as *Kerria japonica* (L.)DC, *Weigela florida* (Bunge) A.DC, *Lagerstroemia indica* L, to enrich visual diversity. Integral forests as background, shrubs have a variety of flowers with great visual appearance, combined with a large area of wildflowers, create the natural atmosphere of the forest rustic altogether.

4. Water saving urban forest plant landscape planning strategies

4.1. The selection and application of native plants

To build the urban forests, the artificial plant communities should tightly correspond to the principles of nature, and the advantages of the native species should be well utilized in the nature-approximate landscape design. Native plants not only include native plants with high environmental adaptiveness, but also alien species that have been able to grow well, proliferate locally and develop local cultural connotations after long-term cultivation and domestication. It is easier to construct stable artificial plant communities by taking full advantages of native plants. Native plants

are widely used in the green space construction as the most adaptable plant group.

82 kinds of trees, shrubs and herbs were recommended in the "Indigenous Plant Resource Development List" of Beijing Municipality. These native plants not only have strong environmental adaptability, but also contain the characteristics of water saving and drought resistance. For example, *Quercus* can grow for hundreds of years under natural conditions. Combined with hundreds of native plants that have been widely used in the construction of green space in Beijing, the selection of native plants with water-saving, drought resistance characteristics and other excellent resistance to build urban forests is beneficial to the stabilization of urban artificial forest communities.

4.2. Application of spontaneous herbaceous plants

In the research of the application of native plants in Beijing, the proportion of herbaceous plants is relatively great. Most of them are not planned plantings in the process of greening, but spontaneous growth and survival under natural conditions, such as *Dendranthema lavendulifolium* var, *Orychophragmus violaceus* (L.) O.E.Schulz. This kind of self-initiated growing herb, without artificial management required, is called spontaneous herbaceous plants. The existence of spontaneous herbaceous plants greatly improves the plant species diversity in the urban green spaces.

In addition to its low-maintenance properties, its aesthetic value should also be

taken into consideration during the construction of urban forests. In the previous research on the status quo of Beijing's own spontaneous herbaceous plants, investigation and statistics of the ornamental characteristics among 142 kinds of spontaneous herbaceous plants in 181 species shows that 86 species of them have ornamental floral organs, accounting for 60.6% of the total. Most of the remaining species also exhibit great group landscape effects.^[5]

The characteristics of self-contained, self-growth plant and great landscape effects of spontaneous herbaceous plants provide the possibility for the construction of low-maintenance, self-recycling, water-saving urban forest. It also lays a solid foundation for the realization of species diversity, enrichment and stabilization of artificial plant communities.

4.3. Plant community configuration

During screening and applying different plant species, it is also necessary to consider the vertical and horizontal structure of plant communities, as well as the more scientific and rational use of interspecific relationships like symbiosis, competition. When considering the use of horizontal mingled forest, the characteristics of the plants should be carefully considered in order to avoid the occurrence of pests and diseases. At the same time, full use was made of the special nature of mixed planting to coordinate the levels and richness of the landscape, according to their ornamental characteristics. On the vertical direction, a careful study should be conducted on natural factors such as light and moisture, while the

advantages and disadvantages should be taken into consideration to satisfy the complementarity and diversity of different plant niches.

Based on the full consideration of the horizontal and vertical structures of the plants, to achieve the stability of the artificial communities, the natural base conditions of the site should be fully utilized to create plant communities with different bases, densities, and abundances, as well as improve the heterogeneity. The ability to respond to external factors, self-repair ability should be enhanced. Stable plant communities are more likely to achieve the goal of low-maintenance and self-recycling development of urban forests, while at the same time, lay the sound foundation for realizing the ecological restoration of urban natural ecosystems.

5. Conclusion

In the context of relieving Beijing's non-capital functions, setting aside vacant land and adding green spaces, the construction of urban forests can serve as an elastic threshold for urban expansion and provide more possibilities for future development. The study of water saving urban forest landscape planning provides new ideas for the creation of stable artificial plant communities and plays an important role in building an urban eco-friendly development model. This article starts from the microcosmic point of view, combined with the calculation of the water consumption of plants, systematically expounds the new ideas of the water-saving urban forest plant selection and community collocation. Based

on this research, the future planning can be distinguished with the traditional urban parks, more detailed allocation of plant configuration, highlighting its unique characteristics of configuration.

Building urban forest is an important approach to imply the construction of ecological civilization. Building water-saving plant communities is a starting point for urban forest landscape planning, but it is the only method. The production, recreation and cultural expression function of urban forest also need to be considered and paid careful attention. Therefore, for different urban forest construction with different purposes, we need to consider all aspects and select the optimal choices and establish different systems to provide more possibilities for urban forest construction.

Acknowledgments

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Study on the Landscape Feature and Regenerative Strategy of Fujimi Historical Town in Japan

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Abstract:

Learning the history of the development of Japanese cities, we can clearly realize that most of cities be created from the belief of mountain culture in the early modern period of Japan. Fujimi Historical Town is a series of cities that can see Mount Fuji and take Mount Fuji as the object of belief and live together with the surrounding ecological environment, even we can call it a kind of Biophilic City we imagine. This paper will start from the historical phenomenon of Fujimi, combined with mountain belief, Japanese Ukiyo-e, and the idea of harmonious development of human and nature, to find the location and urbanism of Fujimi Historical Town in Japan. Taking Fujiyoshida, Shizuoka and Tokyo as examples to discuss the landscape feature of Fujimi Historical Town under the background of different distance from Mount Fuji. Using graphical language to restore the urban space changes in different Japanese historical periods.

In general, this paper will summarize the landscape feature of Fujimi Historical Town in three aspects: landscape scale, urban design, and culture. Meanwhile, according to the social problems, this article will solve the problem by using the original historical environment, explore the regenerative strategy of the Fujimi Historical Town under the belief of the Mount Fuji, the future possibilities of positive relationship between the city and the people, and the imagination on the key features and qualities of Biophilic City.

Key words: Fujimi Culture; Landscape Scale; Urban Design; Cultural Landscape

1. Introduction

The city is an important factor that affects the quality of people's lives. At the beginning of urban construction, each city relied on its own unique charm to make people easily distinguish the differences. In the process of globalization, more and more scholars are aware of the loss of local characteristics and the disappearance of landscape features in the city. With the rapid development of the city, how to consider and construct biophilic city from the perspective of landscape architecture has become a common urban environmental problem today.

Japan's excellent urban planning tradition is the historical basis for the construction of Japan's modern urban planning theory. In addition to the garden city and the landscape city, the Fujimi historical town formed under the belief of the Mount Fuji is also one of the bases for the birth of modern Japanese cities.^[1-2]

2. Background of Fujimi Culture

2.1. Mountain belief and Fuji belief

The mountain belief is a belief that regards the mountain as a sacred object of worship. It is derived from the natural worship, prospered in the religious worship, and integrated into the social worship. In Japan, people have had deep emotions with Mount Fuji since ancient times. Therefore, the Japanese regard Mount Fuji as the god, as well as the object of belief and worship.

2.2. Mount Fuji Ukiyo-e

Mount Fuji Ukiyo-e, which is based on Mount Fuji, belongs to the "famous places" of the Ukiyo-e, and it mainly depicts the

scenery of Mount Fuji from Kanto Area in Japan. "The Great Wave off Kanagawa" is Katsushika Hokusai's most famous work, and one of the most recognizable works of Japanese art in the world. In addition to Katsushika Hokusai's "Thirty-six Views of Mount Fuji" (1823), another famous ukiyo-e painter in Japanese history, Utagawa Hiroshige, was also depicted the scenery of Mount Fuji in the "The Fifty-Three Stations of the Tokaido" (1832), "One Hundred Famous Views of Edo" (1856) and "Thirty-six Views of Mount Fuji" (1859).

2.3. Fujimi

The meaning of Fujimi is looking at Mount Fuji. Fujimi is a expression of the Fuji belief under the influence of Japanese mountain beliefs. It is also a new form of Mount Fuji research that is formed from the visual perspective of "Looking". Mr. Tashiro Hiroshi, a famous Japanese geography scholar, was keen on the research of Fujimi and published the "Mount Fuji Visible Map" in April 1986. Mount Fuji Visible Map is the first graphic representation of Mount Fuji visible analysis in Japan.^[3]

2.4. Fujimi 100 of Kanto

"Fujimi 100 of Kanto" was selected with the aim of promoting beautiful community development through selection of a place where good views to Mount Fuji can be obtained and support for conservation and utilization of surrounding landscapes from May 2004 to October 2005 by Ministry of Land, Infrastructure, Transport and Tourism Kanto Regional Development Bureau. From the aspect of landscape and activity, 128 views and 233 viewing spots of Fujimi in the Kanto area were selected.

3. Materials and Methods

3.1. Area of research

According to the 13 states (Kai, Totoumi, Suruga, Izu, Musashi, Sagami, Awa, Kazusa, Shimousa, Hitachi, Shinano, Kozuke, Shimotsuke) that can see Mount Fuji, “Fujimi Thirteen States Map” was drawn by Akiyama Nagatoshi in thirteen years of Tenpo (AD 1842). The 13 states are provincial administrative divisions established based on the Japanese rule of law, also called decree country, was used from the Nara period until the early Meiji period. The Mount Fuji in the map appears in the form of a plan, which is rare in the maps created during the Edo period. After the Meiji Reform, Japan’s administrative division was changed. Thirteen states had become the present Tokyo, Chiba, Kanagawa, Shizuoka, Yamanashi, Ibaraki, Nagano, Tochigi, Gunma and Saitama. They are collectively referred to as “Tokyo and Nine Prefectures” within the paper. Therefore, this article will use 13 states as the basis to define “Tokyo and Nine Prefectures” as the area of research. (Fig. 1)

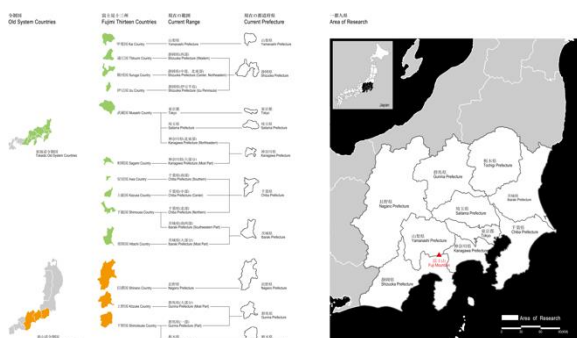


Fig.1 Area of research.

3.2. Materials and data

Japan has a large amount of research on Mount Fuji, but there are relatively few results and basic data on the systematic research of Mount Fuji, Fujimi culture, and the city based on the perspective of landscape architecture. Therefore, the article selected Thirty-six Views of Mount Fuji (1832), The Fifty-Three Stations of the Tokaido (1832), One Hundred Famous Views of Edo (1856), Thirty-six Views of Mount Fuji (1859) and Fujimi 100 of Kanto

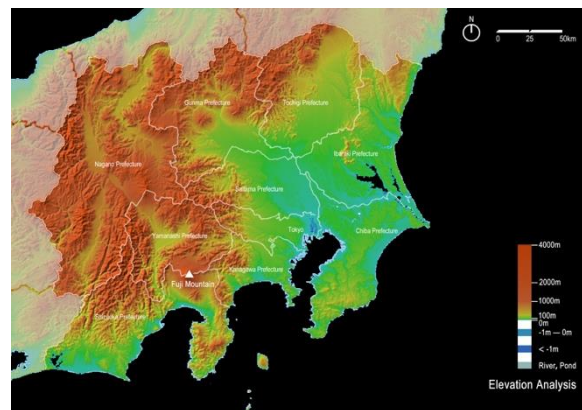


Fig.2 Elevation analysis.

(2005) as the basic database from the two aspects of depicted objects and history.

3.3. Methods

Using Geospatial Information Authority of Japan (Fig. 2), Eris Japan and Mt. Fuji Visible Map (by Tashiro Hiroshi) as the image processing platform (Fig. 3).

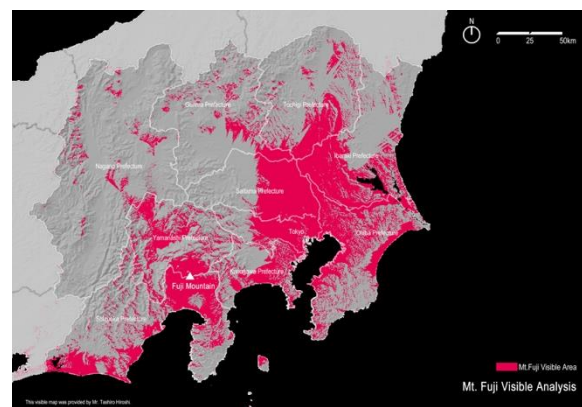


Fig.3 Mt. Fuji visible analysis.

Utilizing spatial humanistic methods and the spatial, computational, and visualization capabilities of GIS to imported the geographical coordinates of Mount Fuji Ukiyo-e and Fujimi 100 of Kanto into the map software for spatial visualization. Analyze the spatial distribution characteristics from the perspective of spatial visualization. At the same time, with the help of the spatial distribution characteristics of Fujimi culture, this paper further analyzed the interrelationship between the historical and cultural phenomena of Fujimi and the urban construction in Japan.^[4]

4. The Spatial Distribution of Fujimi Culture

4.1. Spatial distribution characteristics

In the Thirty-six Views of Mount Fuji (1832), there are 44 ukiyo-e paintings in the area of research, which are mainly distributed in the Mount Fuji area, the coastal area of Tokaido, and the Tokyo area.

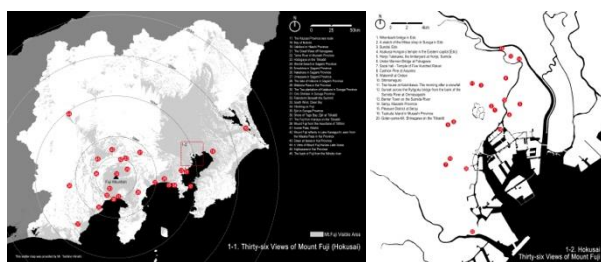
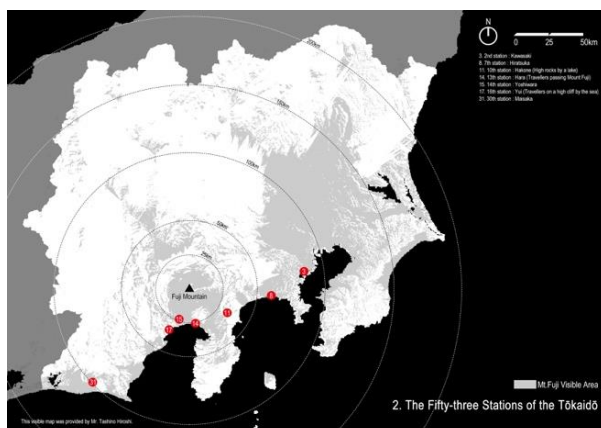


Fig.4 Analysis of Thirty-six Views of Mount Fuji (1832).



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Fig.5 Analysis of The Fifty-Three Stations of the Tokaido.

(Fig. 4)

In The Fifty-Three Stations of the Tokaido (1832), there are seven Ukiyo-e paintings located on the area of research and depicting Mount Fuji, which are mainly distributed in the historical cities along the coast of Tokaido. (Fig. 5)

The One Hundred Famous Views of Edo (1856) mainly depicted the famous scenery of the Edo region. Among them, there are 19 Ukiyo-e prints depicting Mount Fuji in the Ukiyo-e, which are mainly located on the east and north sides of the Imperial Palace, and the Megurogawa area where have a large amount of fujizuka. (Fig. 6)

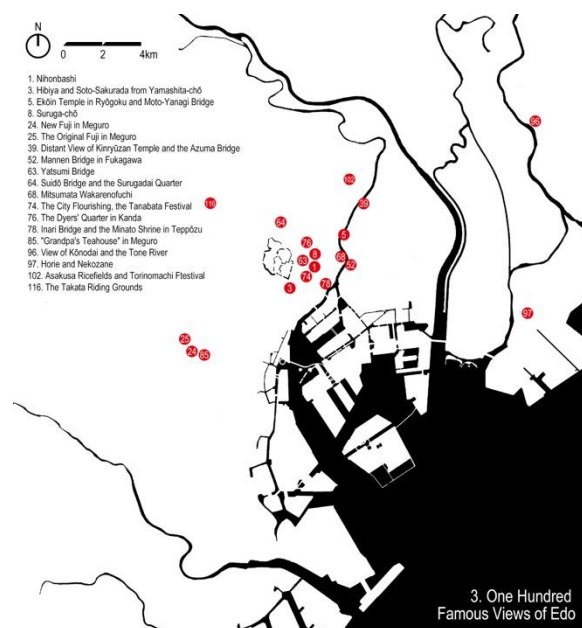


Fig.6 Analysis of The One Hundred Famous Views of Edo.

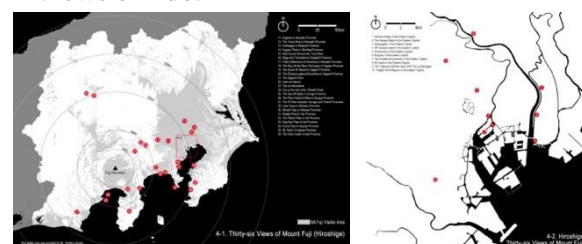


Fig.7 Analysis of Thirty-six Views of Mount Fuji (1859).

In the Thirty-six Views of Mount Fuji (1859), there are 35 ukiyo-e paintings in the area of research. Unlike the Thirty-six Views of Mount Fuji (1832), there are no Ukiyo-e depicted in the Mount Fuji area. (Fig. 7)

In Fujimi 100 of Kanto (2005), we selected 26 locations that have historical connections with Mount Fuji, and the distribution of the the locations was tttscattered, except for the northern of Mount

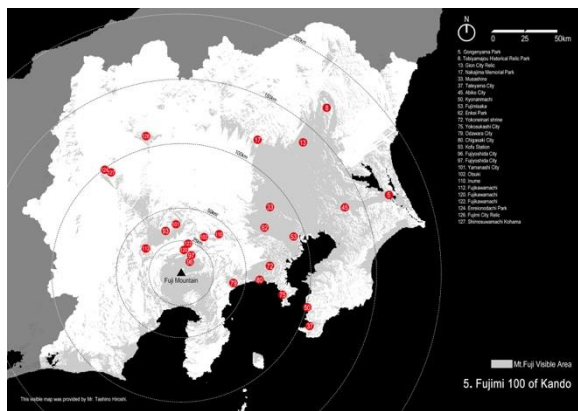


Fig.8 Analysis of Fujimi 100 of Kanto.

Fuji. (Fig. 8)

4.2. Spatial distribution of cities with Fujimi culture

According to Japan's administrative divisions and the spatial distribution of Fujimi culture, each district municipality with Fujimi culture is used as the basic unit to sum up the Fujimi culture within the area of research.

As shown in Table 1, the number of Fujimi culture is 52 in Tokyo. The number of Fujimi cultures in Yamanashi Prefecture, Shizuoka Prefecture, and Kanagawa Prefecture which around Mount Fuji is 18, 14, and 21. There are relatively few Fujimi culture in Tochigi Prefecture, Ibaraki Prefecture, and Gunma Prefecture, because they are far from Mount Fuji. As shown in

Table 2, the number of Fujimi district municipality in each prefecture is also different. There are a total of 17 Fujimi district municipalities in Tokyo, of which 13 are located in special wards of Tokyo, and the other four are concentrated in the west of Tokyo. 39.39% of district municipalities in

Tokyo		Chiba		Kanagawa		Shizuoka	
District Municipality	Fujimi Culture	District Municipality	Fujimi Culture	District Municipality	Fujimi Culture	District Municipality	Fujimi Culture
Chuo	12	Chiba	1	Yokohama	4	Oyamashiro	1
Bunkyo	4	Kisarazu	2	Kamakura	3	Fuji	4
Taito	3	Kimitsu	1	Fujisawa	2	Fujinomiya	1
Sumida	6	Maieru	3	Hiratsuka	2	Shizuoka	5
Koto	4	Ichikawa	2	Niinomiya	1	Haramatsu	1
Shibuya	5	Urayasu	1	Ashgarashimo	1	Izu	1
Meyuro	3	Tateyama	1	Kawasaki	1	Shimada	1
Adachi	3	Abiko	1	Hakone	2	Total Amount	14
Shinagawa	1	Matsumoto	1	Yokosuka	1		
Fuchu	1	Total Amount	13	Odesawa	1	Yamanashi	
Chiyoda	4			Chigasaki	1	District Municipality	Fujimi Culture
Shinjuku	1			Mura	1	Fujiyoshida	3
Kunitachi	1	Total Amount	2	Ema	1	Utsunohara	3
Kofu	1			Total Amount	21	Fujikawaguchikoma	3
Tohima	1					Fuefuki	2
Koganei	1	Total Amount	2			Fujikasa	3
Hino	1			Ibaraki		Kofu	1
Total Amount	52			District Municipality	Fujimi Culture	Yamanashi	1
				Itako	2	Yamanashi	1
				Total Amount	2	Onsaki	2
						Total Amount	18
				Gunma			
				District Municipality	Fujimi Culture		
				Chb	1		
				Total Amount	1		
				The Results of Fujimi Culture in District Municipality			
				The Results of Fujimi Culture in the Research Area			
Prefecture	Area/km2	Population	District Municipality	Fujimi District Municipality	Proportion/%	Total Amount	
Tokyo	2193.96	13,742,906	62	17	27.42%	52	
Chiba	5157.61	6,255,876	54	9	16.67%	13	
Kanagawa	2418.17	9,181,139	33	13	39.39%	21	
Shizuoka	7777.42	3,666,457	35	7	20.00%	14	
Yamanashi	4465.27	823,580	27	8	29.63%	18	
Ibaraki	6097.19	2,896,675	44	1	2.27%	2	
Naagano	13561.56	2,076,777	77	4	5.19%	6	
Tochigi	6408.09	1,961,963	25	2	8.00%	2	
Gunma	6362.28	1,958,409	35	1	2.86%	1	
Saitama	3797.75	7,307,579	63	2	3.17%	2	

Table 2.

Kanagawa Prefecture have Fujimi culture.

Utilizing spatial humanistic methods and GIS to imported the geographical coordinates of Fujimi district municipality into the map software for spatial visualization. From the amount of Fujimi and the importance of the district municipality, we got a map for spatial distribution of cities with Fujimi culture.



Fig.9 Spatial distribution of cities with Fujimi culture.

(Fig. 9)

5. The Landscape Feature of Fujimi Historical Town

In the spatial distribution of cities with Fujimi Culture, although these cities are known as cities with Fujimi culture, most cities do not have a strong connection with Mount Fuji in terms of urban construction. Therefore, we define Fujimi Historical Town as a city that is closely connected with Mount Fuji in urban construction and analyze the landscape feature of Fujimi historical town in landscape scale, urban design and cultural landscape.^[5]

5.1. Landscape scale

Combining ancient literature, historical maps, historical images, and practical research, it has been found that the landscape scale of ancient Japanese cities has the spatial characteristics of a city as the core and circular distribution. It can be summarized as three scales: castle scale, urban scale and regional scale. In the castle scale, castle as the core of the city, it is one of the forms of cities in Japan. It is a city established around the lord's castle. In the urban scale, it is the main body of the city where people live. The natural environment and landscape around the city constitutes the regional scale.

The Fujimi Historical Town has different spatial characteristics from the ancient Japanese cities in terms of landscape scales. The Fujimi Historical Town's observations of landscape are not limited to the areas surrounding the city's landscape, but they will cross the regional scale to find the connection between the city and Mount Fuji. As a result, the unique landscape scale of Fujimi Historical Town is formed. That is the territorial scale which is the territory of the Fuji belief and looking Mount Fuji. (Fig. 10) (Fig. 11)

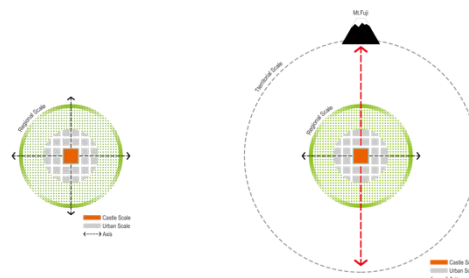


Fig.10 The difference between the city and Fujimi historical town.

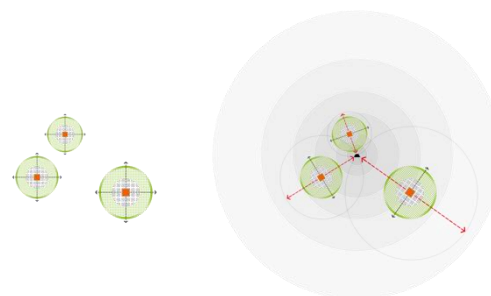


Fig.11 The differences in spatial distribution.

5.2. Urban design

Urban design has its own unique understanding of landscape since the early modern period in Japan. Not all Japanese cities use unaltered urban design techniques. Instead, they adapt to the natural environment while also incorporating the surrounding landscape into the city to create landscape. Fujimi historical town used “Yama-Ate” design method to use Fuji Mountain as a reference axis or borrowing axis to complete urban road planning and water network planning, and completed the overall urban design that integrated the natural environment with local culture.

5.3. Cultural landscape

When Fujimi historical town was consciously planning and building Fujiyama,

it was not only the use of Mount Fuji as a visual target for urban road planning, but also more closely connected Mount Fuji with the cultural landscape of the city. The cultural landscape in Fujimi historical town is not isolated, but is integrated with the city and Mount Fuji in accordance with certain organizational principles. It integrated urban functions, culture, landscape, and Mount Fuji into an overall landscape network.

6. Three Typical Fujimi Historical Towns

Based on the distance from Mount Fuji, landscape feature and the map for spatial distribution of cities with Fujimi Culture, we select 3 typical cities within the three ranges of 25km, 50km, and 100km, and study their respective characteristics of evolution. The three typical cities are Fujiyoshida (0-25km), Shizuoka (25-50km) and Tokyo (50-100km). (Fig. 12)

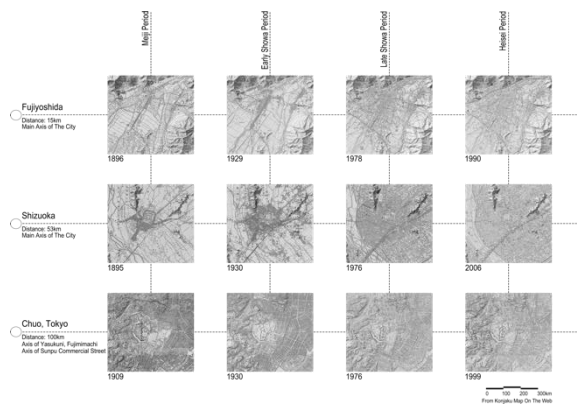


Fig.12 Three typical Fujimi historical towns in different period.

In terms of landscape scale, all three cities have the territorial scale which is the territory of the Fuji belief and looking Mount Fuji. However, the three cities are different in urban design. Fujiyoshida is a city formed on the basis of Oshi town on both sides of the approach of Kitaguchi Motomiya Fuji Asama Shrine. The approach uses Mt. Fuji

as the reference axis and is the main axis of the city. Unlike the Fujiyoshida, Shizuoka City is a grid-shaped city when it takes Mount Fuji as the main axis of city. Urban design in Tokyo did not form a clear urban main axis. However, in the area around the Imperial Palace, the area axis of the area is formed with the Mount Fuji as its axis. (Fig. 13)

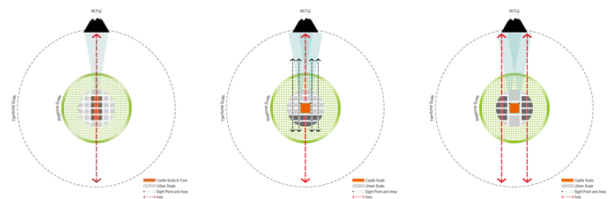


Fig.13 Urban design pattern of Fujiyoshida, Shizuoka and Tokyo.

In terms of cultural landscapes, the approach of shrine and Oshi town in Fujiyoshida City, the reconstruction of the Suruga Castle and the Aoba Avenue in Shizuoka City and the axis of Yasukuni Shrine and the Surugamachi Commercial Street have integrated the urban cultural landscape and Mount Fuji scenery. The Japanese Imperial Palace was established on the basis of Edo Castle. In Japanese, Fujimi has the same pronunciation as invulnerability. At present, there are still buildings named after Fujimi in the Imperial Palace, such as Fujimi Yagura and Fujimi Tamon. These Fujimi buildings express the Tokugawa Ieyasu's longing for rule. (Table.

Landscape Feature of The City at Different Distances From Mt. Fuji				
City	Distance From Mt. Fuji	Shizuoka	Shizuoka	Tokyo
	0-25km	25-50km	50-100km	
	Castle Scale	Approach	Suruga Castle	The Imperial Palace
	Urban Scale	Castle Town	Castle Town	Castle Town
	Regional Scale	Northern of Mt. Fuji	Southern of Mountain Alps	Kanto Plain
	Territorial Scale	Mount Fuji	Mount Fuji	Mount Fuji
	Main Axis	●	●	●
	Others Axis	●	●	●
	River Approach	●	●	●
	Kitaguchi Motomiya Fuji Asama Shrine	Fujimi Castle Tower	Fujimi Castle Tower & Building	
	Suruga Castle	Yasukuni Shrine	Yasukuni Shrine	Nihonbashi Bridge
	Oba Town	City Road	Approach	Suruga Commercial Street
	Yasukuni Shrine			

Table 3.

3)

7. Discussion and Conclusions

Through the analysis of the landscape features of Fujimi historical town and the analysis of three typical cities, we can conclude the following three urban regenerative strategies applicable to Fujimi historical town. (Fig. 14)

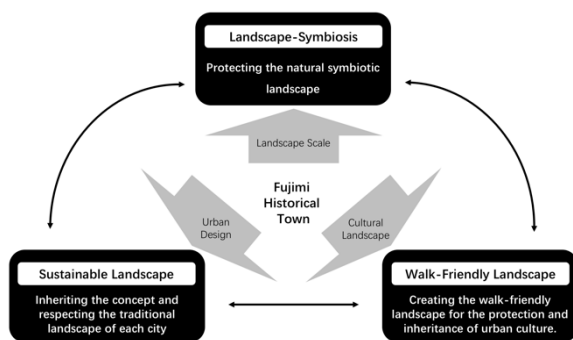


Fig.14 The regenerative strategy of Fujimi historical town.

7.1. Protecting the natural symbiotic landscape

The natural symbiotic landscape is a feature of the urban planning that has evolved through the practice of thousands of years in Japan. We should fully understand the inseparable relationship between the city and the surrounding natural environment and promote the harmonious development of the city and the surrounding natural environment.

7.2. Inheriting the concept of sustainable landscape

In the urban construction practice of Fujimi historical town, a unique landscape recognition was formed. Bringing the concept of sustainable landscape into modern urban planning and construction,

respecting the traditional landscape of each city.

7.3. Creating the walk-friendly landscape

The walk-friendly landscape creates a high-quality outdoor public space by building a linear space environment, bringing new functions and vitality to the old city. The historical landscape and humanistic space in the process of urbanization can all be organically linked with walk-friendly landscape. In the renewal plan of the old city, the use of walk-friendly landscape instead of a motor-driven urban space has important practical significance for the protection and inheritance of urban culture.

Acknowledgments

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Coexisting with nature: traditional knowledge and modern practice of the urban natural landscape system – in case of Kyoto, Japan

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Abstract

The relationship between human and nature should not be conflicts or conquests, but a harmonious coexistence. The purpose of this study is to seek out experience from traditional cities in Japan, like Kyoto, to find ways for the construction of a biophilic city. This article firstly compares the natural environment changes of Kyoto Basin into the process of urban development to seek for the inside dynamic balance. Then, the study subdivides the natural landscape system into five elements, which are closely related to the traditional cities: mountain, water, forest, farmland and green space, to analyze their relationship with the urban structure respectively and summarize the traditional knowledge of the urban natural landscape system in Japan. Finally, the article analyzes the planning and management system of urban natural landscape by Japanese government in recent years, to explore what role landscape architecture is playing in Japan in order to coexist with nature.

Keywords: Kyoto, natural landscape system, coexisting with nature, landscape architecture, ecosystem services

Nowadays, rapid growing cities has brought many problems, such as urban waterlogging disasters, massive devastation after earthquake, biodiversity decrease, haze, lacking of places for citizens to relax in leisure time..... The relationship between human and nature is getting worse day after day, while we gradually recognize that the relationship should not be conflicts or conquests, but a harmonious coexistence. The purpose of this study is to seek out

experience from traditional cities in Japan, like Kyoto, an ancient capital has a 1200-year long history and now is one of the most famous historical and cultural cities in the world which appealing to more than 50 million visitors each year, to analyze the Japanese concept of ‘coexisting with nature’ and methods in urban construction and management, which can be expressed in the dynamic balance between human and nature systems.

Yuxin Ti, Beijing Forestry University, Master of Landscape Architecture

1. Kyoto Basin

The Kyoto Basin is about 300 km² and located in Kyoto Prefecture. The topography is high in the north and low in the south, like an inland basin surrounded by mountains on three sides, the east, north and west. In the ancient ages, it was once a lake, and gradually formed the land. To give birth to hot summers and cold winters, at the same time, it brought high groundwater level and fertile soil. The formation of rivers and deltas made an increasing numbers of migrants after the 5th century. People lived along the river and developed agriculture through the fertile soil of alluvial plain, and the remarkable development of farming techniques also changed the landscape pattern of the basin (Fig. 1).

In October 794 AD, Emperor Kanmu moved from Nagaoka-kyo to Heian-kyo, from then the city had been the capital of Japan until Tokyo finally became the capital in 1868. Prior to this, Japan had relocated capitals several times, such as Naniwa-kyo, Fujiwara-kyo and Heijo-kyo. Nagaoka-kyo, a city located in Kyoto Basin as well, became the capital in 784 and had only existed for 10 years. In case of the inconvenient land transportation in the ancient ages, water transport was significantly important. Closing to the junction of Yodo River, Katsura River, Kizu River and Uji River and Ogura Lake, Nagaoka had a more convenient waterway than Heian-kyo, however, once it rained heavily, the entire city would submerge in the flood. Eventually Emperor Kanmu moved the capital to Heian-kyo, which was in the highest point of the northern basin ^[1].

In addition to the height advantage, there were no natural rivers inside Heian-kyo, which suffered lower flooding risks. The city was modelled after the Tang dynasty Chinese capital of Chang'an in block planning and the planning area was one-fifth of Chang'an. The internal drainage of the city is based on digging trenches on both sides of the road, although not fully along with the terrain, a conscious improvement has been put forward by making the width of the ditch proportional to the road ^[2]. Two artificial canals were dug on both sides of the city, called Hori River and Nishihori River, simultaneously guarding against the flood and becoming the water traffic ways. The palace was built in far north of the city and surrounding by office area. The commercial area was in the south and residential area mainly in the east, the cultivated land was scattered in the west (Fig. 2).

At the end of the 10th century, Yoshishige no Yasutane wrote in Chiteiki: "Population in the west zone (Ukyo) was decreasing and going to ruin. Only those who have moved out but no moved in and houses collapsed." People lived crowded in east zone (Sakyo), especially in the north. The functional distribution has changed: the city was spanning across the Kamo River and developing eastwards. There were new urban centers such as the Shira River area, Toba and Rokuhara (Fig. 3). The weakness of the legal system and aristocracy led to citizens' self-organization and then separated the city into upper and lower parts. The commercial centers and streets have developed.

The chaos Onin War lasted from 1467 to 1477 made one-third of Kyoto burned in the flames of war, especially the upper area¹³⁾. Then starting with Toyotomi Hideyoshi, a series of urbanization campaigns were planned to restore and redevelop the city, such as the construction of odoi, the new city of Fushimi and the dig of Hozu River and Takase River (Fig. 4). The pattern of urban space has been further changed as the gravity of center was developing along the Kamo River, laying the prototype of modern city.

2. Natural landscape elements

The pattern of urban space is closely related to the surrounding natural landscape and is the result of both human and natural conditions. Natural landscape system which is composed of mountains, water, forests, farmlands, and green spaces, continues to interact and infiltrate with urban system in the process of human construction and eventually forms a landscape complex that integrates natural and human environments.

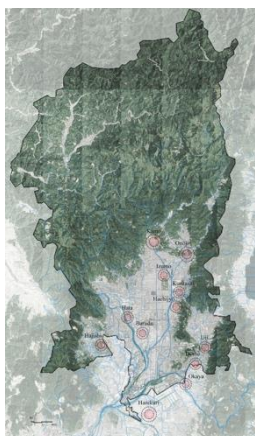


Fig. 1. Ancient Kyoto.

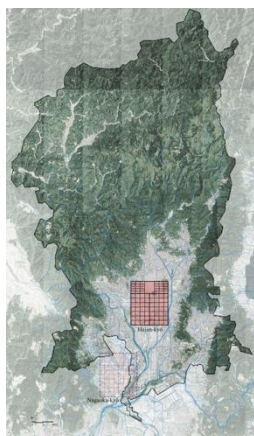


Fig. 2. Original Heian-kyo planning.

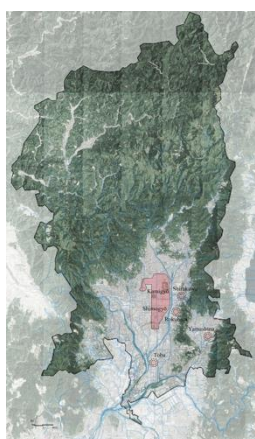


Fig. 3. Multi centers.

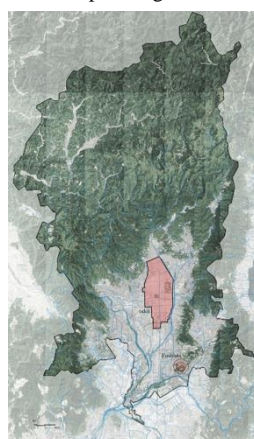


Fig. 4. Odoi and Fushimi area.

2.1. Mountain system

2.1.1. Site selection

According to Nihon Shoki, Japan's first capital was "surrounded by beautiful green hills, though small, the enclosed space makes people feel peace and leisure." This site selection concept was derived from Chinese Feng shui. "Feng shui" first appeared in the Book of Burial by Guo Pu in 4th or 5th century, which means places where could gather "Qi" (energy). Kyoto is a natural city with mountains in the north and rivers in the south, which is definitely a perfect spot with good qi.

In addition to Feng shui, there was also "Four Gods Suitability" widely spreading, which originated from the concretization of ancient Chinese astronomical concepts, and corresponded the site conditions to nature landscape in four symbols - Azure Dragon of the East, White Tiger of the West, Vermilion bird of the South and Black Tortoise of the North, which represents natural mountains and rivers to form a symmetrical place. There is still no conclusion of what four symbols

precisely represent ^[4], but the corresponding relationship between the city and the surrounding mountains is meaningful.

Mount Mandala, Hidaridaimonji, Funa, Nishi, Higashi and Daimonji form the first layer of the city from west to east in the north, where are also places of “Gozan no Okuribi” - a traditional festival to "send-off fire". The combination of natural mountains with religion and history carries spiritual desires and develops together with the city.

Outwards, Mount Ponpon, Arashi, Sajikigadake, Kurama, Hiei and Daigo continue to form the “Three Mountains” of Kyoto. The Western Mountain is from Mount Ponpon to Atago with the altitude from 400m to 600m; The Eastern Mountain is from Mount Hiei to Inari, includes areas from Mount Daimonji to Mount Otowa and Daigo; Connecting the two, The North Mountain is mainly from 400 to 600m with some mounts over 900m, such as Mount Minago, Minetoko and Mikunidake. Mountainous areas account for approximately half of the city area and the vast northern regions are filling with mountains (Fig. 5).

2.1.2. Axis and boundary

The axis and boundaries are constantly changing during the developing of the urban pattern. Mount Funaoka - Suzaku Avenue – Rajomon – Mount Kannabi formed the original north-south central axis. Unlike China, Japanese cities do not have defensive walls and are directly connected to others through streets with a name of "Kyoto's seven entrances". Streets passed

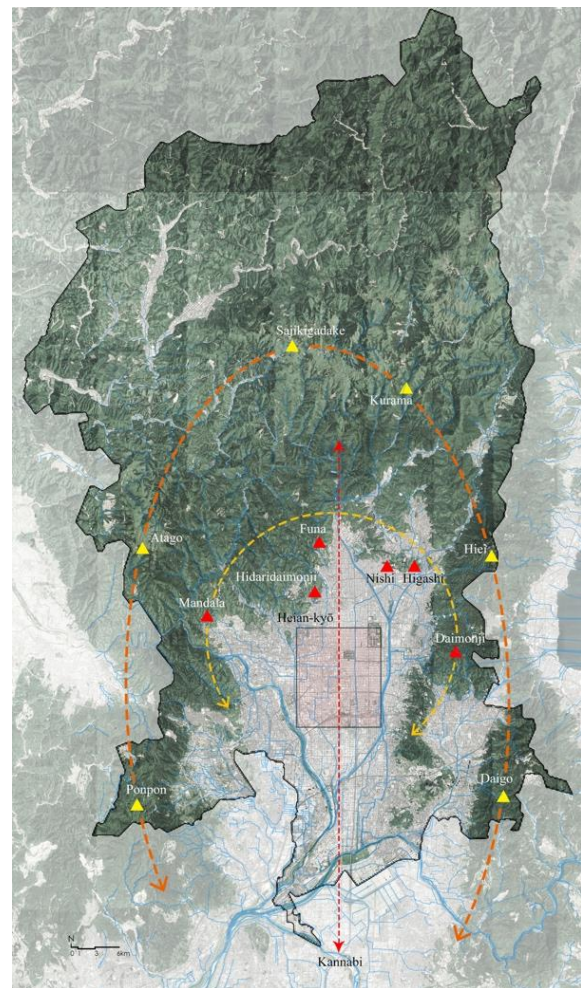


Fig. 5. Mountain system and Heian-kyo.

through mountains and rivers, and some formed villages at the nodes. For instance, Street Kurama is the vital road connecting Kyoto with Tamba. Villages and streets developed rapidly after the construction of Kurama Temple. The valley terrain and the wild arable farmland formed by the scouring of the Kurama River created a characterized village environment.

After the eastward movement of the city, the Suzaku Avenue was gradually abandoned and some residents turned it into farmland.

The new axis was located between Nijojo and Kyoto Imperial Palace. The establishment of odoi enabled the city to have a three-meter-high city wall and formed a new distinction between the city and suburbs. The current urbanization continues to erode towards the mountains and the relationship between the city and mountains is becoming more and more intimate.

2.1.3. Villas and overlook viewpoints

The diversity of landforms in mountainous area makes it a perfect site for gardens, temples and villas down the ages. Since Heian Period, there have been countless villas in the rolling foothill area, like Saga Villa, Shirakawa Villa and so on. Buildings and gardens are distinctive thanks to a variety of terrains and become precious cultural heritage (Fig. 6).



Fig. 6. Overlook from Mount Daimonji to urban area

Overlook from Kamo River's right bank to Mount Daimonji

Overlook from Funaoka Park to Mount Daimonji

2.2. Water

2.2.1. Water system

The alluvial plain creates a large number of rivers, lakes and swamps, and the historical urban construction has also brought countless artificial water canals. The main natural water system consists of Katsura River and Kamo River, which flow from

north to south and meet Uji River in the south. The artificial water system has 12 artificial canals built during early Heian period: Hori River (12m wide) and Nishihori River were mainly used as water transport and drainage channels, other drainage channels included Tenjin River, Sahi River, Nishiomiya River, omiya River, Nishinotoin River, Machi River, Muromachi River, Torimaru River, Higashinotoin River and Tomikoji River, arranged from west to east and were based on the planning and topography to dig from north to south with most only existing in street names. In modern times, Hozu River, Takase River and Lake Biwa Canal were excavated for water transport. There are also Lake Biwa in the east, Ogura Lake in the south and Midoro Pool in the north, but Ogura Lake has already vanished due to urbanization.

2.2.2. Water Transport

Rivers used for water transport in Kyoto include Katsura River, Uji River, Kamo River and artificial rivers such as Takase River and Lake Biwa Canal. The Katsura River, which originates from the northern mountain, is the primary channel because of its deep depth, flow rate and quite a few tributaries. It was this river to be used to transport timber from Yamakuni, Tamba, Yamashiro and Settsu in the north to build the city of Heian-kyo through an approach called "raft flow". In the 17th century, Suminokura Ryoi, a wealthy businessman, excavated the Hozu River under the permission of the shogunate, making it possible to use a wooden boat called "Takase Boat" to transport timber more conveniently and efficiently, creating an important traffic route

connecting Kyoto to Tamba and San-in, which prospered the villages alongside – like Sonobe, Hozu, Yamamoto, Umezu and so on, and turned Mount Arashi into a tourist resort.

Uji River and Takase River are also important waterways. Uji River is located in the south of the city, flows from east to west and eventually merges into Yodo River. The river was turbulent with a shallow depth and only put into use after several modification works for a long time. Takase River is a canal belonging to Kamo River. Due to the unstable flow rate and frequent flooding of Kamo River, in 1611, Suminokura Ryoï decided to open up a new water traffic artery to replace it for better transport. It began in Nijokiya Street and flowed southward to Fushimi Port with 7 meters in width and 10 kilometers in length. In this way, through the connection to Fushimi Port and Osaka, the economic circle of Kansai has formed. The economy of Kyoto was developing rapidly and streets, ports and villages along the rivers were prosperous, too.

2.2.3. *Kamo River*

Every well-known city around the world is associated with an equivalent famous river, such as Paris and the Seine, London and the Thames. When it comes to Kyoto, it must be the Kamo River. Due to the early decline of Ukyo and the shift of the city center to the east, Kamo River has become the primary river which profoundly influences the development of the city and the daily life of citizens. The history of Kamo River and the city is not only the history of flood control and disaster prevention, but also culture and recreation.

Kamo River flows from the highest peak Sajikigadake in the north to Katsura River in the south with about 100m changing in elevation. The water flow is rapid and unstable, which causes frequently floods. In the Heian Period, there has been a specialized position for flood prevention and levee construction, called Bokashi. Because of the floods, Emperor Shirakawa described it as "one of the three most unmanageable things in the world." In the Azuchi-Momoyama period, the war continued. In 1591, Toyotomi Hideyoshi built the odoi surrounded by moats to defend the city and prevent the flood. The construction of Takase River and the renovation of Kamo River itself also improved the preventing level to a certain extent. In the process of continuous floods and transformation works, Kamo River gets its current embankments and waterfront parks.

Frequent flooding and flow changes brought Kamo River a broad river plain, making it a habitat for homeless people. As time passes, the plain had gradually become a public space which allows residents to gather around to talk, taste tea or watch art performances freely, and develops feature landscape like Noryo-Yuka (platforms above waterfront). Public spaces led to commercial prosperity on both sides of the river, light industry such as textile and wine developed, population grew. Shijo Kawara for instance, is still a vital cultural and commercial area in the city. Nowadays, Kamo River has become a landmark with its picturesque scenery and various views at all seasons.

2.3. Forests

Forests are not only the treasure house of genetic resources and urban green lung, but also significant cultural resources. Since ancient times they were sites for temples and shrines, backdrops for gardens and overlook views of the city. There're immense biodiversity with 55% of endangered plant species and 50%-60% of familiar species' habitats in Kyoto ^[5] .

Forests account for 74% of the city area, with broad-leaved most and mixed ones also a lot due to long-term artificial logging and ecological succession. The Tadasu no Mori, located in Shimogamo Shrine, preserves the ecological condition of primeval forests in the northern mountain. It is both a sacred grove for nature worship and a place for people to hang around, talk, rest in shade, taste tea and get close to nature.

Planted forests are parts of the forest landscape. For example, in the Northern Mountain area, relatively steep and narrow terrain and low-humidity air are suitable for the growth of fir trees, making it a well-known forestry production area. Production and operation activities prompted the formation of villages, and the terrain and wood production modes also led to a unique village distribution architectural structure, created characteristic wood culture for Kyoto.

2.4. Farmland

In addition to supplying food, farmland plays a significant role in the transition between nature and the city - buffering

rainstorms and floods in the mountains and preventing over-expansion of the city. Together with the surrounding mountains, it forms a green belt to protect the city.

Since the Edo period, residents' excrement was shipped to farmland in the suburbs, Settsu and Kawachi on the banks of Yodo River to be valuable agricultural fertilizers through the canals. This self-sufficient circulation system laid a firm foundation for the development of agriculture and also improved the public sanitary environment. As the city expanded outwards, there were mixed modes of residences and farmyards, such as the Kamigamo Shrine area, where still remains such historical buildings.

2.5. Green space

As a part of urban planning, the green space planning is closely related to the social background and the trend of the times ^[6] . Urban green space in Japan can be divided into parks, cemeteries, traffic spaces and others. In the 1200-year long history of Kyoto, there were numerous classical gardens, shrines, temples, villas and Machiya courtyards to form the biophilic city.

Kyoto is the epitome of Japanese classical gardens. Karesansui gardens like Rosan-ji garden and Zuiho-in garden, promenade gardens like Katsura Imperial Villa, the Paradise Gardens like Byodo-in Temple and others like tea gardens, pond gardens and so on. Shinsen-en, founded in 824, had abundant water sources with springs gushing and was a sacred place to pray for rain and ward off evil.

There are nearly 700 parks in Kyoto including the Umekoji Park, Kyoto Gyoen, Okayama Park and so on, which are both places for sightseeing and refuges against disasters. The acres of parks per capita is 4.68m².

Machiya is a historical component of Kyoto. Its courtyard is used to entertain guests and provides ecological regulation services in the narrow and crowded neighborhood, which is honored as the forest of the city.

3. Modern natural landscape system

The planning and management of the natural landscape system needs constantly revising, adding and integrating. It was firstly accepted into the Japanese landscape system as chapters of the National Park Law, Urban Planning Act and Conservation of Natural Historic Monuments Law. After the 1960s, people gradually realized that it would only bring about more and more problems due to increased economic-oriented urbanization. In 1966, The Old Capital Preservation Law was established to regulate the development of the city from a historical perspective. Afterwards, the Basic Environmental Law (1993) and Landscape Law (2004) were successively issued.

Kyoto has experienced the conversion from policies focusing only on economy to taking nature as priority. Because the government moved to Tokyo in the Meiji period, there was Kyoto Development Policy to be formulated in case of a decline. The policy was divided into three phases aimed at modernizing and rejuvenating the economy

and then transformed Kyoto into an industrial city. With the rethinking of national policies, people recognized that the natural landscape system played an important role in the old capital's tradition - rich resources of material and tourism, however, would be harmful if not taken seriously. In 1995, the Natural Landscape Preservation Regulation was promulgated.

In the urban planning, began with the Kyoto's Basic Concept in 1999, the Kyoto's Basic Planning and several classification plans were successively formulated, including Urban Master Planning, Landscape Planning, Green Space Planning, Comprehensive Transportation Strategy with a goal of walking, Tourism Promotion Planning and Historical Landscape Improvement Planning and so on.

The Landscape Planning, formulated in 2005, aims to protect and renew the ancient landscape of more than 1,200 years and preserve regional features. The first measure is the conservation of characteristic basin landscapes and coexistence with nature. Others include the adjustment of urban streets, regulations of overlook landscape and urban building construction^[7]. The Kyoto's Overlook Landscape Regulation, published in 2007, selects 38 locations and makes it possible to borrow distant natural scenery without being obstructed by modern buildings^[8].

The green Space system is also an indispensable part of modern cities, which integrates the natural landscape into the urban planning system to plan as a whole. The Green Space Planning, established in

1999, aims to defend against climate change, improve the environment and protect the beautiful scenery. The objects are all of the plants, surrounding lands and spaces, divided into five areas to form an ecological resilient network of water and green ^[9].

4. Conclusion

The natural landscape system is an important part of the urban system. With the development of technology, environmental and humanistic consciousness and the increasing demand for the quality of human living environment, the natural landscape will take an ever-increasing significant place. What role is a landscape architect playing to help get a harmonious coexistence between cities and nature? Japan's experience provides us a good model. Kyoto is a calamitous city, but every disaster has led to a more perfect rebirth, where the urban construction intelligence lies. Seeking out experience from traditional cities in Japan, combining traditional knowledge with modern theories and practice - coexisting with nature and making a city biophilic, is the direction for future urban development.

Acknowledgments

This study is inspired by my professor's studies in human living environment, based on various books, government documents and materials from the internet and libraries.

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Preliminary Analysis on the Vertical Farming Landscape

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Abstract

The concept of vertical farming put forward due to food shortage and other urbanization issues has received more and more attention in landscape, ecology and social fields over the past 20 years. This paper reviews the development and extension of vertical farming theory and practice, and discusses three vertical farming landscape strategies from the perspective of landscape architecture through a wide-range literature and case studies: building a biophilic city with massive green facade, innovating high-density community communication space model and making landscape grow inward by leading vertical farming techniques into the interior of building. Subsequently, the Vertical Farming Indicator System Framework was formulated based on the objectives and potential of sustainable development of vertical farming.

Keywords: vertical farming; vertical landscape; strategy; biophilic; indicator system framework

1. Introduction

1.1. Background

As urban population continues to grow and as arable land is diminishing rapidly across the globe, food shortage issues has become a huge hidden danger. Some of the worlds' leading agronomists concede that an additional 109 hectares of land (roughly the size of Brazil) will meet human needs for food by conventional methods. [1] A fundamental change in food production is needed, [2-3] thus led to the proposal of the concept of vertical farming in 1999. The concept of vertical farming has been in progress. The original proponents were more

concerned about the field of agriculture to solve the actual food supply problem. With the intervention of other fields such as landscape architecture and ecology, vertical farming applications gradually focus on people's work and life, and it spreads to facades and interior space of city building, also appears in community gardens under the strain of the urban land resources. Vertical farming makes green and brings nature back to city, creates a biophilic city to promote human health and living environment.

1.2. Methods

This paper assesses existing and future vertical farming practices: relevant websites, media and literature studies from 1999 to 2018. It examines a wide-range of literature related to agronomy, urban agriculture, vertical farming, landscape architecture, ecology and sociology, and tries to understand the theory and practice of vertical farming from the perspective of landscape field. It also reviews involved technologies, principles and evaluation models for qualitative research.

The research includes an extensive literature review of over 65 references, 18 case studies from 16 cities, expert consultation and peer review in salons. It evolves systematic examination of generic and specialized literatures on vertical farming by using various online search engines and databases including Scopus, ProQuest, and Google Scholar. These sources comprise 42% peer-reviewed academic journal articles, 20% books and book chapters, 6% theses, 9% conference papers, and 23% websites. Most of the reviewed literature is relatively recent, dating 2010–2018. The reviewed projects come mainly from North America, Europe, and Asia.

1.3. Vertical farming development and extension

The idea of "vertical farming" was attributed to the discussion in classroom taught by Dickson Despommier, a professor of public health and ecology at Columbia University in 1999. He came up with the idea of taking urban rooftop gardens a step further, creating vertical farming "towers" in buildings, that would allow all of a building's floors, not just the rooftop, to be used for

producing crops. He described vertical farming as "the mass cultivation of plant and animal life for commercial purposes in skyscrapers". [4]

In 2001, the Dutch architects of MVRDV designed a "Pig City" high tower network and waste collection system merely dedicated to pork production, indicating that buildings could use waste to power. [5] The idea of La Tour Vivante- The Living Tower was conceptualized in 2005, for first time designer proposed a self-contained multi-functional vertical farming building combining agricultural production, housing and activities in a single system. [6] In 2007 Graff Gordon pointed out the necessity of sustainable energy for vertical farming based on economic and ecological benefits, and designed The Sky Farm theoretically prove the feasibility of its economic fundamentals. [7] In 2009, Vancouver, Romses architects pointed out the ecological benefits of a multifunctional vertical farm in support of the City's 2030 Challenge of reducing carbon emissions and addressing climate change. [8]

The exploration of Sky farming is limited to design drawings due to economic factors, but the middle and low-rise vertical farms have been put into commercial operation. Sky Greens is the innovator and builder of the world's first low carbon hydraulic water-driven vertical farming system in 2012 achieving objective of significantly increasing output per unit area with a minimum amount of land use, water and energy, and carrying out educational projects in surrounding communities. [9] In 2016, Pasona in Kyoto realized the idea that indoor vertical farms not only provide food, but also create a landscape into a healthy working environment for employees by blending work space with farm space. [10]

Thus vertical farming has solved urban diseases within landscape method.

2. Vertical Farming Landscape Strategy

In 2014 Professor Dickson Despommier mentioned the role of landscape in vertical farming: create an environment that encourages sustainable urban life, promoting a state of good health for all those who choose to live in cities. [4] From landscape perspective, vertical farming actually excavates unexploited three-dimensional spaces for over-exploited cities, adds massive green space for city façade and creates a biophilic city. The use of vertical farming to create landscape facilities also provides new opportunities for urban high-density development and provides technical support for the environmental renewal and transformation of land space such as financial streets, high-density residential areas, shanty towns, slums and hutongs. In addition, vertical farming is beyond aesthetic and visual improvement. It creates a unique workplace environment that promotes worker's productivity, mental health, and social interaction and engages the wider community by showcasing the benefits and technology of urban agriculture.

2.1. Building a biophilic city with massive green facade

According to a theory of the biologist E.O. Wilson, biophilia means “an innate and

genetically determined affinity of human beings with the natural world” [11] Passion for life and closeness to nature are human nature. Skyscrapers will transform into sky farms, changing conventional buildings into late-model landscape buildings of sky farm and this new architectural system from vertical landscapes will seek to invite nature back into our city facade and return human to agricultural experience. They have magnificent appearance, impacting people's vision and mind, add a much needed touch of green, help clean the city air and possibly even produce small scale crops, thus make it a landmark of the city's iconic, productive, sustainable giant green landscape architecture. (Figure 1).

In addition, the conversion of middle and low-rise buildings with prototypes to vertical farms has been slowly changing our urban landscape. The invention of lightweight hydroponic farm systems makes vertical farming attach to any unused wall space along sidewalks or behind buildings. [12] Green wall of vegetables is changing landscape into a powerful thing not just for food production, but for people, because we weren't designed to live in the concrete jungle. (Figure 2). Study shows the green wall between buildings reduces the levels of nitrogen dioxide and suspended particulates by 40% and 60%. It acts as a huge steel tree: it provides oxygen, filters the air, relieves urban heat island effect and provides a home for nearly a dozen bird species. [13]

2.2. Innovating high-density community



Fig. 1. A proposed vertical farm by Plantagon.

communication space model

Vertical farming enters community gardens, providing a new model for community greening and activity space to meet people's demand for nature and biophilic communication space. Vertical farming technology actually compresses community gardens into three-dimensional dimension, saving land area and obtaining optimum crop yields. In addition to planting vegetables or flowers, this model provides community residents with a space for sharing labor and fruits, and has a positive effect on promoting social interaction, providing environmental education opportunities for all age groups, especially children, cultivating citizens' sustainable development and ecological awareness and increasing the type and number of pollinating insects, and maintaining the urban biodiversity. [14]

The vertical farming hybrid housing proposed by Singapore SPARK company can solve the problem of population aging. The project called "Family Farm" combines vertical farming and roof planting with high-density residential housing to provide affordable housing for retired people. Residents will be employed by caring for

green leafy vegetables growing on the external walls and roofs of buildings, in



Fig. 2. A nine-story vertical farm built in Tokyo.

return, the greenness provides residents with an ideal living environment. Once the project is realized, it will greatly improve the economic and living conditions of the old Singaporeans. (Figure 3).



Fig. 3. Retired seniors taking care of vertical farming combined with housing.

Under the promotion of international organizations, universities, and other civil institutions and technology companies, vertical farming has enabled low-income people to obtain fresh food and certain economic subsidies. For example, planting



Fig. 4. Lemon and passion fruit trees used as partitions for meeting spaces.

vegetables on the wall in a slum of Los Angeles, named "Vegetable Walls", shaped by rapid assembly of unit modules adds greenness to the crowded environment. [15] Vertical farming is also increasingly investing in high-density urban greening. At the 2016 International Vegetable Science and Technology Exposition, ornamental vegetables featured with strong aesthetics, high economic value, and profound educational significance were demonstrated for use in vertical landscape facilities, which promoted landscape development of vertical farming. [16]

2.3. Making landscape grow inward to the building inside

The biggest benefit of vertical farming entering buildings with each floor growing a different set of edible plants including fruits, vegetables and rice is to lead nature into human being daily life and work environment. Vertical farming facilities integrated within the building bring a world of indoor greenness, such as offices, an auditorium, corridors, reception area and cafeterias. Using both hydroponic and soil based farming, crops and office workers share a common space. For example, tomato vines are suspended above conference tables, lemon and passion fruit trees are used as partitions for meeting spaces (Figure 4). and salad leaves are grown inside seminar rooms. The main lobby features a rice paddy and a broccoli field. Vertical farming facilities help isolate noise, absorb carbon dioxide to improve indoor environment, and significantly alleviate modern sick building syndrome, etc. urban issues.

3. Vertical Farming Indicator System Framework

3.1. Confirm target

Cuello's Law has articulated this sustainability potential of the Vertical Farm industry. In support of the global vertical farming industry and as a way to inspire and incite the industry to proactively work toward achieving its sustainability goals and potential as embodied in Cuello's Law, the Vertical Farming Indicator System Framework is hereby launched. It is based on five strategic objectives for sustainable development of vertical farming and three strategies of vertical farming landscape field discussed in this paper. [17]

3.2. Build framework

Vertical farming planning and construction involves four key dimensions:

1. agricultural production, ensuring that high-tech production obtains optimal crops, including monitoring of quantity, scale, quality, and safety.
2. Eco-efficiency, ensuring vertical farming's assessment of water resources, energy and land sustainability, climate and ecological environment.
3. Social economy, the health benefits of urban residents' lives and work, and the economic benefits and costs of vertical farming.
4. Landscape performance, vertical farming assessment of urban greening, space use, and aesthetic experience.

3.3. Indicator classification

In order to achieve these four dimensions, each vertical farming project should strive to achieve 16 indicators in order to achieve sustainable development of vertical farming. The research shows that these indicators

have dual roles of supervision and assistance for each vertical farming company or institution. These indicators provide guidance and recommendations when they face the contradiction between environmental protection and economic benefits while furthering or fulfilling their corporate social responsibilities. We need to recognize the relative importance of each indicator within the framework and how to achieve the uniqueness of each vertical farming project. (Figure 5).

Agricultural production indicators: 1. High crop yields, optimized vertical farming production efficiency, and measurement of crop yields 2. Fresh food transport,

producing fresh crops that remain fresh when delivered to buyers 3. Sustainable production system, vertical farming system separated from natural functions enables sustainable food production in the face of environmental changes and resource shortages. 4. Quality and safety, nutrient content of crops, and food safety.

Eco-efficiency indicators: 5. Species diversity of animals and plants, species richness of inhabiting or passing animals and planted species 6. Recycled water sources, recycling water resources systems 7. Ecosystem restoration, allowing large areas of land to restore ecosystem functions and services, and build natural landscapes 8.

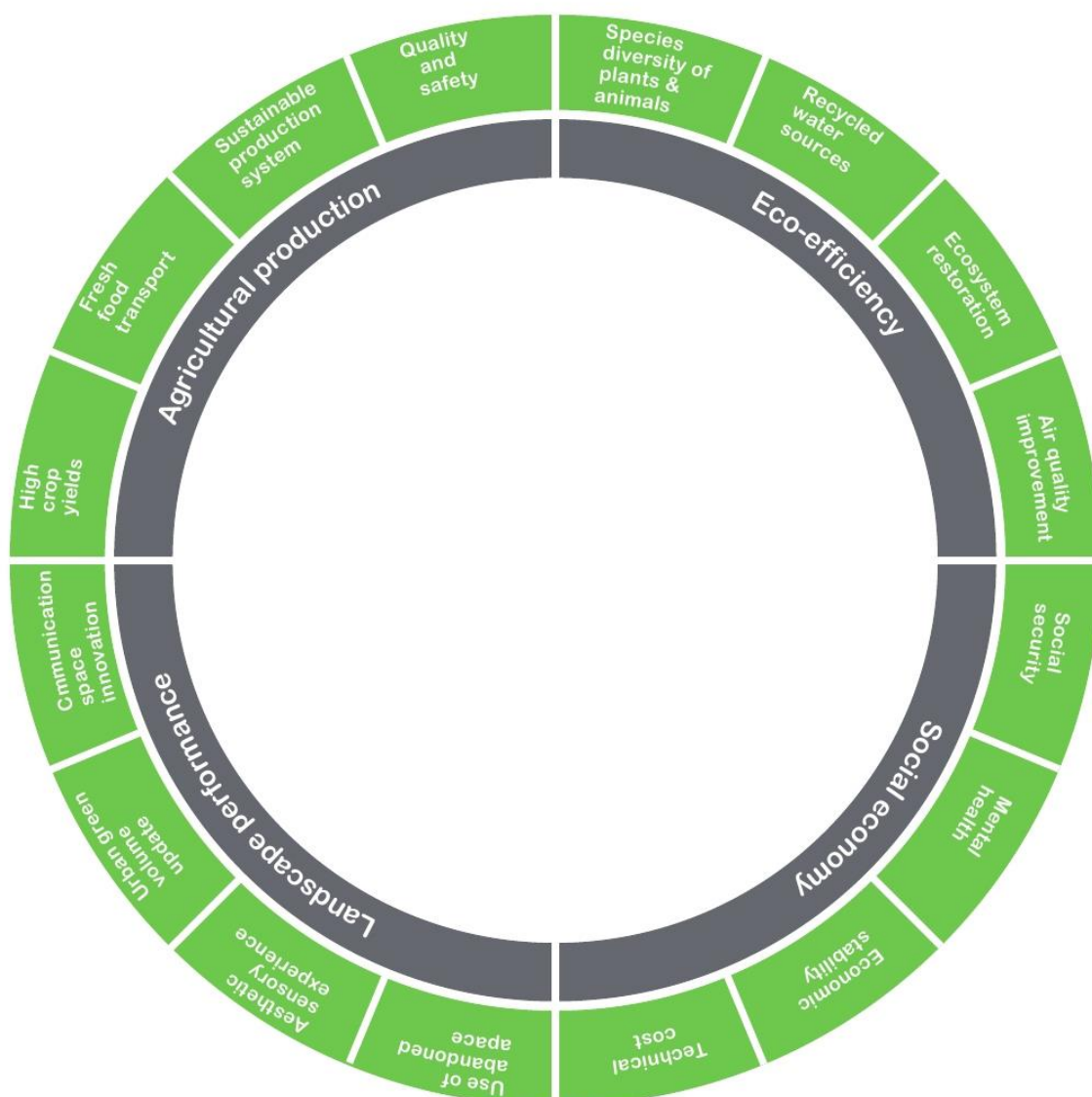


Fig. 5. Vertical Farming Indicator System Framework.

Air quality improvement, and the level of air purification and renewal of crops.

Social economy indicators: 9. Social security, ensuring people of different social classes benefit from vertical farming. 10. Mental health, creating a good living and working environment for people, promoting people's physical and mental health 11. Economic stability, a certain scale of sustainable agricultural production to bring stable income 12. Technical cost, balancing the contradiction between high-tech Input costs and sustainable production system benefits.

Landscape performance: 13. Aesthetic sensory experience, vertical farming building facade and indoor landscape on people's feelings of the visual and spiritual experience 14. Urban green volume update, vertical farming greening volume data 15. Communication space innovation, the transformation and update of vertical farming in city's communication space 16. Use of abandoned space, to make use of abandoned or unused space in a city for vertical farming production.

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A Study of Close-to-Nature Urban Forest Evaluation and Design -- Taking the Beijing Bai-wang Urban Forest Park as a case

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Abstract

In the context of greening strategies within rapidly growing cities, more and more city managers emphasize the conceptions of nature and ecology in urban landscape designs and planning, including the recent policy calls for Biophilic City construction which is also called the National Forest City in China. The National Forest City is aimed at rebuilding a natural circumstance which reduces the industrial pollution and urban heat island effect and provides a natural urban environment for all the living beings. However, there is lack of an evaluation to estimate if a specific urban forest is close-to-nature or how natural it is. It is the first study in China that attempts to build a close-to-nature evaluation system of urban forest and gives a case of how to design a close-to-nature urban forest based on this evaluation. This study is divided into two parts. The first part expounds the construction process of the close-to-nature evaluation system. In the first step, evaluating indicators from landscape architecture and other subject related to landscape architecture, such as bionomics, aesthetics and forestry, are comprehensively considered in the evaluation system. AHP (Analytic Hierarchy Process) analysis is used in this study to balance the influence of eighteen indicators in five criteria Layer that include species diversity, horizontal structure, vertical structure, stand state vitality and landscape aesthetics of the forest community. Then two typical urban forest parks around the site of Beijing Bai-wang Urban Forest Park are evaluated so that the practicability of preliminary evaluation system can be tested and proved. According to the result of final evaluation system, the grades of evaluation are divided from 0 to 1.0 which are regard as from fully artificial to completely natural. Forest community is identified as a close-to-nature urban forest only when its evaluation grade is higher than 0.8. The second part proposes to plant forests and design a close-to-nature urban forest park based on particular combination of eighteen indicators in five criteria Layer which are required to achieve the close-to-nature standard of the evaluation system. Beijing Bai-wang Urban Forest Park Design is a case that puts nature first in its design. In the first five years, trees and forests are planted in a close-to-nature way and people are forbidden from bothering the succession of forest. Only simple hiking road are allowed to build in the first decade. Then more roads and more playgrounds are added to the forests during the second decade without breaking the structure of close-to-nature forest. Finally, the study of close-to-nature urban forest achieve its aim that create a natural urban environment for all the living beings.

Keywords: Biophilic City; Close-to-nature forest evaluation; Close-to-nature urban forest design; Ecosystem services of urban forest; Nature first

1. Introduction

1.1. Study background

As a developing country, China's economic and society have been developing rapidly in a short period of 30 years. Besides the fast growth rate of urbanism, the environmental pollution and ecological destruction has been one of the most serious problem across the country. As a result, the concepts such as nature, ecosystem and biophilic design are frequently mentioned in Chinese landscape architecture projects Nowadays. From the large-scale planning like the Call for National Forest City Construction in 'Beijing city master plan from 2016 to 2035' to the tiny-scale design such as a rainwater garden project, almost every landscape architect considers that their project is a biophilic and natural design.

1.2. Objective and meaning

It is quite significant for a biophilic design that how to estimate whether the landscape architecture projects are a biophilic design or how close-to-nature the design is as the biophilic design is usually regard as an artificial nature. These two basic questions can never be answered if there is not a quantitative evaluation system to estimate the degree of close-to-nature in landscape architecture. On the other hand, with such a quantitative evaluation system, citizens will be convinced and landscape architects will be more distinct to design a close-to-nature project. Therefore, it is significant to construct an evaluation system to estimate the degree of close-to-nature in landscape architecture. It is not difficult to find out that the conception of close-to-nature evaluation is firstly proposed as a quantitative evaluation system in forestry management after literatures concerned. Also, regarding as a response to the Call for National Forest

City Construction, this study attempts to construct a close-to-nature evaluation system of urban forest and then verify this evaluation system by attempting to design a close-to-nature urban forest project.

1.3. Technical route

In the first step, as a response to the Call for National Forest City Construction, this study aims at establishing a close-to-nature urban forest evaluation system and attempt to design a close-to-nature urban forest park based on the system (Fig. 1. Technical Route).

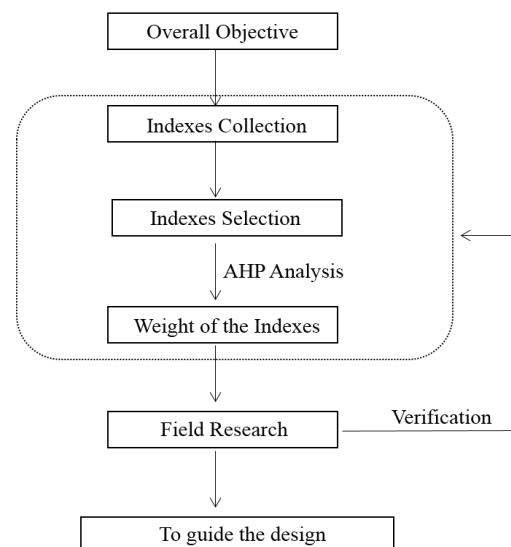


Fig. 1. Technical Route

The detailed process of how to establish a close-to-nature urban forest evaluation system is the second step of the technical route, which includes Indexes collection and Selection, Standardization and AHP (Analytic Hierarchy Process) analysis of index and the Close-to-nature urban forest grade division. The third step is a practical test of the close-to-nature urban forest evaluation system which is used to evaluate the build-up urban forest park around the site area which is going to be designed as an example of a close-to-nature urban forest

park. In the fourth step, the experience obtained from the practical evaluation is concluded and used to guide a new urban forest park design which is regarded as an example of a close-to-nature urban forest park.

2. Methods

2.1. Close-to-nature evaluation system construction

2.1.1. Indexes collection and Selection

Owing to seldom close-to-nature evaluation system can be found after literatures concerned, a great number of indexes from several subjects including forestry, ecology and landscape aesthetics, which are closely connected with landscape architecture, are collected widely. According to the frequency of occurrence and importance, 18 indexes including species richness, evenness index, Shannon-Wiener index, dominance index, average diameter, average crown, crown density, mixed degree, canopy structure, average height, combination of tree, shrub and grass, trees' age distribution, proportion of native species, health condition, forest form's characteristic, seasonal characteristic, ornamental characteristics and spatial diversity, in 5 criterion layers, which are Trees' species diversity, Horizontal structure, Vertical structure, Standing forest's vitality and Landscape aesthetics, are selected to form the preliminary framework of close-to-nature evaluation system.

2.1.2. Standardization and AHP analysis of indexes

The indexes in the preliminary framework were standardized and each of the index's weight is calculated through AHP (Analytic Hierarchy Process) analysis (Table. 1.).

Table. 1. The close-to-nature urban forest

Objective layer A	criterion layer B	Weight A-B	Index Layer C	Weight A-C
Close-to-nature urban forest	Trees' species diversity	0.2	species richness	0.0952
			evenness index	0.0552
			Shannon-Wiener index	0.0406
			dominance index	0.1381
	Horizontal structure	0.2	average diameter	0.0172
			average crown	0.0368
			crown density	0.0741
			mixed degree	0.0848
	Vertical structure	0.2	canopy structure	0.0658
			combination of tree, shrub and grass	0.1238
			average height	0.0223
	Standing forest's vitality	0.2	trees' age distribution	0.0781
			proportion of native species	0.0317
			health condition	0.0128
	Landscape aesthetics	0.2	forest form's characteristic	0.0102
			seasonal characteristic	0.0766
			ornamental characteristics	0.0250
			spatial diversity	0.0108

While calculating the weight of indexes in the close-to-nature urban forest evaluation system, this study collected 9 relevant experts' consideration of the importance between the indexes and used YAAHP software to calculate the weight.

2.1.3. Close-to-nature urban forest level division

According to the standardization of indexes in close-to-nature urban forest evaluation system, the degree value of close-to-nature urban forest is a comprehensive result that made up of 5 criterion layers including species diversity, horizontal structure, vertical structure, standing forest's vitality and landscape aesthetics. The value of calculation results distribution between 0 and 1, which is also considered convenient in the practical design of the close-to-nature urban forest. Combining with studies of German close-to-nature urban forest level division and the feature of the urban forest on plain in Beijing. Considering of combining both quantitative and qualitative methods, the close-to-nature urban forest level division is divided into five levels, which is shown in Table. 2.. The lower value level indicates a difference from close-to-nature design, and the level of high value that beyond 0.8 represents a close-to-nature urban forest community, which is showed in the table.

Table. 2. Close-to-nature urban forest level

Level	Close to nature degree	Specify description
I	Highest (0.8-1.0)	Top forest community with lowest human disturbance. multi-layer structure and diverse growth stages forest. The maximization of ecological benefits and with great aesthetic value.
II	Higher (0.6-0.8)	At the middle or late stage of the forest succession with lower human disturbance. Uneven aged forest community with multi-layer structure. The ecological benefit is prominent.

III	Medium (0.4-0.6)	Succession forest with pioneer forest community occasionally. Multi-layer structure of different type of forest such as coniferous forest, coniferous mixed forest, broad-leaved forest and broadleaf mixed forest.
IV	Lower (0.2-0.4)	At the early stage of succession, the forest of pioneer community with mainly native species. Single - layer structure of the Even-aged Forest.
V	Lowest (0-0.2)	The non-adaptive forest community with foreign tree species. Single layer structure of plantation and shrub with high level of disturbance, low ecological benefits and lack of landscape aesthetic.

2.2. Close-to-nature evaluation of build-up urban forest parks

After the close-to-nature urban forest evaluation system is established, two build-up urban forest park are chosen to be evaluated by this evaluation system. There are five quadrats (20M*20M each) of tree communities selected and evaluated randomly in each park, which are used to reduce the error by calculating the average value.

2.2.1. Evaluation of the Baiwang Mountain Forest Park

The Baiwang Mountain Forest Park is located on the Baiwang Mountain which and has various terrain and abundant habitats. It is covered by plantation planted two decades ago.

According to the evaluation result of the field research showed in Table. 3., the average value grade of the Baiwang Mountain Forest Park is between 0.4-0.6, which is identified as medium close-to-nature level. It also shows that the levels of species richness, crown density, proportion of native species and canopy structure are high in the Baiwang Mountain Forest Park. However, the levels of the whole landscape aesthetics indexes are in a relatively low level.

Table 3. Evaluation result of the field research in the Baiwang Mountain Forest

Index Layer C	Weight A-C	I	II	III	IV	V
species richness	0.0952	0.50	0.60	0.70	0.70	0.60
evenness index	0.0552	0.41	0.62	0.78	0.77	0.52
Shannon-Wiener index	0.0406	0.39	0.41	0.51	0.44	0.42
dominance index	0.1381	0.36	0.49	0.46	0.56	0.57
average diameter	0.0172	0.70	0.80	0.70	0.70	0.80
average crown	0.0368	0.80	0.80	0.80	0.80	0.80
crown density	0.0741	0.62	0.81	0.75	0.70	0.86
mixed degree	0.85	0.78	0.89	0.82	0.84	0.88
canopy structure	0.0658	0.38	0.46	0.56	0.59	0.47
combination of tree, shrub and grass	0.1238	0.79	0.88	0.90	0.89	0.88
average height	0.0223	0.70	0.90	0.90	0.90	0.80
community's age distribution	0.0781	0.30	0.20	0.30	0.30	0.10
proportion of native species	0.0317	0.90	0.90	0.90	0.90	0.90
health condition	0.0128	0.32	0.64	0.36	0.43	0.45
forest form's characteristic	0.0102	0.44	0.28	0.34	0.25	0.43
seasonal characteristic	0.0766	0.56	0.43	0.34	0.33	0.55
ornamental characteristics	0.0250	0.20	0.30	0.30	0.40	0.30
spatial diversity	0.0108	0.30	0.40	0.30	0.40	0.40

2.2.2. Evaluation of the Baiwang Urban Park

Baiwang Urban Park is a normal and flat urban park that emphasize on the landscape aesthetics of the tree communities.

According to the evaluation result of the field research showed in Table 4., the average value grade of the Baiwang Urban Park is between 0.2-0.4, which is identified as lower close-to-nature level. Different from the Baiwang Mountain Forest Park which is various in terrains and habitats, the

Baiwang Urban Park is outstanding in landscape aesthetics. On the other hand, without considering about the community's age distribution, all the communities are plant by full-grown tree with large diameter and height. Besides, it has lower crown density, mixed degree and combination of tree, shrub and grass.

Table 4. Evaluation result of the field research in the Baiwang Urban Park

Index Layer C	Weight A-C	I	II	III	IV	V
species richness	0.0952	0.30	0.30	0.40	0.20	0.30
evenness index	0.0552	0.30	0.33	0.28	0.27	0.33
Shannon-Wiener index	0.0406	0.38	0.45	0.44	0.44	0.40
dominance index	0.1381	0.31	0.44	0.43	0.36	0.37
average diameter	0.0172	0.80	0.90	0.90	0.80	0.80
average crown	0.0368	0.60	0.60	0.60	0.70	0.70
crown density	0.0741	0.34	0.32	0.21	0.15	0.20
mixed degree	0.0848	0.73	0.82	0.78	0.81	0.74
canopy structure	0.0658	0.28	0.34	0.40	0.30	0.32
combination of tree, shrub and grass	0.1238	0.63	0.72	0.75	0.61	0.77
average height	0.0223	0.60	0.70	0.60	0.60	0.70
Community's age distribution	0.0781	0.10	0.10	0.10	0.10	0.10
proportion of native species	0.0317	0.10	0.10	0.10	0.10	0.10
health condition	0.0128	0.32	0.64	0.36	0.43	0.45
forest form's characteristic	0.0102	0.64	0.68	0.54	0.55	0.43
seasonal characteristic	0.0766	0.76	0.73	0.64	0.81	0.72
ornamental characteristics	0.0250	0.80	0.70	0.80	0.70	0.70
spatial diversity	0.0108	0.80	0.70	0.70	0.80	0.80

2.3. The close-to-nature urban forest park design

2.3.1. Surrounding analysis of the design site

The design site is located in an area with natural surrounding environment. At the north side of the site is the Baiwang Mountain which is part of west mountain range of Beijing. Jingmi diversion canal, the main water supply line in Beijing, flowing by south of the design site.

2.3.2. Objective of the design

Basing on the study of the close-to-nature urban forest evaluation system and the experience from the field research evaluation of build-up urban forest parks, this design aims at attempting to find the method of building up a close-to-nature urban forest park, which means the close-to-nature degree of this urban forest park is beyond 0.8, besides the basic function of other urban forest park.

2.3.3. Process of the design

According to the principle of the close-to-nature urban forest evaluation system, the evaluation result of a urban forest community will reach the highest close-to-nature level, which is equal to its Close to nature degree is beyond 0.8, if the grade of each 5 criterion layer of this community is higher than 0.8. Therefore, the process of the close-to-nature urban forest design starts with figuring out how to design a close-to-nature urban forest community pattern whose grades of each 5 criterions layer are all higher than 0.8.

According to the relationship between the grade and the actual meaning of each index identified in the standardization of index, it is feasible to figure out the actual form of each 5 criterion in a highest level close-to-nature urban forest community. Meanwhile, based on the different weight

given to the indexes by the AHP analysis, nine indexes of the heaviest weight are selected to build up the close-to-nature urban forest community pattern in the highest level (Fig. 2. Close-to-Nature Urban Forest Community Pattern).

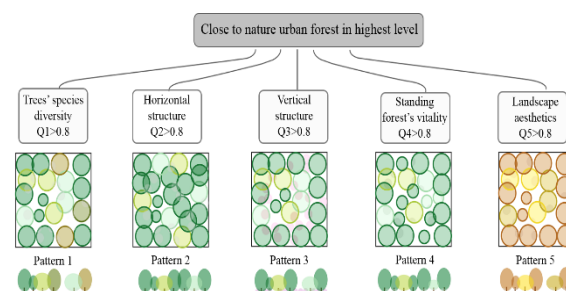


Fig. 2. Close-to-Nature Urban Forest Community Pattern

Two indexes are selected in the Trees' species diversity criterion that the species richness is more than 80% of the urban forest species in local nursery garden and the number of advantageous tree species is more than 35%. In Horizontal structure, the crown density is higher than 0.75. In Vertical structure, combination of tree, shrub and grass is considered the most representative that all area should be cover by grass plants and the proportion of tree to shrub is more than one third. In the Standing forest's vitality, the proportion of young tree to full-grown tree is more than two thirds and there should be more than 80% native species among them. As for the Landscape aesthetics, three indexes are involved that indicates obviously winding canopy line, having ornamental characteristics of flowers, leaves, fruits or barks in at least three seasons.

After that, the overall planting design covering the site area is created by the combination of the close-to-nature urban forest community pattern and vertical design, which is also in a natural way that continues the Baiwang Mountain range. The combination is necessary that the

specific plant species of each community pattern are able to be selected according to the specific habitats which is influenced by the vertical design.

In the end of the design process, considering of the basic function of an urban forest park, the tourism facilities are overlaid with the vertical design and the overall planting design (Fig. 3. Superposition) and the final design of the Baiwang urban forest park as a highest level close-to-nature urban forest project is accomplished.

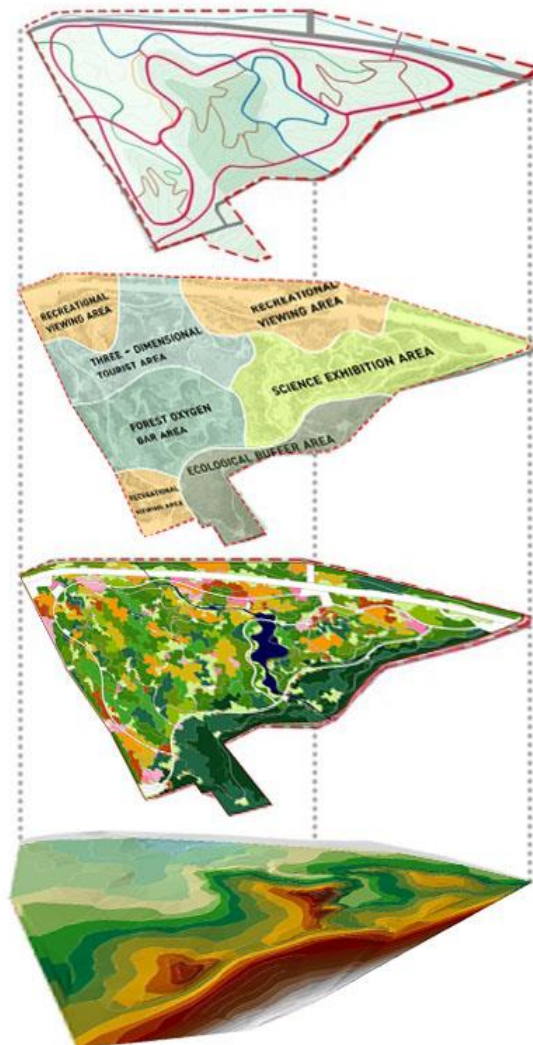


Fig. 3. Superposition

3. Results

3.1. Result of the close-to-nature urban forest evaluation system

This study establishes a close-to-nature urban forest evaluation system including a calculation table with 5 criterion layers and 18 indexes, and a close-to-nature urban forest level division which is used to evaluate the level of a close-to-nature urban forest.

3.2. Result of the close-to-nature urban forest design

Based on the close-to-nature urban forest evaluation system, this study proposes a new attempt that the planting design is firstly considered before the tourism facilities design and the vertical design (Fig. 4. Master plan of the Baiwang Urban Forest Park). It is also a completely new perspective of planting design that the planting of whole site area is designed after the close-to-nature planting pattern is designed.



Fig. 4. Master plan of the Baiwang Urban Forest Park

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Researching On Urban Park Landscape Planning With Industrial Heritage

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Abstract

In the history of urban development, industrial facilities have an important historical status, which is a witness to the economic development and historical process of cities and regions. With the rapid development of urban construction, all major cities are actively adjusting the layout of industrial land and improving the urban environment, resulting in a lot of industrial wasteland in this process. It is an important way to construct a biophilic city and transform the abandoned industrial facilities into green infrastructure through ecosystem restoration. This article will update for the study of industrial culture landscape to start. Taking a space along the Jialing River in Chongqing as an example, this paper expounds how to realize the transformation of industrial facilities to green infrastructure through ecological means. The aim of this study is to provide urban residents with good leisure and recreation, meet people's demand for green, improve the function of urban ecosystem, and provide reference and reference for the construction of a biophilic city.

Keywords: landscape urbanism, industrial landscape renewal, green infrastructure

1. Introduction

In the history of urban development, industrial facilities have an important historical status, and they often bear witness to the economic development and historical process of a city and region. For nearly half a century, developed countries such as Europe and the United States have received more and more general attention on the reuse of abandoned industrial land, which affects the whole world. Transforming the urban industrial wasteland by ecological system restoration and landscape renewal would find a new way to solve social and environmental problems.

At the same time, China is at the stage of accelerating urbanization, and the city construction is developing rapidly. Faced with the integration process of the global

economy and the pressure of urban competition, all major cities are actively adjusting the layout of industrial land and improving the urban environment. A great deal of industrial wasteland has been produced in this process. Recently, there has been a succession of landscape renewal practices in industrial wasteland and urban industrial districts in China. However, it is still urgent to learn and develop the ideological method of the urban industrial wasteland renewal in western developed countries to solve specific problems in China.

Taking a section of the space along the Jialing River in Chongqing as an example, this study expounds how to realize the transformation of industrial facilities to green infrastructure through ecological means to make the industrial wasteland reused again. Besides, it provides comfortable green spaces for urban residents, meets the needs of

tourism and improve the function of the urban ecosystem.

2. Relevant Theory

2.1. *Industrial Landscape Renewal*

The objects of the study, namely industrial heritage, were defined in the “Nizhny Tagil Charter”. It points out that “industrial heritage consists of industry cultural relics, and historical, technical, social, architectural or scientific value. These relics include buildings, structures, machinery, workshops, and other related material and non-material manifestations. In addition, social sites associated with industry, such as residences, religious places of worship, and educational institutions, are also areas of industrial heritage.” These abandoned industrial heritage have important historical and research values. At the same time, they also reflect important social values and regional cultural values [1]. The industrial relics in the planned site mainly include the remaining industrial plants and some industrial facilities and materials.

2.2. *Green Infrastructure*

“Green Infrastructure” is a concept that is broadly defined and it needs to be understood according to the specific situations. There is no clear definition of this concept. The green infrastructure encompasses human activities in the landscape at the broadest level. This includes not only the structure that is close to nature, but also the human factors in the open space.

The green infrastructure is a low-cost, resilient landscape that links all systems,

including ecosystems, to one another, and transforms unused space and infrastructure in cities into comfortable green spaces that people can reuse. It also enables people and other creatures to create versatile and dynamic living environments [2]. The transformation of abandoned industrial facilities into green infrastructure is the focus of this study.

Here are some of the green infrastructure commonly used in urban parks.

Rain gardens are diverse and widely used. They are one of the most important facilities for flexible landscapes. They can collect and absorb surface runoff, optimize the ecosystem, and create a beautiful landscape.

Grassed swales are actually a kind of narrow and long rain garden and often distributed on the roadside in a linear landscape form.

Permeable pavement uses lower-cost pavement materials to filter, process or store rainwater.

Ecological parking is a good choice for the application of green infrastructure where many green infrastructure elements are put to good use, including permeable pavement, rain gardens, grassed swales and so on. It can effectively reduce the heat island effect in densely populated areas and make people use a more comfortable environment.

Roof gardens can purify rainwater, effectively control the quality of roof rainwater collection and reduce the cost of room temperature maintenance.

3. 3. Planning Strategies

3.1. Study Area

This study area is located along the Jialing River in Chongqing, which is the key area of the overall strategic planning of the Yangtze River in Chongqing. According to Chongqing city master planning, the area of 15 hectares as the park green space in the region. The eastern side is connected to the urban roads. The south side faces the Jialing River. In addition, the western and northern sides are the existing brick factory buildings. The area is one of the landmark gateways for the Jialing River to enter Chongqing's downtown area.

3.2. Planning Goal

Focusing on the characteristics of the site and combining with the needs of ecology, landscape and function, the planning goal of the research area was proposed. It is to create a site that fully respects the texture of the site and to achieve the collision and integration of the industrial landscape and the natural scenery while the urban park area satisfying the artistic display, recreation and comprehensive service functions. It will mean realizing the transformation of industrial wasteland to green infrastructure.

3.3. Planning strategies under the green infrastructure framework

3.3.1. Landscape strategy -- the shaping of industrial landscape renewal

The industrial plant left over from the site is an important part of the planning, and there are generally three aspects of the processing strategy.

The first is to preserve the physical architecture and optimize functions. For example, by partially changing the material of the roof or facade, the industrial plant will be transformed into a greenhouse, a tearoom, and a promenade. For the production and transportation facilities left behind by the original brick factories, they were treated and preserved for a few moments to form a positive response to the industrial culture, causing people's associations and memories.

The second is to retain only the physical structure of industrial buildings and form gray spaces. For example, the pillar net framework of the industrial plant is used to transform it into a landscape gallery through growing climbing plants.

The third is to dismantle the building and integrate it into the natural environment, such



Fig.1. The distribution of the present situation



Fig. 2. Preliminary assessment of industrial buildings

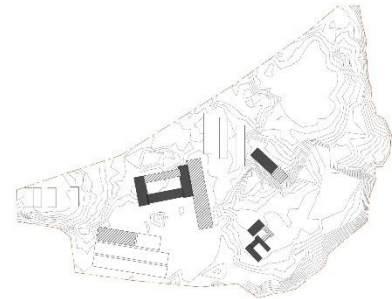


Fig. 3. The strategy of the retained buildings



Fig.4. Landscape of industrial relics

as the removal of the building's roof into a horticultural garden, the preservation of the basement as an activity site, the preservation of the pillars as lampposts, or the preservation of the rails to shape the site's texture. The traces of the stains left behind by nature in industrial facilities are not deliberately concealed or destroyed. Instead, we respect the texture of the site and use artistic processing methods to make it an important element in the landscape [3].

This three-point strategy optimizes the space for industrial buildings, so that abandoned industrial relics can be reused, and better integration with the surrounding green space improves the landscape value of industrial wasteland.

3.3.2. Ecological strategy -- the construction of sponge system

The current terrain has topographic features such as high platforms, mountains, depressions, and gullies. The planning sufficiently respects the current situation, increases micro-topography, strengthens the water transfer lines, connects the gullies and forms the site's water system. This strategy can fully collect site rainwater, combine its own microcirculation system, and play a role

in the sponge function of the green infrastructure [4].

According to the vertical elevation of the site, water collection facilities such as grassed swales and rain gardens are arranged near the source of surface runoff. When rainfall occurs, the natural elements are sufficiently used to transport, filter and infiltrate surface runoff. In the stage of rainwater retention, the use of current state storage of rainwater will not only enrich the landscape of the area, but also facilitate the reuse of groundwater, irrigation and other purposes.

In addition to the existing landform and terrain collection facilities, the original industrial facilities can be converted into rainwater collection devices such as reservoirs, drains, and bio-retention pools to achieve the perfect transformation from industrial facilities to green infrastructure while satisfying the landscape.

3.3.3. Functional strategy -- the implantation of recreation system

Industrial wasteland often presents a passive state that has not been utilized. In addition to solving the problem of rain collection in a sponge city, the green



Fig.5. The transformation of industrial relics into horticultural gardens



Fig.6. The rain garden

infrastructure is more important to transform unused space and infrastructure in cities into comfortable green spaces that people can reuse. At the same time, it will be a versatile and dynamic living environment for people.

The entire site is divided into three areas based on function, including the main entrance and integrated service area,

industrial garden area and ecological recreation area. The site mainly uses the original industrial relics as the carrier to implant the park's recreation system.

The existing railway texture of the site can be designed and transformed to form a Riverside bicycle path. Some industrial buildings or industrial structures formed in



Fig.7. The site-plan

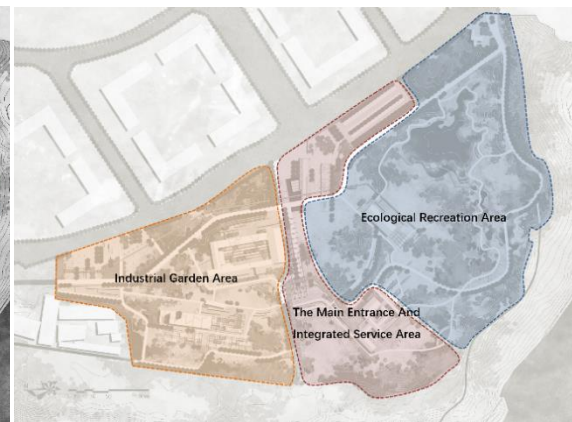


Fig.8. The Functional zoning plan

the activity area can provide a place for people to exercise, exercise and think. It is beneficial to improve people's physical and mental conditions. Low-lying rain gardens have positive implications for maintaining and enhancing biodiversity through the retention of rainwater and the cultivation of aquatic plants.

4. Conclusion

The research area is mainly based on the relevant theories of Industrial Landscape Renewal and Green Infrastructure. Taking a space along the Jialing River in Chongqing as an example and formulating a clear research goal, strategies for the three aspects of landscape, ecology, and function were studied to achieve the transformation of industrial wasteland to urban parks. It will provide urban residents with good leisure and recreation, meet people's demand for green, improve the function of urban ecosystem, and provide reference for the construction of urban green spaces.

Economic Management Institute[J]. 2009(03):13-15

At present, China's urban industrial landscape planning with its industrial heritage is still in the experimental and demonstration stage. For the creation of industrial landscape, there are still many difficulties in the process of element definition, planning and design, protection and restoration, and construction and implementation. The transformation of abandoned industrial facilities into green infrastructure and the construction of parks through ecological means are all options and attempts to renovate the landscape of industrial wasteland and the construction of a biophilic city.

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Landscape Planting Design of Garden Expo in the Eco-City perspective

—A Case on the second session of the Hebei Provincial Garden Expo in China

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Abstract

The basic requirements of eco-city is that a city should put nature first in its design, planning, and management and plant landscape is the essence of nature. This paper bases on documents review and the special semi-humid continental monsoon climate as well as intense weathering geographical conditions, taking the second session of the Hebei Provincial Garden Expo in China as an instant to analysis the landscape planting design on space and time. The space included three aspects. The first one was dotted plant landscape in terms of the specified plant garden, the featured theme garden and the functional entrance. In the second aspect linear plant landscape contained the aquatic plant coastline and the park boundary. The third one included the present plant groups and the local plant groups as plane plant landscape. The case is a primary trial integrating the eco-city in landscape planting design of garden expo, aiming at exploring how the plant landscape works during the eco-city construction. Addition, future research and design is warranted for more efficient and profound methods.

Key words: landscape architecture , eco-city, garden expo , landscape planting design

1 Background

The concept of eco-city is brought forward with the continuous development of human civilization and the continuous distillation of the relationship between man

and nature. Huang et al. (2004) indicate that eco-city is a human settlements form with harmonious society, efficient economy and virtuous circle of ecology, as well as an organic whole include nature, city and people in harmony to form a symbiotic structure. Eco-city is a diversified and

sustainable development urban pattern formed by the combination of economic development, social progress and environmental protection, and the ecological virtuous circle form an ideal regional shape. Chinese emphasis more on traditional characteristics in research of ecological urban construction and planning, focus on grasping the direction of urban ecological construction with integrity and systemic to achieve harmony between man and nature, but the research is mainly in the fields of ecology department and architectural planning cause a more macroscopic theory which is lack of comprehensive subject research and limited to play a guiding role in the specific practice.

China International Garden and Flower Expo (hereinafter referred to as "Garden Fairy") to some extent, is a city of major events, in terms of major events activities, influence on the building of ecological city, and the effect significantly, is currently China's cities government to one of the basic motive of these activities have a high enthusiasm. The plant landscape of Fairy Park is important natural elements in the overall landscape elements, it is not only beautify the urban environment ornament materials, especially to build ecological city, regional sustainable development an important driving force. Fairy Park industry

is a new technology, new ideas, new model of a centralized exhibition, this way of communication makes the new technology, new idea, new model of promoting more rapidly, the study of the landscape to build ecological city play a good demonstration effect.

2. Overview of the overall planning and design of the second session of the Hebei Provincial Garden Expo

2.1 Site profile

The project area is located in west Qinhuangdao economic and technological development district of Hebei in China, covers an area of about 1.33 square kilometers, and the area development potential is huge due to intersection of the mountain tourist area, the coastal tourist area and the central city area,. The surrounding water and land transportation are very convenient, Jingha and Qincheng expressway are on the north side, the west is close to the coastal highway, Qinfu expressway is in the south side, the east is near to Bohai bay. The city is 60 kilometers away from Beidaihe airport, and is half an hour traffic circle at Qinhuangdao railway station, Beidaihe railway station and Qinhuangdao Port.

The Fairy Park in Hebei clasps national strategic positioning, response to regional integration development needs, carry out innovation, coordination, new development



of the green, open and sharing ideas, chose "Mountain Harbor city, Green Dream" as the theme. The project's goal is five one garden expo, junior communion Qiyun Mountain, to create innovation Fairy Park , low carbon Fairy Park, sponge Fairy Park, wisdom Fairy Park, people's Fairy Park.

2.2 Overall structure analysis of the second session of the Hebei Provincial Garden Expo.

The figure 2 show that the overall planning structure of the Fairy Park is three valleys, one vein, and three nuclear as well as double groups. The structure is striving to display the elegant style of contemporary garden art and the Beautiful China plan with a multi-dimensional innovation perspective. First, three valleys is the characteristic valley landscape formed on the basis of the present situation. Second, the one pulse is the water vein landscape throughout the North and South Park. Third, the three nuclear is a core control points formed by the three core buildings, namely the main pavilion. Finally, the northern city exhibition garden group and the southern special exhibition garden group formed the double groups. There are four categories 30 different exhibition garden are constructed, including exhibition garden of city in Hebei province, Qinhuangdao and District County exhibition garden, Theme Creative garden, Regional Customs garden and etc. There are also 10 specialty theme garden including the Children Science Park, the Jing-Jin-Ji

Regional demonstration garden, the Rose garden, the Chrysanthemum garden and so on.

3. Plant landscape planning and design of the second session of the Hebei Provincial Garden Expo.

The total area of green space in the



Fig. 2. Master plan of the Garden Expo

Fairy Park area is as high as 68.8 hectares and the overall plant landscape planning is closely related to the theme of " Mountain Harbor city, Green Dream" to build the green engine in the area of Qiyun Mountain. The plant configuration is based on the basic principle of local conditions, taking into account the seasonal changes and the landscape effect during the Garden Expo, forming a plant landscape with "three quarters of flowering, every green", giving full play to the ornamental characteristics of all kinds of plants and enriching the overall view layer of the Garden Expo.

Rich garden plant species, 30 species of evergreen trees, more than 100 species of deciduous trees, more than 40 species of trees, flower shrubs more than 200, more than 110 kinds of flowers, more than 110 kinds of perennial flowers, and more than 50 species of ornamental grasses, and more than 40 species of aquatic plants.

3.1 The overall structure of plant landscape in Garden Expo

The Garden Expo plant landscape of the North and South Park is featured with different styles. Qinhuangdao and District County exhibition garden and there theme Creative gardens are distributed in north garden. Plant landscape in north garden combined with three kinds of different terrain of city exhibition garden group in Hebei province. The frame of north garden plant landscape is the realm of typical plant materials in different regions formed with the realm of public landscape. Among them, three theme parks are focused on the plant landscape, which forms the features of the plant landscape. While, the south garden is lined with *Hydrangea macrophylla* (Thunb.) Ser. along the two sides of the primary road, which connects the five Specified gardens, Theme Creative garden and Regional Customs garden. The plant landscape is abundant in layers and characterized by science popularization.

The North Garden focuses on the three main types of landscape in Hebei province, including Mountain-Plateau group, the

River-Lake-Wetland group and Sparse-Forest-Grassland group. In addition, this garden distribution three theme parks, Aquatic Botanical Garden, Children's Garden and Golden Leaf Garden.

The south garden contains six specified garden, the Chinese Rose Garden, Characteristic Botanical garden of Jing-Jin-Ji, Chrysanthemum Garden, Crape myrtle Garden, Shade tolerant Botanical Garden and Herb garden. They are connected by the unique *Hydrangea macrophylla* (Thunb.) Ser. strip, formed the plant landscape structure of the south garden which takes science popularization as the main part.



Fig. 3. Rendering of Children's Garden

3.2 Dotted plant landscape of Garden Expo

The Children's Garden, also known as "Ocean Dream Garden," is located in the northeast corner of the park and covers an area of approximately 1.94 hectares. The overall structure connects the four theme activity areas in a sea blue ribbon path, including a children's garden, a popular science garden, a sports paradise, and a

future garden. Science Garden displays the five marine organisms at the time of extinction and the existing saline-alkali-resistant plants. From figure 3, the sports park organizes wood platform activities in conjunction with the beach. In the future, the garden plants perennial flowers and arranges walking paths. A large area of grass slopes next to the site is planted with *Helianthus annuus* Linn. and *Kochia scoparia* (Linn.) Schrad. to guide children to experience the beauty of nature. Many green islands are also designed on the site to ensure vegetation coverage and provide children and parents with comfortable recreational space.

The Aquatic Botanical Garden is located on the east side of the main lake area of North Park and covers an area of about 1.33 hectares. The overall structure of the wooden plank road tandem pool, science shows a variety of aquatic plants and related water features culture. One of the three fish ponds is an independent water surface, and the other two are connected to large water surface. The revetment treatment consists of two types of wooden stakes and steps into the water. 15 kinds of *Nymphaea tetragona* Georgi, 13 kinds of *Nelumbo nucifera* Gaertn. and 15 kinds of other aquatic plants are planted. There are also and *Salix babylonica* Linn. and *Salix matsudana* Koidz. to enclose the space. On one side of the wooden plank roadway, there will be a Lotus Fragrance Pavilion on the side of the boardwalk. The pavilion faces the main lake so as to smell the fragrance of

Nelumbo nucifera Gaertn. At the same time, a Louts Wind pavilion is set up on the hillside of the east side of the wooden plank road. Take the mean of “The fragrance is far away, the wind is full of wind”.

Golden Leaf Garden is located in the southeast corner of North Park and covers an area of approximately 1.3 hectares. With two golden landscapes belt combined with three golden mini gardens to form a golden plant viewing interface, it stands out in the dark green nature of the summer, giving visitors a unique visual experience. Among them, the two golden landscape belts rely on the roads in the theme park and are planted with gold branches and gold leaf plants on both sides, with *Sophora japonica* 'Winter Gold' and *Acer negundo* 'Auea' forming a golden garden road; three golden mini gardens along the primary road layout is planted with 25 kinds of gold herbs, such as *Gaillardia*



Fig. 5. Rendering of Golden Leaf Garden



Fig. 4. Rendering of Aquatic Botanical Garden

pulchella Foug., *Rudbeckia laciniata* Linn., and *Coreopsis basalis* (A.Dietr.) S.F.Blake. Looking out at the Golden Leaf Garden, five kinds of gold leaf arbors such as the *Ulmus pumila* cv., *Acer negundo* 'Auea' and the golden leaf trees leafhopper cooperate with the topographic design, and visitors can enjoy a strong visual impact of the golden color of the whole mountain.

3.3 Linear plant landscape in Garden Expo

There are two kinds of border in Fairy Park, one is the boundary of the red line result in closed management of Garden Expo, and another kind is land-water boundary.

The park border has two kinds of processing way, north close to the boundary of the broad road garden as close to the parking lot, stream, fence planting ornamental effect is good, flowering and session consistent double gland cane, cane for annual double gland vines, not suitable for large area planted, so the park east, west, south three boundary fence are planting flower vine shrubs of the relatively small amount of red roses, artificial barrier for shelter.

There are two methods to deal with the boundary of the red line. The border of the north side is close to the garden Bo Avenue, which is close to the parking lot and the flow of people is large, thus the *Dipladenia sanderi*. is planted on the landscape fence as an annual vine which is good ornamental effect during the Garden Expo and the

period of the flowering is the same with the opening time of the Garden Expo. As a biennial plant, The *Dipladenia sanderi*. is not suitable for large area planting. Therefore, the fences on the three borders of the Fairy Park are planted with *Rosa Rubus* which is a twining shrub with relatively small amount of flowers, but has a certain shelter for artificial fences.

The treatment of land-water boundary mainly utilizes the transition of aquatic plants, so that the two sides of the boundary can be integrated with each other but not rigid. In close quarters, plant many kinds of delicate aquatic plant in small area to reflect the purpose of high-quality goods exhibition garden. From the boundary far away from the people, the landscape of the River-Lake-Wetland group in Hebei Province was reproduced in a large area and a single species of planting.

The Highland Plateau group is located in the northwest corner of North Park and covers an area of about 2 hectares. The plant landscape is dominated by cool plants, which embodies the rich forest atmosphere, and combines the landscape of large-scale wildflowers to reproduce the natural features of Hebei's highland plateau landscape. The center flowers sea chooses 12 species of native perennial flowers were used to seed mixing so as to create the atmosphere of alpine meadows. Five types of plateau trees, *Quercus mongolica* Fisch. ex Ledeb., *Quercus wutaishanica* Mayr, *Betula platyphylla* Suk. and other two kinds of evergreen trees: *Picea asperata* Mast and

Pinus tabuliformis Carrière were used to enclose the boundary of the group with. Visitors can enjoy the sea of flowers and *Betula platyphylla* Suk., and feel the atmosphere of the alpine meadows.

3.4 Plane plant landscape of the Garden Expo

The River-Lake-Wetland group is located in the south-central part of the North Park. It consists of a vertical and horizontal water system and covers an area of about 3.5 hectares. It is the core of the water system connecting the North and South Park. The plant group is mainly composed of the display of the rich mountain forest atmosphere and the natural features of the plateau mountain in Hebei Province, creating a horizon landscape based on the wetland of the river and the lake and the mosaic of the urban exhibition garden. Within the group, based on the rich water types, combined with the height difference of the water system, the two thematic landscape belts of Peach Blossom Valley and Begonia Island were designed in order from the west side of the shallow mountain valley area to the main water surface on the east side. Go west, enjoying the beauty of Peach Blossoms on the clear springs and the outside of the forest. And turn east, you can walk down the creek along the river and enjoy the sea view and the view of the lake between the dotted islands. The plant group consists of *Salix aureo-pendula*.,

Salix matsudana var. *matsudana* f. *umbraculi*

fera Rehd., *Pterocarya stenoptera* C. DC. and so on as skeletons, and *Malus halliana* Koehne, *Chaenomeles cathayensis* Schneid., *Amygdalus davidiana* (Carrière) de Vos ex Henry, *Amygdalus persica* cv. *Pendula* and so on as flower viewing belts. *Phragmites communis*, *Acorus calamus* L. and other aquatic plants to enrich the waterfront and form a waterfront space.

Sparse Forest group is located in the middle of North Park and covers an area of about 2.4 hectares. It displays the rich landscape of plain grassland in Hebei Province around a special service building. The sparse open space of the Sparse Forest group is in contrast with the rich and compact exhibition garden system surrounded by it, enabling visitors to enjoy a comfortable viewing experience during a relaxing visit. The group's terrain is high in the north and low in the south, and the whole is relatively gentle. The plant group utilizes the Autumn Discolored Tree such as *Sophora japonica* Linn., *Acer buergerianum* Miq. as the skeleton, together with lots of *Yulania denudata* (Desr.) D. L. Fu, *Malus spectabilis* (Ait.) Borkh., and *Cerasus serrulata* var. *lannesiana* (Carr.) Makino, scented trees and shrubs as well as herbs flowers in various colors to form a rich viewing interface and create a largescale open space which spring flowers and autumn leaves.

4 Conclusion

The Garden Expo is the highest event that shows the level of a country or a regional gardens. It will have a profound impact on the development of regional or even world landscapes. The development trend of plant landscapes is to create a soft space composed of plant monomers or communities that exhibit habitat characteristics, lasting, and pleasant, and that have regional characteristics, but at the same time can adapt to the laws of natural evolution. Simultaneously, this plant landscape could propose the establishment of design ideas based on habitat, function and regional characteristics, Garden Expo will undoubtedly provide a stage and guidance for the display of landscape plants.

The overall plant landscape planning of the second session of the Hebei Provincial Garden Expo follows the planning strategy

Acknowledgments

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of “respecting the status quo, highlighting the theme, distinctive features, and taking into account development”. Plant landscape design is based on the utmost preservation of the status quo. The current status Chinese pine forest in North Park, the mixed forests in the southwest corner ,of South Park, the *Populus tomentosa* Carrière forest of South Park and beautiful tall trees are maintained, fully respect the site status. In order to highlight the theme of the Garden Expo, a large number of seasonal flowers and various green sculptures will be used during the exhibition to underline the overall atmosphere of the session. The entire park will become a permanent green space for residents to enjoy in the Qiyun Mountain area, and will be integrated into the community greenway system to provide leisure and recreation services for the Qiyun Mountain area.

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Study on the Construction of Taiyuan Ecological City in The Northern Song Dynasty to the Ming Dynasty (A.D. 960 to 1644) from the Perspective of Landscape

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Abstract

The construction of ancient cities in China is closely related to natural Ecologicals. The inadequacy of human production technologies leads to the limited ability to transform nature. Therefore, people are filled with relevance of nature and hope to reach the harmony between man and nature to build human settlements with the help of natural forces. Compared with the tensions of land use and modern cities as well as the plundering of resources, ancient cities are more focused on local conditions and ecological sustainability. As the foundation of the Ecological construction, Ecological and scenery researching on the construction of ancient urban Ecologicals helps to understand the contemporary urban Ecological and explore the unique regional culture of the city. Taiyuan City is a national historical and cultural city with a 4700 years history of civilization and a 2500 years history of as a city. Historically, its political strategic position has been valued by rulers of all ages. This land has left a wealth of experience in urban construction. Taiyuan City is built on the basis of the Ecological environment. After artificial transformations and interactions, the Ecological pattern of the artificial environment and the Ecological Environment are formed. This article takes the interior and exterior urban and rural environment of Taiyuan in the Northern Song Dynasty to Ming Dynasty as the research object. From the perspective of landscape architecture, it summarizes the process of landscape evolution in Taiyuan and analyzes the urban development of Taiyuan, including the boundary of the city wall, rivers and lakes, road systems, and explores the characteristics of the layout of urban zoning, such as the official residence area, the city workshop area, neighborhood residential area, etiquette ritual area. This study which is about the construction of Taiyuan ecological city landscape may throw some light on urban conservation and development.

Keywords: landscape perspective; ancient Taiyuan; ecological city; Ecological construction

1. Introduction

The construction of ancient ecological cities in China is based on the Ecological environment. After human development and construction, the basis for creating a human settlement environment, cities are integrated with the long-term coordination of nature, and ultimately are closely linked with the environment on which they rely. This article explores the Ecological pattern and urban construction of Taiyuan. It refers to the regional Ecological pattern that includes the combination of cultural landscape and natural landscape, including Taiyuan City, surrounding natural landscapes and artificial buildings. The development of the city has undergone a long evolution with the development of the times. However, the landscape environment has always played an important role in the development of the city. It is the basis for the construction of an ecological city and the basis for the development of an ecological city. While adapting to the Ecological environment, the city also changes the Ecological environment and forms a continuous regional overall environment within and outside the city.

2. "Controlling Mountain and Water Stream" - Ecological Environment of Taiyuan Region

The Taiyuan Basin is high in the north and east, low in the south and west. Historically, the Taiyuan area has abundant precipitation and many lakes. The Taiyuan Basin is surrounded by mountains on three sides, the eastern side of the Lvliang Mountains, on the west side of the Taihang Mountains (Figure

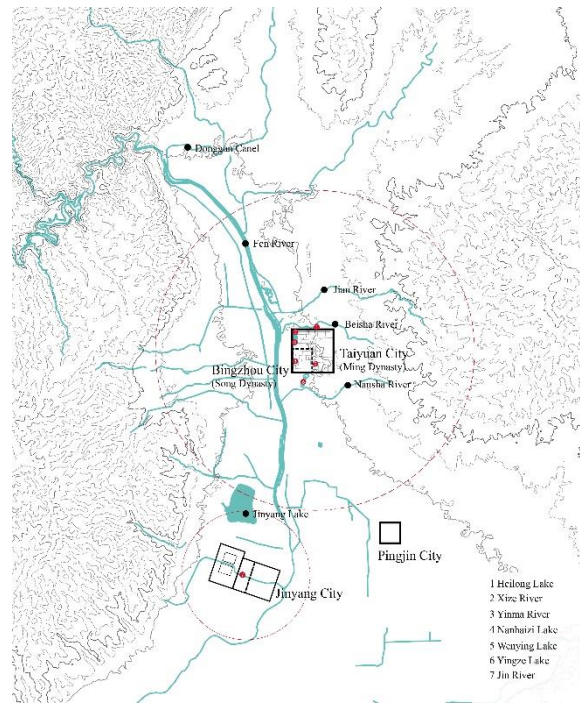


Fig. 1. Taiyuan regional Ecological Environment

1). The Fen River flows into the Lvliang Valley and passes through the basin from north to south. According to the earliest written records, Zhou Cheng Wang ruled it to his uncle Tang. "Because the building is located in the north of Jinshui, the name of the ancient city is "Jinyang". Jinyang City is located in the Jinyuan District of Taiyuan City today. The surrounding historic sites are built with Jinyang City as the regional center. However, the Jinyang City is located in the southeast of the basin and cannot effectively control this area. Then the center of the area shifts toward the center of the basin.

The Northern Song Dynasty was built and the state government chose Tangming Town as the foundation and moved more than tens of kilometers to the northeast from Jinyang City, which is located in the center of the

Taiyuan Basin. However, because of the close proximity to the Fen River, it lacks effective flood prevention facilities, and the state towns are often affected by floods. However, the rich water system provides the conditions for urban Ecological construction. The northern, eastern and southern plains also provide space for the development of the city. The Ecological pattern of the Taiyuan Basin directly affects the location and expansion of the city, and the construction and development of the Taiyuan City also promotes the evolution of Ecological patterns outside the city. The environment after mutual influence is more suitable for human habitation.

3. " Fairview Taiyuan City " - Ecological City Construction

The Song Dynasty is a city built for political and military purposes. "The government was set up Beijing State Administration, and the official ownership system was the same as the second Beijing". After building a city wall on the basis of Tangming Town, the internal development of the city, so the pattern of Tangming Town laid the axis and the basic pattern of Taiyuan City; the expansion of the Ming Dynasty city also first built Jinwangfu and the city wall after the development of new cities. Compared with cities developed due to economic needs, the subjective initiative of people in Taiyuan City has more influence on the layout of cities. From this, the traditional planning concept can be clearly seen, and the structure is adjusted accordingly based on the current conditions to make the city more ingenious. Local characteristics. Compared to modern cities developed due to economic

needs, the subjective initiative of Chinese traditional cities has more influence on the layout of cities. From this, the traditional planning concept can be clearly seen, and the structure is adjusted accordingly based on the current conditions. The city has ingenious local features, as is Taiyuan City.

In the first year of Tang Dynasty (713), Tangming Town served as the resident of Hedong Jiu; Song Taiping seven year (982) and the State City built Tangming Town on the basis of the preservation of Tangming Town as the Zi Cheng in Taiyuan. In conjunction with the state city, Tangming Town is retained as a sub-city, and the State City (Luo cheng), Nanguan City, Beiguan City, and Dongguan City are expanded. In the golden and the Yuan period, the sub-city was destroyed due to the war and was converted into a square. In the year of Ming Hongwu nine year(1376), Jinwangfu was newly built on the east side of the state capital, and the wall of Mingfucheng City was moved eastward, southward and northward. The area of Fucheng District was 9.32 square kilometers, which was second only to Beijing in the north of the Yangtze River. The walls of the Ming Dynasty are tall and magnificent. They spread over the lakes and meadows. The west of Yeosu River and the west of Liuxi Liantang become public gardens. The city and the surrounding rivers and rivers are known as the "Fairview Taiyuan City". During the peak period of the ancient Taiyuan City construction in the Northern Song Dynasty and the Ming Dynasty, Ming Taiyuan City left a rich historical and cultural landscape. Therefore, this article takes the Northern Song Dynasty and Ming Dynasty as the research category to explore the

formation of the Ecological pattern of Taiyuan City.

3.1. The hills and the lakes

The superiority or inferiority of the geographical location directly affects the scale and layout of the city's development. The water in south to the mountain in north is the ideal Ecological Environment for the city, and the location of the Jinyang city meets this principle. However, the city can be prosperity with water or ruin by water. The Fen River in the Northern Song Dynasty was introduced into the city of Jinyang, resulting in the destruction of the city.

The town of Tangming is located in the center of the basin. The Fen River is the main target for the construction of the city in the state of Bingzhou. At that time, there was a constant stream of ships from and to the Fen River, and the shipping was busy. The poet Zhang Yun of the Ming Dynasty wrote a poem "The Late Rivers at the Fen River": "The mountains are set in a thousand forests, and the ferry is returned as a colony". And the state city site is located on the east bank of the Fen River. First, it is conducive to military defense. The Fen River becomes the natural moat of the Bingzhou City. Second, it is convenient for waterway transportation. The goods passing through the Fen River can be easily entered into the city. At the same time, the landscape of the Fen River will also be within the sight of Taiyuan City. The Fen River has slowed down the vertical slope in the basin, so flooding is often poor. At the beginning of the Song Dynasty, the Fen River often collapsed in the northwest of Bingzhou City. The state's state magistrate, established the five miles new embankment on the eastern side of the dam to control the flooding

of the Fen River. This will bring the water from the Fen River to the dam bank, which can act as a buffer during the flood season. The riverbank mud is full of lotus flowers, named "Furongzhou", and tens of thousands of willows will be planted along the embankment. It will be called "Liu Dike," and will be built on the embankment. The Jianhua Hall and Tongxia Pavilion will be built on the embankment. A view of the stream lotus pond. This governance will transform the uninhabited flood-stricken areas of the suburbs into a beautiful public garden. In addition, the state towns and cities draw water to form moats. Today, Yuchi, Houxiao River, Donghousiao River and other places can infer the location of the moat at that time.

During the expansion of Ming Taiyuan Prefecture, Liuxi Liantang and Xize River, Yinma River, Yangyu Pond, Xihaizi, Nanhaizi and other urban west river systems were included in the urban scope. In addition, the southeastern side of Tangming Town formed two water pools called Yuanhaizi and Changhaizi due to its topography. The name Taiyuan City was expanded into a lake in the

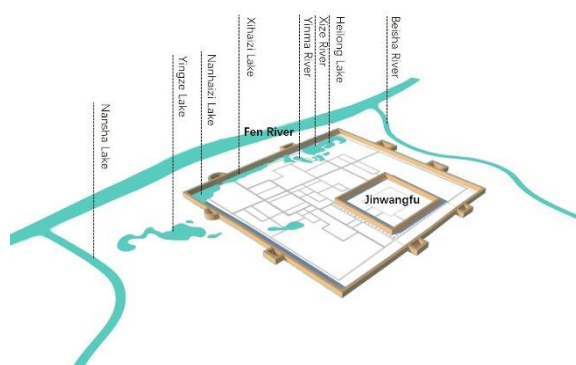


Fig. 2 Taiyuan city water system recovery map in Ming Dynasty

city. Due to its proximity to the Gongyuan, it became a student excursion site for the examination of the province and had the name of “Wenying Lake”. The New South Lake outside the city is about three kilometers away, and the trees on the banks of the shore are overcast. The natural scenery is so beautiful that it captures the scenery. It is like a moat in the river Shahe, and the Beisha River is a north city wall moat (Fig. 2).

Prominence on the plane is an important starting point for the construction of the city. Tangming Town is closer to the Taihang Mountains, creating a basis for subsequent urban development. The north city wall of Song Dynasty is located along Meishan Mountain, and the east wall is located under the Jinji Hill. The Ming Dynasty palace was built in front of Songhuapo, Songhuapo and Guizhishan became the palace gardens; the north city wall and some of the eastern city walls of the prefecture city remained in the city and became the commanding heights of the northwest of the city. Jinji Hill became the commanding point of defense and observation in the southeast corner of the city (Figure 3).

The ancient Taiyuan area has abundant terrain, terrain, rivers, lakes and springs which provided the basis for the development of the city and created conditions for the creation of urban landscape.

3.2. City Wall Boundary

There are few records of Tangming Town in historical materials. According to the “Yongle Grand Ceremony,” the “Song on the Fifty-seven Steps on Friday” was recorded in Song Bingzhou, and the sub-city was built on the basis of Tang Ming Zhen. Therefore, the

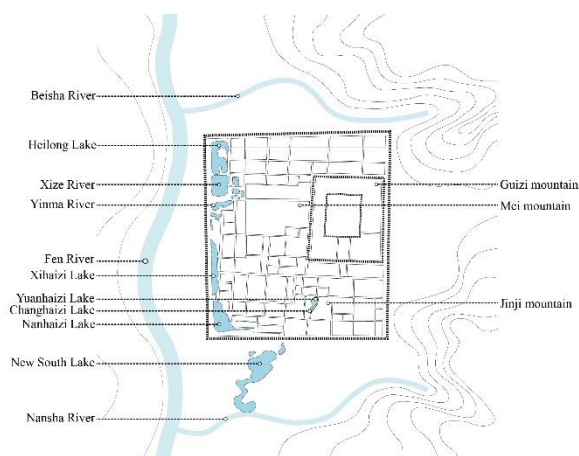


Fig. 3. A caption is positioned left-justified below the figure or scheme.

size of Tangming Town is presumed to be different. Similarly, the city is a square, about 3 kilometers.

In the Northern Song Dynasty, Pan Mei was ordered to build a state capital. The north and west borders of Luocheng were adjacent to the sub-city walls, and the east and south boundaries expanded outwards. They were “two hundred and seventy steps” in the week. In comparison with the town of Tangming, the area of Bingzhou City has nearly doubled. The sub-city is located in the west of the state city and is located to the north of the west. The “South Gate has military forces from the east and the east”. It is the balance left by the Tang Dynasty. It is called the “Hedong Army Gate.” The remaining three gates are commensurate with “Zidong, Zinan, and Zibei.” The state city also “built four gates: the east towers and the south towers, the south tower sailed away, the west towers Jinsu, and the north towers run wild.” Not to each other. Song Chunhua three years (992) for the establishment of the South Guan City for the use of troops, the East Gate City, North Gate City also built for the Chunhua

years. Song Bingzhou City built a closed urban inward-looking space, which laid the general scope and development direction of the city in the future. However, the development scope defined by the city wall for the city cannot meet the required space with the development of the city.

According to "Taiyuan House Records," the records of the Ming Dynasty City Wall "Twenty-four years of the city week, thirty-three feet high, three bricks out of bricks and three feet of Yao Shen", two walls on each side of the city walls, and eight city gates were built on the city wall. There are a total of 12 buildings on the four corners of the city wall. There are also 90 small buildings on the walls. After the Ming and Qing dynasties, three small towns of Nanguan, Beiguan, and Xinbao were successively built outside the city (Figure 4). It can be described as "a magnificent world."

The expansion of Taiyuan City is to include the original city inside the new city (Figure 2), continuing the original city's texture. The west wall and south wall of the

Song Dynasty merged into the Ming City Wall, and the northern section of the East Wall was transformed into part of the Western Wall of the Jinwang Palace. The Northern City Wall became the internal series of hills in the city; the west side of the moat became the water system in the Ming City. The Ming City Wall provides land for the city's internal construction. Twelve buildings and 90 small buildings enrich the city's sight. With two expansions, the relationship between the city and the Ecological Environment is closer, and the beautiful scenery of the river and the lake hills are contained within the city.

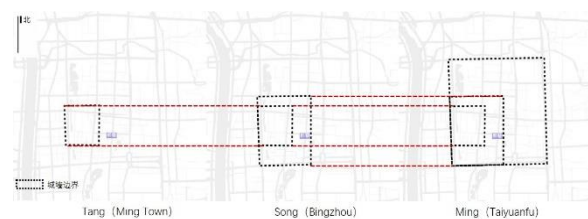


Fig. 4. Taiyuan city wall boundary evolution map

3.3. "T-Street"

The road of Taiyuan City is different from the road system of the "Nine-ninth-south and nine-latitude" cities of the contemporary capital, but it is a unique "T-shaped Street" layout. According to investigations and studies, Ting Street has appeared in Tangming Town during the Tang Kaiyuan period. The Song Zi City is located in the northwest of Bingzhou City. There are five main streets in the city, Dongmen Street and Ximen Street form the east-west main shaft, and Beimen Street, Nanmen Street and Fuqian Street form a T-shaped intersection

with each other. "Six" shaped three north-south t-shaped street. According to the "Yongle Grand Ceremony" record, the four gates of the state city are not connected to each other, and the south gate is centered. The north gate is west, the east gate is centered, and the west gate is south. The four main avenues facing the four are T-shape Street, Dongmenzheng Street and Zicheng East Wall, Nanmenzheng Street and Zicheng South Wall, Ximenzheng Street and Nanmen Street, North Gate Zhengjie and Zicheng North Wall. Sizheng Street and Xiaojie District divide the city into 4 major districts and 23 community districts.

The suburban city of Taiyuan disappeared during the Ming dynasty, and the regular pattern of the state city was disrupted. The South Gate Street and the North Gate Street were connected. The West Gate Street and the East Gate Street were connected and extended to the Jinwang Palace. The pattern of T-shaped Street gradually shifted to the Cross Street, and the closed “Lifang System” was transformed into an open street-level space. Some streets and lanes between the square and the Fang disappeared into the long river of history, while other streets developed along with the eastward movement of the city center. (Figure 5).

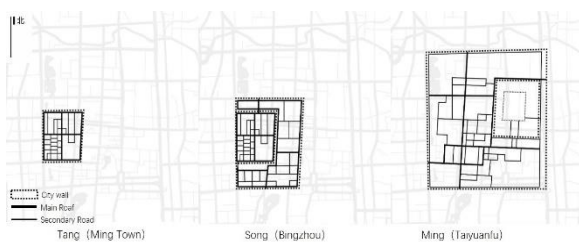


Fig. 5. Taiyuan city street evolution map

3.4. City partitioning

From the city of Taiyuan in the development process analysis, the city functions There are five main types, the first is the Government Office administrative functions on behalf of the rulers of the city administration and political things, responsible for protecting the city safe is the core function of a city, generally located in the city's most important place and is usually not the geometric center; secondly city restaurants trade functions, in order to meet consumer demand for the ruling class and the upper class, "where", "Square" began to

emerge and become the city city restaurants trade area, but also to the people, and opening transactions in goods it is a basic requirement of urban social activities; tied with a square inside residential function, and the people of the most basic requirements of daily life, but also occupy most of the city space function; followed by worship ritual system function, when the settlement developed to a certain extent The function of religious belief came into being and became the spiritual sustenance of the people. In the process of development, Taiyuan City formed an open space based on the lake's water system to meet the needs of the people for their outings and public exchanges at the weekend. These functions were gradually completed during the development of Taiyuan City. The study of changes in urban functional areas in different periods can provide a more comprehensive understanding of the evolution of the city.

The sub-city within the Song State of the Northern Song Dynasty follows the administrative centralized layout of Tangming Township Administration. Within the Luocheng City, the Lifang system and the T-shaped road pattern are adopted. The residence and the barracks are distributed at intervals. The city's streets are arranged on the south gate where the downtown area is more prosperous and concentrated. Lifang is more concentrated at the northern gate. Changes in the spatial pattern of the Taiyuan City during the Ming Dynasty took place mainly in the Wanggong aristocratic houses and city trade. The construction of the Jinwangfu in the northeastern corner of the city changed the administrative pattern of the Taiyuan City's administrative office and became a new political center, which in turn

affected the urban structure. Dagan nobles built government houses in front of the Jinwang Palace to form a new axis, and drove the development of the neighboring city's trade districts, which were linked to the city's old district of the South Gate; the closed Lifang district became an open alley. The market and religious ceremonial space are interspersed with more flexibility.

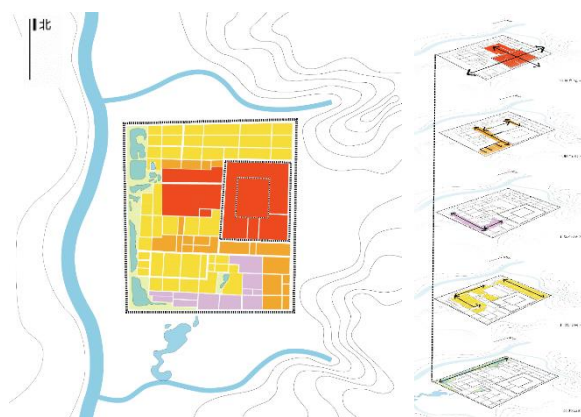


Fig. 4-8. Schematic diagram of the functional distribu

4. Conclusion

Taiyuan City used its advantageous terrain to gradually improve the urban functions through the development from the Northern Song Dynasty to the early Ming Dynasty. It gradually became the regions' political and economic center from a city focusing on the military function and formed a special city scape. This article focuses on the evolution of the Ecological Environment and the urban pattern in the process of Taiyuan City's construction and development. It explores the Ecological city process based on the natural barriers and basements of the Fen River and

the Three Mountains.. The rivers and lakes hills, the city wall boundary, streets and lanes, and the district selection and location are all combined with the Ecological Environment. Using the Taihang Mountain extensions as the official residential area place near the basin with a convenient transportation as the municipal business workshop area, the flat land as the residential area of lifang, place along with the Fen River and its landscapes as etiquette and rituals. City is not an independent part, but closely linked to form a unique urban Ecological.

The city continues to develop. The place of prefectural city still inherited its ancient functions. It forms the political district of the provincial government, the commercial area of Gulou Liuxiang, the cultural temple of the Chongshan Temple, and the residential area scattered on the original site of prefectural city. It inherits and continues the historical functions. Taiyuan has been listed as a historical and cultural city. Research on the ancient city of Taiyuan can help maintain the characteristics of the city and cultural continuation of the city. It hopes to provide theoretical support for the protection and planning of the city.

Acknowledgments

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THE LANDSCAPE RESTORATION OF CHAKA SALT LAKE

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Abstract

The Chaka Salt Lake, 3000 meters above sea level, 200 miles to Xining City, is also known as the “Mirror of the Sky” in China. The existing salt refinery area, built in the 1960's, is a multi-functioning building cluster with an early-new-China architectural style, and includes public primary school, hall, business buildings and residential buildings. The scenic railway for salt transportation has a long history and has also witnessed the developments in the salt industry over 110 years. We can still find the words "Carnegie 1906" on the rusty rails, and display these rails as precious cultural relics in the museum that was renovated from the auditorium.

While the majestic natural scenes in Chaka Salt Lake attracted plenty of tourists to the area, the related damage done by car parking, vendors selling goods and visitors trampling the ground took a terrific toll on the weak ecosystem around the salt lake. The salt bed was broken down, silt was upwelling and the Mirror of the Sky was fading from the scene. Consequently, we were invited to participate in the design of Chaka Salt Lake.

The damage from tourist activity is concentrated on the sides of the lake, so special attention should be paid to the lake sides in the design process. After studying the formation cause of the salt lake and considering tourists' needs, we planned to shift non-core functions like parking, tourist services and vendors to the salt refinery residence zone 700m from the lake district and to add a sightseeing stand and a paddling pool that can separate the activity square from the salt lake, in order to protect the salt lake. Considering thrushes and other plant wetlands in the area, we plan to make good use of reclaimed water to preserve and extend this wetland system, protecting the salt lake. The main foundation of the trail that passes through the lake is a small train; the track foundation is made of straw bags filled with rubble, and paved with timber bunks; no concrete is used.

Buildings with an early-new-China architectural style, like the auditorium and primary school have been preserved and renovated into a tourist center and museum. Open space between buildings are renovated into a welcome square and distribution transfer square which can serve a daily capacity of 40,000 tourists. Steel frames are used to connect the existing buildings into a whole, to highlight industrialization characteristics and provide shade

facilities. All existing trees are preserved. Salt-transporting infrastructure extends to the transfer square in front of the auditorium, providing a convenient system for visitors.

Sensitive Land; Restoration; Chaka Salt Lake

1. Project Overview

Chaka salt lake (Graph. 1.), a scenic area west 200 miles to Xining City, had experienced a rags-to-riches story from 2013 to 2015. Its resources amenity attracted 160,000 visitors in 2013, 480,000 in 2014 and 1.1 million in 2015. The booming tourists brought in considerable benefits to the local economy. However, the rise in economic development was followed by a series of problems. On one hand, excessive tourism exerted unbearable press on the salt lake (Graph. 2.), which resulted in a degrading of the habitat of the salt lake. On the other hand, recreation facilities were incapable of supporting such a massive of tourists.

The series of problems in Chaka salt lake aroused highly attention of local authorities. In August 2015, this scenic area was closed and asked to be renovated. The government set an ambitious goal to finish the renovation before June 1st, 2016. By this, limited time is left to the design and construction team. Against this background, project team of Tsinghua Tongheng started to work on this case on September 12th, 2015, which consisted of numerous urban planners, landscape architectures and architectures.

Consequently, we were invited to participate in the design of Chaka Salt Lake. Our work had two primary responsibilities, the first was to better protect and restore the ecosystem of the lake area, and the second

was to resolve the chaos brought upon by the high quantities of tourists.

2. Site Analysis

2.1. Site History

The railway for salt transportation had a long history over 110 years. We could still find the words "Carnegie 1906" on the rusty rails. Furthermore, we discovered salt excavation, salt transporting, and salt refining machinery in the factory. The existing salt refinery area, built in the 1960's, was a multi-function building cluster with an early-new-China architectural style, including primary school, workers hall and residential buildings (Graph. 3.).

2.2. Salt Flat

Our team now had a better understanding of the causes of the Chaka Salt Flat. When water is about 15 cm deep on the salt crust, it will get the strongest light reflection. On days where there is no wind, the lake would create a beautiful mirror, reflecting the surrounding mountain, the blue sky, and everyone who stands on it.

2.3. Nature's Force

The damage done by car parking, vendors selling goods and visitors trampling the ground took an enormous cost on the weak ecosystem around the salt lake. The salt bed was broken down, silt was upwelling and the Mirror of the Sky was fading from the scene.

Our team found that the edge of the lake was the most vulnerable area, which was badly destroyed by tourists. Normally, it

2.4. *Tourist Reception Area*

We were shocked when we first arrived at the site. The local government planned to demolish a large area of existing buildings so that there would be sufficient place for a new tourist reception center. These old buildings, such as the primary school, hotels, workers hall, could date back to the 1960s and 1970s. Previously, they serviced workers as a small community. The demolition would definitely cost a sum of money and bring with complaints and even protest. Thus, we must find a new route which can meet the requirement of the new development while protecting the existing buildings.

3. **Scheme generation**

3.1. *Layout*

Our team first measured the distance between the existing old buildings and the edge of the lake. The 700-meter length was an acceptable distance for walking (Graph. 4.). The existing public buildings – which included the Workers Hall, Primary School, Hospital, and Hotels – would all be converted into new amenities and visitor center (Graph. 5.).

The playground of the primary school would be used as a new plaza (Graph. 6.). The old school building would be converted into a ticket center (Graph. 7.). Workers Hall would be transformed into a Salt Museum (Graph. 8.). The basketball courts next to the

was difficult for this area to form the salt shell through crystallization on account of the fluctuating water level.

hall would serve as a transfer center for electric vehicles and small trains.

The plaza in front of the hall would be used as a venue for festivals and tourist activities. Even the medical center would be converted into a youth hostel, with 80 available beds.

And finally, salt machines would serve as landscape features (Graph. 9.). Steel corridors linked all of these old buildings and features together. It not only functioned for strength and structural integrity, but also provides shelter from severe weather conditions.

3.2. *Protection Priority*

Due to the lake's unstable edges, our team utilized two methods to protect it from further deterioration.

The first method tapped into ecological restoration. We devised a 600-meter ecological restoration area within the site (Graph. 10.). We then used straw bags filled with gravel to create a cofferdam, stabilizing water levels. This design also accelerated the speed of crystallization, aiding in the recovery process of the salt flat landscape.

The second method was through designed navigation. Understanding that tourists are eager to interact with the salt flats directly, our team designed artificial pools between the plaza and the edge of the lake, which acts as a barrier to prevent direct contact with the flat (Graph. 11.).

Additionally, after considering the lake's salt layer structure, tourists are now not

permitted to approach within 1km of the lake's shore. The salt layers further than 1km from the shore are quite thick, some parts reaching a thickness of 30m, in these areas tourists can have a more pleasant environment to enjoy the beauty of the "Mirror of the Sky."

Acknowledging the limits of the ecosystem's carrying capacity and the distribution of space, we still strictly controlled the quantity of tourists coming into the area. The daily maximum amount of allowed tourists is now 40,000, which has both protected the lake, and ensured a high quality and comfortable experience for the tourists.

3.3. *Special Technics*

Poor engineering conditions coupled with tight schedule forced our team to adopt a fast and sustainable construction and mechanical system. The lake itself would integrate a specialized mechanical technology system to aid in salt flat recovery.

Traditional technics were used both on the boardwalk and dock. Sloped boardwalks were made up of straw bags filled with gravel, which could withstand lake erosion. Walkways and ground material varies according to traffic flow: sleeper pavement, sleeper salt combination, salt. All of this can be recoverable easily (Graph. 12.).

The flexible paving with geogrid and gravel is beneficial to the infiltration of rainwater in parking lot. It would reduce ground subsidence caused by winter construction. The team used sureblock bricks as the garden wall design feature to reduce construction lead time, and selected local

stones as foundation and structural material to reduce transporting time from off site.

4. **Implementation effect**

From October 2015 to June 2016, which includes 6 months of winter construction, we completed the project. 240,000 square meters of lake was dredged and repaired, 10,000 square meters of artificial pond was constructed, 110,000 square meters of new pavement was laid, and the new 2 km Lake Road was created. Not to mention the 100,000 square meters of parking lot and 10,000 square meters of building façade renovation and interior design also rounded out the project build.

On June 1, 2016, Chaka Salt Lake Scenic Spot was opened on schedule. In October 2016, Chaka Salt Lake was rated a Class 4A Scenic area. In December 2016, it was awarded the "Best Order" scenic spot by the National Tourism Administration. In 2016, Chaka Salt Lake received 1.7M visitors, totalling \$15M USD, doubling from the year before.

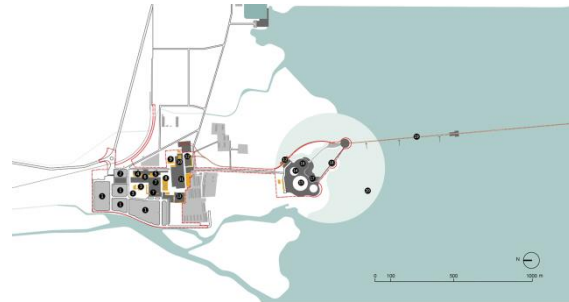
5. **Conclusions**

The concept of conservation priorities and local modification techniques effectively solved the problems encountered in the development of Chaka salt flat, which can provide a reference template for the restoration of ecologically sensitive scenic spots.



Chaka Salt Flat
 Tourists in the "Mirror of the Sky".

Graph. 1. Tourists in the "Mirror of the Sky"



Master Plan
 ● Parking Lot ● Gallery/Frame ● Old Hall Square ● Sky Mirror Square
 ● VIP Parking Lot ● Welcome Plaza ● Little Train Station ● Padding Pool
 ● Hotel ● Visitor Center ● Container Market ● Salt Sculpture
 ● Administration Building ● Youth Hostel ● Viewing Platform ● Board Walk
 ● Temporary Visitor Center ● Museum ● Prayer Flags ● Ecological Restoration Area

Graph. 4. Master Plan



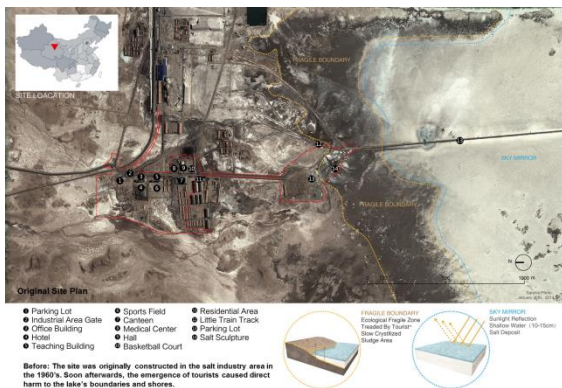
Existing Context
 Before: "Mirror of the Sky" was damaged by tourists and the dilapidated salt refinery plant area.

Graph. 2. Salt refinery plant area



Birds' Eye View after Construction
BEFORE ● Bottomland ● **AFTER** ● Parking Lot ● Entrance Mark ● Hotel ● Sports Field ● Welcome Plaza ● Office Building ● Teaching Building
BEFORE ● Medical Center ● Hall ● Basketball Court ● Little Train Track ● Parking Lot
AFTER ● Youth Hostel ● Museum ● Little Train Station ● Board Walk ● Sky Mirror Square

Graph. 5. Birds' Eye View after Construction



Original Site Plan
 ● Parking Lot ● Sports Field ● Residential Area ● Little Train Track ● Parking Lot ● Salt Sculpture ● Basketball Court
 ● Industrial Area Gate ● Office Building ● Medical Center ● Hall ● Teaching Building
Physical Boundaries
 Ecological Fragile Zone
 Reached By Train
 Blue Crossroad
 Budget Area
30% permeable
 Sunlight Reflector
 Drainage Water 150-100mm
 Salt Disposal

Graph. 3. Original Site Plan



Revitalization
 The red bricks and irons at the entrance of the scenic spot give the area an intense post-industrial style.

Graph. 6. Entrance of the scenic spot



Revitalization
 The new gallery and preserved big trees can prevent strong sun radiation at such a high altitude.

Graph. 7. Ticket office and plaza



Bird's Eye View of the "Mirror of the Sky" Plaza
 Protection: The plant area has been renovated into a tourist center. An artificial paddling pool is built to provide a viewing platform while protecting the "Mirror of the Sky" from damage, making it purer and serener.

Graph. 10. Ecological restoration area



Revitalization
 The exterior of the hall has been cleaned by high pressure water system. The interior has been renovated into a history museum of salt industry, and the visiting ends up with the projection of a documentary film.

Graph. 8. Workers hall convert into salt museum



Protection
 The renovated site now allows tourists to play in the pool while enjoying the beauty of the salt lake.

Graph. 11. Artificial pools



Revitalization
 Revitalization: the auditorium and the infirmary are renovated into a museum and a youth hostel. The old machine that exhibited on the plaza ground reveals the industrial history.

Graph. 9. Workers hall plaza



Protection
 The original transportation tracks are now used as tourism roads, preventing damage from additional construction.

Graph. 12. Special boardwalk

Landscape Design for Ciliwung Riverside in Sudirman Business District Central Jakarta Indonesia

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Abstract

Jakarta is the capital city of Indonesia with a high population density. This phenomenon gives social and environmental problems such as crimes, flood, traffic jam, and pollution. Jakarta passed by many rivers, the river as one of Jakarta open space also give contribution for city's environmental problems. It is can be resolved by a good space utilization. Ciliwung riverside area is an open space that has potential to be developed. Therefore, it is necessary to study the Landscape Design for Ciliwung Riverside in Sudirman Business District Central Jakarta Indonesia. With the establishment of a riparian park, the park is not only provide aesthetic functions, but can be used for ecological function and as a space of social interaction. The purpose of this study are to identify the conditions and characteristics of the landscape at the site, analyze and make synthesis at the site to get the appropriate space, and make the concept and design of the riparian park. The study is using the method of Gold (1980) with adjustment. The main concept of this design is green urban framework, which is simple, futuristic, and give more spacious visual effect by put some sculptural form in the site. The landscape design is using several concepts as its development concepts such as city view concept, waterfront concept and pedestrian concept. The design also gives the identity for the park by it green sculptural form such as photo frames for user, framing the artworks and framing the plants.

Keywords: riparian park; urban landscape; central business district

1. Introduction

Jakarta is the largest metropolitan city in Indonesia. It has an area of 664.1 km² and population of 10,036,939 people. The current situation is getting worse as population of Jakarta grows rapidly year to year. Central Bureau Statistics of Jakarta 2015 mentioned that the current population of Jakarta increases by 105,760 people per year. Can we imagine the condition of Jakarta in the following ten years if it remains this way? This phenomenon raises the problem of population, spatial, and environment.

The increasing number of the population results in the decrease of environmental carrying and supporting capacity in Jakarta. It triggers the occurrence of floods, traffic, increasing pollution and even criminality. One effort that can be carried out to improve the quality of urban environment is by managing the riparian area. According to Presidential Decree of the Republic of Indonesia No. 32 of 1990, riparian area is the area along the right and left side of the river, including artificial river/ canal/ primary irrigation canal, which have important benefits for maintaining the sustainability of river functions. Furthermore, Presidential Decree of the Republic of Indonesia No. 32 of 1990 and Government Regulation of the Republic of Indonesia No. 47 of 1997 set the width of the river path in which it is sufficient for the inspection road; around 10-15 m. Therefore, it is necessary to improve the spatial management of Jakarta, especially in riparian areas as an effort to improve the quality of the environment.

Arranging and managing the riparian areas in Jakarta are still lacking in action. Many empty riverside areas are utilized by communities without permits. The utilization is not appropriate and even damaging the environment. The form of management that can be carried out is to utilize the riparian areas into a riparian park. According to Big Indonesian Dictionary (KBBI), riparian means edge, in this case riparian means the river bank.

One of the underutilized riparian areas is Ciliwung Riverside in the Sudirman Central Business District of Central Jakarta. In addition not to be well-managed, the riparian area of Ciliwung River is a central business district with dense activity so it is appropriate to be used and designed as a park. By having the park, it is expected to be a new place for the city community, especially around the site such as office workers and residents in doing their activities and enjoying their leisure time. The location is strategic; it is in the middle of central business district. In addition, there are two stations directly adjacent to the site that make it has the potential to become a functional park. The design of riparian park of Ciliwung River can be a pilot of a functional and aesthetic riparian park design in the central business district. It is the background of the study of "Landscape Design for Ciliwung Riverside in Sudirman Business District Central Jakarta Indonesia."

2. Objectives

The objectives of this study are as follows:

1. Identify the landscape conditions and characteristics on the site

2. Analyze and synthesize on the site to obtain the appropriate space
3. Make the concept and design the riparian park of Ciliwung River in the central business district at Sudirman Street, Central Jakarta

3. Research method

3.1. Research setting and time

This study was conducted at Ciliwung river bank in Menteng Sub-District of Central Jakarta. This study was conducted from April to August 2016. The orientation map of the research setting can be seen in the following Figure 1.



Fig. 1. Research Setting.
 Source: <http://google.maps.com>

3.2. Research Method

The study was conducted by referring to Gold's (1980) designing process with some adjustments of preference method of potential users of the site on preliminary design to obtain the final design. According to Gold, conducting the design required inventory data, analysis, and synthesis that could then be used as a reference to produce a design. The following are the description of the methods used in this study. The methods used in this study were as follows:

1. Inventory of primary and secondary data through survey, interview, distributing questionnaire, and literature study through books, undergraduate thesis and graduate thesis.
2. Analysis and synthesis using descriptive analysis method and spatial analysis, including: physical, biophysical, and social aspects to generate the arrangement of zoning and the concepts.
3. The concepts to be developed were basic concepts, design concepts, development concepts, vegetation concepts, circulation concepts, visual concepts and form-pattern concepts. The concepts had been made into a reference in making the design development. The end result of this stage was the block plan of the concepts concatenation that had been made. The first entry in this list
4. Design
 - 4.1. The preliminary design referred to the block plan. All three alternative designs were then selected one to be a site plan with the interview method of the potential user preference on the site. According to Gay and Diehl (1992), this interview was conducted on 30 respondents. The chosen design alternative was made into a site plan and the basis of design development.
 - 4.2. The design process was continued with the design development to obtain the detail of the design.

4. Findings and discussion

4.1. General Condition

Physical and Biophysical Aspects

The research setting was located along the river banks of the Ciliwung River on the bridge of HOS Cokroaminoto Street to the bridge of KH Mas Mansyur Street, Menteng Sub-District of Central Jakarta with an area of ± 1.8 hectares and with length of 1350 meters. The northern boundary of the site was the railway line from Mampang Station and Sudirman Station to Karet Stations. The western boundary was the bridge of KH Mas Mansyur Street. The southern boundary was Galunggung and RM Margono Djojohadikoesoemo Streets while the eastern boundary was Ciliwung River. The average height of the site was 1 mdpl. There was a quite high flood retention level on the site of 1 meter which blocked the view from the site toward the river. The soil of the site was the alluvial soil mixed with the remaining soil of the embankment construction. The hydrological condition of the site was quite good because it had a fairly high contour and had been completed by the embankment so that it was not affected by the flood. The site had an average temperature of 28.1°C, average rainfall of 332.8 mm/ month, and 70%-85% of humidity.

Vegetation on the site was mostly planted by related agencies and already had a fairly regular planting pattern with the function as the shade and absorber of the pollution. The vegetation includes *Tabebuia Chrysantha*, *Cocos Nucifera*, *Tamarindus Indica*, *Delonix Regia*, *Samanea Saman*, *Swietenia Mahagoni*, *Muntingia Calabura L.*, *Erythrina Crista-galli*, *Plumeria Rubra*,

Spathodea Campanulata, *Eucalyptus Deglupta*, *Mangifera Indica*, *Cerbera Manghas*, *Ficus Benjamina*, *Polyalthia Longifolia*, *Pometia Pinnata*, and *Tectona Grandis*. Animals on the site were the animals that naturally presented in river bank ecosystems such as snakes, rats (*Rattus Norvegicus*), and frogs (*Fejervarya Limnocharis*).

The research setting was directly adjacent to the entrances and the exits of Sudirman and Karet Railway Stations so that it was an easy access for railway station users. Access to the site was for pedestrian only. The circulation conditions on the site were mostly natural pedestrians without any pavement.

Social Aspect

The majority of site users were office workers. There were also street vendors selling around the site. The site was adjacent to two stations so that the site had the potential to become a new place in the center of the city. In addition, there were also routine activities held every week; it was car free day. In regard to that matter, the site was very potential to facilitate the activity. Based on the results of interviews with some users of the site in which the majority of them were the office workers, it was expected that the design of the park on Sudirman Street was not only a decorative park but also can facilitate the users of the surrounding site.

4.2. Analysis and synthesis

Physical and Biophysical Aspects

The site was a riparian area located in the Central Business District area and directly bordered with two railway stations that

potentially had many visitors when it was used as a park. The park could be used as a pedestrian lane for railway station users and as a rest area for the surrounding users in which the majority of them were the office workers who took a break from the hustle and bustle of the city.

The topographical conditions and the flat tread slope making it suitable for the park. Obtaining the comfort of the space and the aesthetics of the park could be performed by soil dredging until the soil surface was flat to the embankment limit. By changing the height of the soil on the site, the park would also be more comfortable because the user can be more free and enjoyable in taking a look around the site. In addition, the surface of the site became more visible from the outside, so the site will look better. The existing site conditions and the site conditions with grading can be seen in Figure 2.



Fig. 2. Illustration of the existing and after-grading site topography

Based on the average annual climate data on the site, the site was quite hot. According to Robinnete (1993), a comfortable air temperature for humans was 21°-27°C. It meant that the air temperature at the site was less comfortable. Then, according to Laurie (1986), the ideal humidity was 40-75%. Meanwhile, the humidity of the site was about 70-85% and it had entered human discomfort. Average wind speeds of 11.2 km/h were quite moderately moving from south to north, and the direction of the sun

moves from the east side of the site to the west.

Existing vegetation contained on the site had a function as shade, control and wind controls so it would be maintained and rearranged to make it more interesting. It was necessary to add functional and aesthetic vegetation such as screen/ border vegetation, sound suppression vegetation, and identity vegetation. Animals found on the site included snakes, rats, and frogs in which must be reduced because it will disturb and endanger the park's visitors. Animals such as birds were few and needed to be maintained.

Accessibility on the site could only be

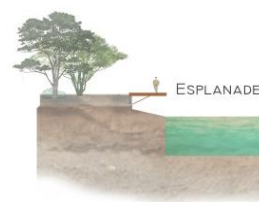


Fig. 3. Illustration of waterfront made up of four entrances. These four entrances must be maximized for the accessibility to the site. All entrances should be widened, easily visible and accessible. Near the railway station should be given more close-to-the-inside room and entrance to make room for the crowds of the station.

The potential (good view) on the site such as Green open space on the beautiful site can be utilized. Along the south side of the site, there was Ciliwung River which could be utilized its potential appropriately as a river view and be made its esplanade to explore the water feature. The most prominent thing was the view of the city scape of Central Jakarta.

It took a lot of time making the facilities and utilities of the park. A park must meet

several facilities such as parking lots, security posts, hygiene facilities, toilets, water installations, electrical installations and drainage systems (Hakim and Utomo, 2004).

Social Aspect

The social aspect was analyzed based on social principles in designing the garden based on what was mentioned but Lennard (1987) by having some adjustments for the user preferences as the following:

1. Provide security and easy access for users

The security in the tread was still very poor so there must be a special guard post to manage the site so that the park user could feel comfortable and feel more secure.
2. Facilitate the function of the space as a social place

The majority of respondents wanted a social impact from the park. One of the social impacts was to provide new places to gather in the middle of the hustle and bustle of the city. In addition to the social function, the respondents also wanted a park function for sports, community parks, decorative parks and other park functions.
3. Direct and facilitate community activities

Based on its location, the majority of the users around the site were office workers around the site. This site was potential as a pedestrian access connecting the offices on HOS Cokroaminoto Street to Sudirman Railway Station. It also connected Sudirman Railway Station to the offices on KH Mas Mansyur Street.

There were routines on every Monday around the site; it was car free day. The park of this site allowed such activity because the site was directly bordered with Sudirman Street which becomes the implementation place of such activities. To facilitate the activities of car free day, it must be provided with adequate pedestrian in the site because all people walk for sports.

4.3. Concept

The basic concept of riparian park design of Ciliwung River was a park that provided pedestrian facilities and a place to rest for a moment to the users of the site whom the majority of them were office workers. The design of this park optimized city view and waterfront on the site.

The design of this site included in the urban design. It was based on the site location which was in the middle of central business district and downtown. The concept of urban flow design was in accordance with this site because it met the criteria of the theme and the needs of the site in which it accommodated the movement of the office workers. The concept of the design was simple, futuristic and would also make an impression of wider area of the site.

4.4. Development Concept

1. Waterfront concept. In the application of the design, this concept was applied by turning the gazebo and bench view directions to the waterfront. Another development was by developing an esplanade. This esplanade would be developed slightly indented to the waterfront so that the park users will get

different sensation on it. The promenade could not be applied because the water surface of Ciliwung River was very volatile.

2. City view concept. The site had a nice city view so that the potential will be maximized in this design. The design would maximize the borrowing scenery of city view. The application of the design was by not creating a barrier that can block the view. In addition, the placement of the bench and gazebo must face the city view as well.

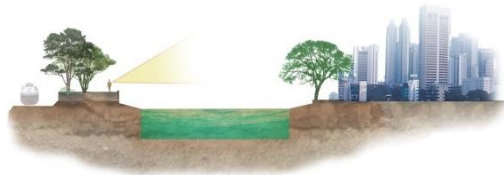


Fig. 4. Illustration of city view

3. Social space development concept. Based on respondents' preferences, most of them expected that the park had also social functions such as hangout and relaxation. The arrangement of bench at some point would be the user place to gather around.
4. Vegetation concept. The vegetation concept of this site largely followed the analysis and synthesis that had been made before and adapted to the development concept. Some concepts of vegetation to be applied were:

4.1. Aesthetic vegetation

Aesthetic vegetation on the site should not make the site to look narrower. Aesthetic vegetation to be made was vegetation with rare canopy and palm vegetation to make the site more spacious. Shrub vegetation was



IFLA World Congress Singapore 2018
 Fig. 5. Illustration of aesthetic vegetation concept

minimally carried out because it reduced the space.

4.2. Guide vegetation

The guide vegetation would be very prominent in the welcome area of the site. The design of the welcome area that formed the corridor of the plant desperately needs the role of the guide vegetation. The vegetation used was



Fig. 6. Illustration of guide vegetation concept

Thuja Orientalis.

4.3. Shade vegetation

In this study, the shade vegetation to be used was the existing vegetation. Most of the existing vegetation was shade plants, such as flamboyant, rain tree,



Fig. 7. Illustration of shade vegetation concept

and cape.

4.4. Screen/ border vegetation

The meaning of border vegetation in this study was the vegetation whose function as a barrier between the site with the railway. This vegetation was expected to reduce the noise and air pollution from the trains.

5. Circulation concept. The pedestrian would be made wider because of the high



Fig. 8. Illustration of aesthetic vegetation concept

intensity of users around the site. Pedestrian on the site was designed widely to anticipate the site user from Sudirman and Karet Railway Stations. In addition, there was a routine car-free-day activity held at Sudirman Street on Sunday. The location was directly border to the site so the pedestrian on site would also be designed to facilitate that activity.

6. Visual concept. The arrangement of other vegetation and landscape elements of the site was designed not to disturb the user's view of the site towards the waterfront and city view. The visual concept was designed not to deviate from the concept of waterfront and city view development. The visual concept of this design would still provide its own aesthetics and character for the visual aspect from the outside of the site.
7. Color and shape pattern concept. According to the survey results, the pattern to be used was a flexible organic pattern. Moreover, the color concept would be designed in harmony with the basic concept of this park design to provide comfort for users to relax. The colors to be used were cool colors that give the impression of calm, comfortable and refreshed and analog color (adjacent color mix), such as neutral and not flashy

colors. The basic colors of this design were green and brown because the two color were dominant as plants, soil and river water in the site existing.

5. Design

5.1. Preliminary design

Site plan began by creating three preliminary designs that would be selected based on respondent's preference. From the preference results, it could be concluded that the most preferred preliminary was preliminary 1 that was chosen by 53% of respondents. So, the site plan would be made according to preliminary 1. Three preliminary design can be seen in the following Appendix 1 and site section can be seen in the Appendix 2.

The survey was conducted for two days on weekday and holiday with the number of respondents 30 people per day. The number of respondents was chosen based on the theory of Gay and Diehl (1992) that the number of representative minimum samples in correlational research was 30 subjects. Pedestrian design.

5.2. Welcome area design

Welcome area design of this park was green corridor concept. The corridors were formed from pine trees that were arranged lengthwise. The aim of this concept was to provide a clear boundary between the inside and outside of the site so that park users enter the park in a new refreshing atmosphere.

5.3. Esplanade design

This esplanade served as a resting area for the user so as not to disrupt other pedestrians. Promenade would not be made in this site because the water level of Ciliwung River was fluctuated and it was feared to be a danger area on the site.

5.4. Social space design

The social space of the site was applied to the gazebo and bench. All designs referred to the initial design concept of urban flow. The shades on the site were considered as sufficient for the standard of comfort.

5.5. Park design

The park of the site referred to the design concept. The application on the site was by the use of plants that did not vary in term of color. It was enough for adjacent colors so it had a simple impression. The selection of plants had not much variation so that it would be more simple became the identity of the site at the same time. Perspective view illustration can be seen in the following Appendix 3-6.

Conclusions and suggestions

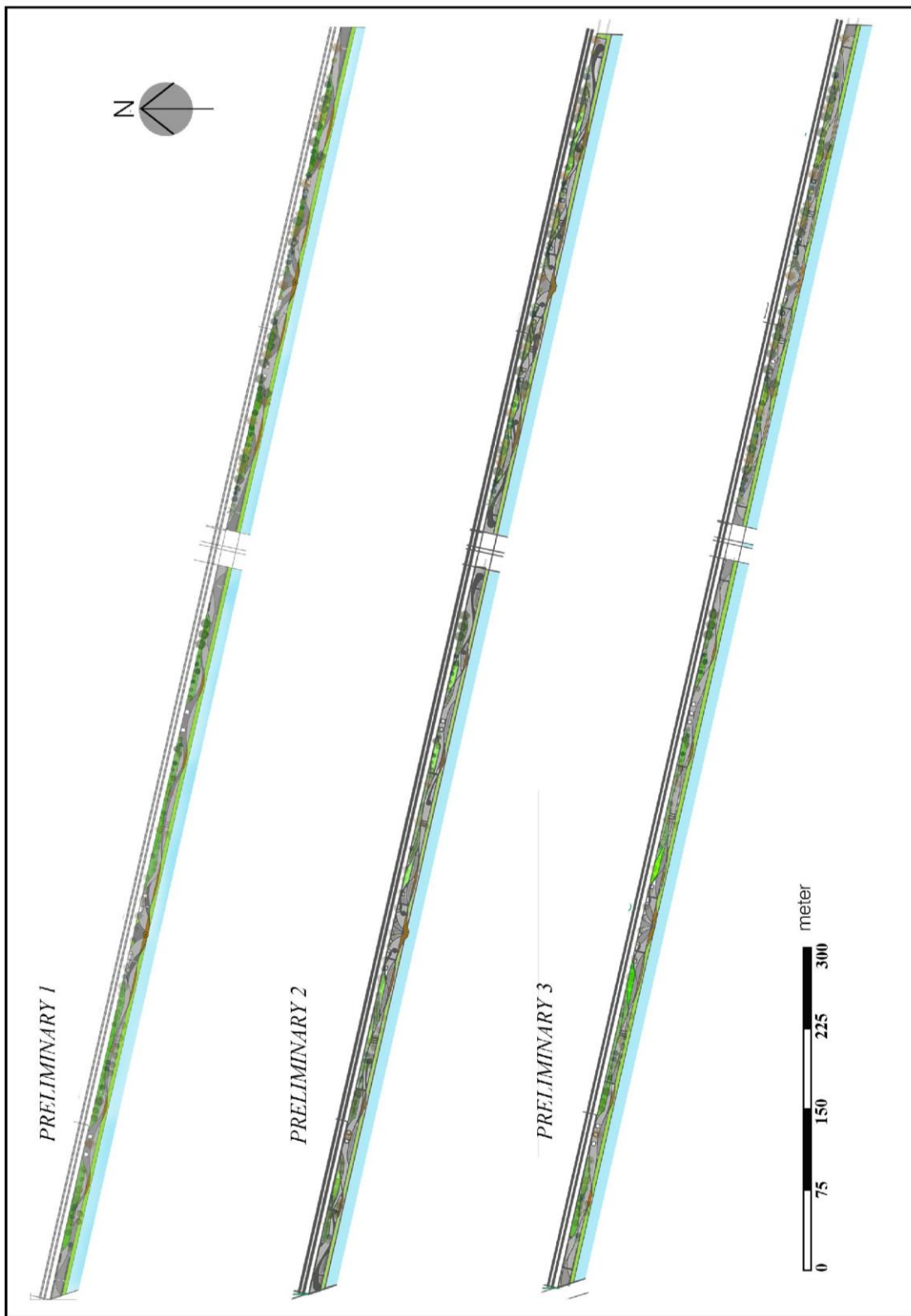
The site was located in the central business district which had a high enough density. This site connected the central business district of Sudirman Street, HOS

Cokroaminoto Street and KH Mas Mansyur Street. There were two railway stations on the site namely Sudirman and Karet railway stations. Therefore, it required appropriate road access and space facilities as a social place for gathering and relaxing for the majority of the office workers. The design concept applied the urban flow concept. The development concept applied to the site was the concept of city view, waterfront and pedestrian parks. The vegetation design of the garden, gazebo, and other buildings on the site was designed not to spend so much space so the site impressed widely.

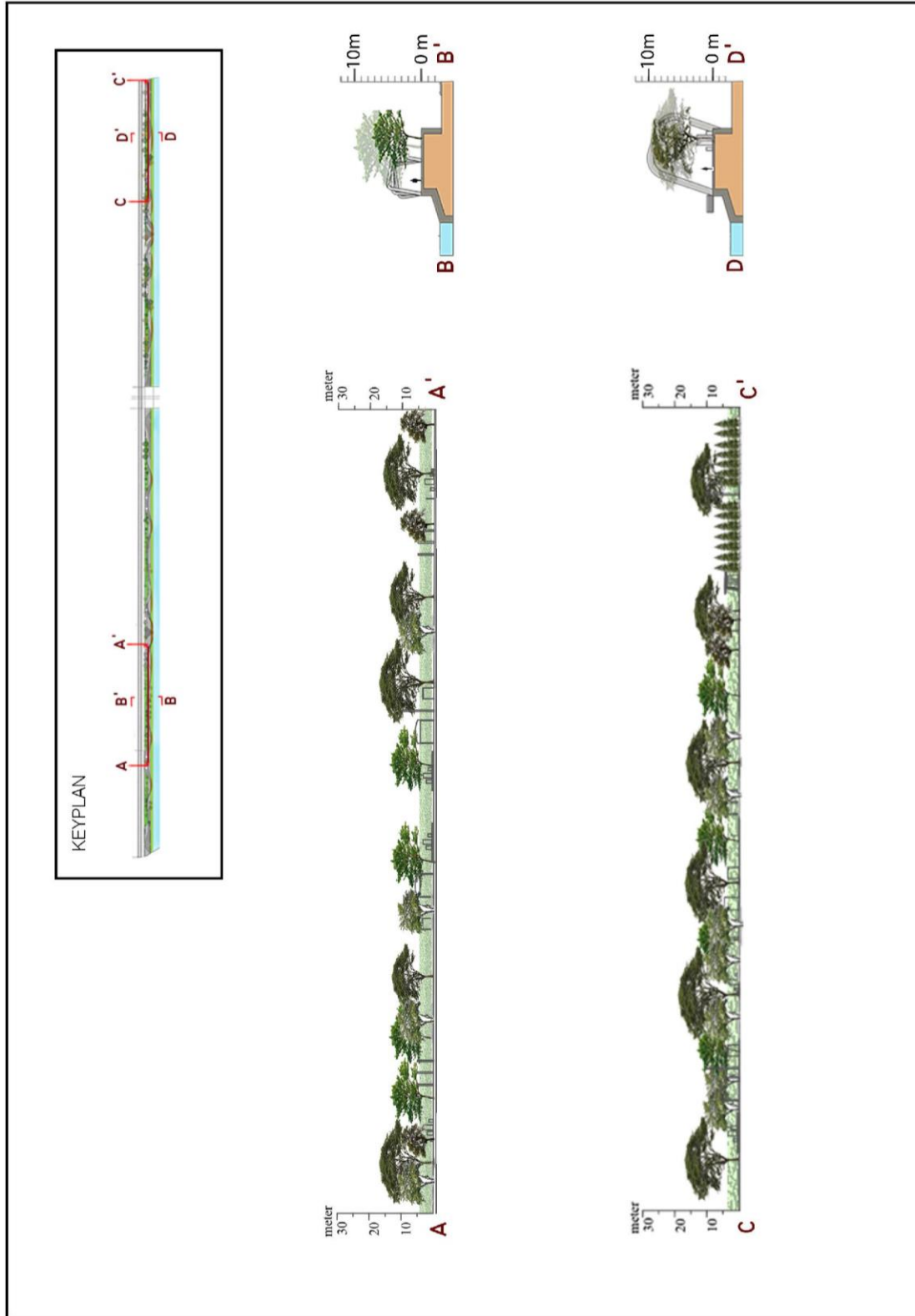
Designing the park in the central business district needed to pay attention to the characteristics of the surrounding user activities and the facilities required by the site users. Thus, it will provide the appropriate space function. Green open space on riverbank must be realized in accordance with the applicable regulations. Community and urban planners should work together to create a new space in the city center to optimize land use and the available space to have appropriate function.

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Appendix. 1. Preliminary Design



Appendix . 2. Section plan



Appendix. 3. Perspective view illustration 1



Appendix. 4. Perspective view illustration 2



Appendix. 5. Perspective view illustration 3



Appendix. 6. Perspective view illustration 4

Explorative study on benefits of vertical landscape to achieve sky rise interior spatial quality in terms of thermal, acoustic, visual and air quality in urban areas

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Abstract

It has been known for some time that the benefit of greenery in urban spaces extends to many facets of public and private life. The more recent implementation of sky rise greening in the form of vertical greenery has highlighted even more the ways in which landscaping can become an integral part of urban development, ensuring communal interaction with the natural world. As one proponent of green spaces has emphasized, “The integration of the living, organic systems are characterized by green walls and green roofs, with the inorganic and lifeless structures that have come to dominate the modern architecture, holds the promise of a new type of living architecture and interior. Especially sky rise building interior spaces need lot of energy to function the spaces as those are filled with thermal uncomfortable areas, poor air quality, acoustic issues and poor visual quality. If vertical landscape is applying to the high rise building’s exterior and interior, the interior can be maintained good manner in thermal, acoustic, visual and air quality.

Key words –sky rise vertical landscape/ sky rise interior

1. Introduction

It has been known for some time that the benefit of greenery in urban spaces extends to many facets of public and private life. Vertical and rooftop gardens are not a new concept; they have provided occupants with shade, aesthetically pleasing views and functional live façade create diversity and fresh feeling to the building user.

During more recent implementation of sky rise greening in the form of rooftop gardens and vertical greenery have highlighted even more the ways in which landscaping can become an integral part of urban vertical development, ensuring communal interaction with the natural world. As one proponent of green spaces have emphasized that, “The integration of the living, organic systems are characterized by green walls and green roofs, with the inorganic and lifeless structures that have come to dominate the modern architecture, holds the promise of a new type of ‘living’ interior”. Further green building rating systems are trying to implement and maintain energy saving buildings to the world and during that journey vertical landscape plays a big role.

Especially sky rise interior spaces need lot of energy to function the spaces as those are filled with thermal uncomfortable areas, poor air quality, acoustic issues and poor visual quality.

When we consider about the urban areas, if vertical landscape is applying to all the high rise buildings, urban heat island effects can



Urban heat island effects -01



Existing city view – Hong Kong city-02

be reduced effectively. Vertical landscape applied sky riser’s interior is having good thermal, acoustic, visual and air quality. With all these the building interior quality improvement can be maintained with low energy.

Objectives

- Built-up connectivity in-between sky rise interior and vertical landscape.
- Get more benefits from vertical landscape to the sky rise interior.
- Identify the issues in sky rise interior spaces.
- Analyze sky rise interior spatial issues through thermal, acoustic, visual and air quality
- Find out solutions to improve urban sky rise interior spatial living quality by the vertical landscape.

Method

Best on a literature review by exploring the building's interior spatial quality with vertical landscape and without vertical landscape based on interior thermal quality, interior acoustic quality, interior visual quality and interior air quality.

Result

Based on the literary evaluation of the sky rise with vertical landscape and sky rise without vertical landscape, we can find changes based on interior thermal quality, interior acoustic quality, interior visual quality and interior air quality.

2 Environmental issues with sky risers

Together with many social and economic benefits of urbanization, there are also environmental problems. Cities comprise less than 3% of the Earth's surface, but there is an extraordinary concentration of population, industry and energy use, leading to a massive local pollution and environmental degradation. In the cities, approximately 78% of carbon emissions are due to human activities. The ecological footprints of cities (through emissions, consumption and other human activities) go far beyond their urban boundaries to forests, agriculture, water and other surfaces, which supply their residents so that they have an enormous impact on the surrounding rural, regional and global ecosystem.

Cities are therefore centres of consumption (energy, materials ...), greenhouse gas production, waste and emissions of pollutants in water and air. Ecological and sociological footprints of cities have expanded over increasingly large areas and created urban - rural continuum of communities, who share similar aspects of individual lifestyles. There are less and less areas in the world which are not under the influence of the dynamics of cities.

The world faces enormous environmental challenges in terms of climate change, resource use and protection of the natural environment. Urban areas have a high environmental impact that can be felt globally, as well as within its own borders.

With regard to these environmental issues, urban sky risers are having interior spatial issues which are based on thermal quality, acoustic quality, visual quality and air quality.

Thermal issues- sky risers create heat island effects with building materials in city areas. Most of the sky rise interiors are having full glass windows and those openings are getting more sun light to the interior which results in creating thermal uncomfortable situation in the interior. And also sky rise building's envelope exposes to more sunlight without any barrier and building material temperature goes up and eventually leads to an uncomfortable building interior with high temperature.

Acoustic issues- sky risers which are located in middle of the city areas with heavy traffic road network and motor vehicles are disturbed by large and endless noise throughout the day. And also aircraft and building construction sites are producing significant sound pollution which creates an uncomfortable acoustic quality in interior.

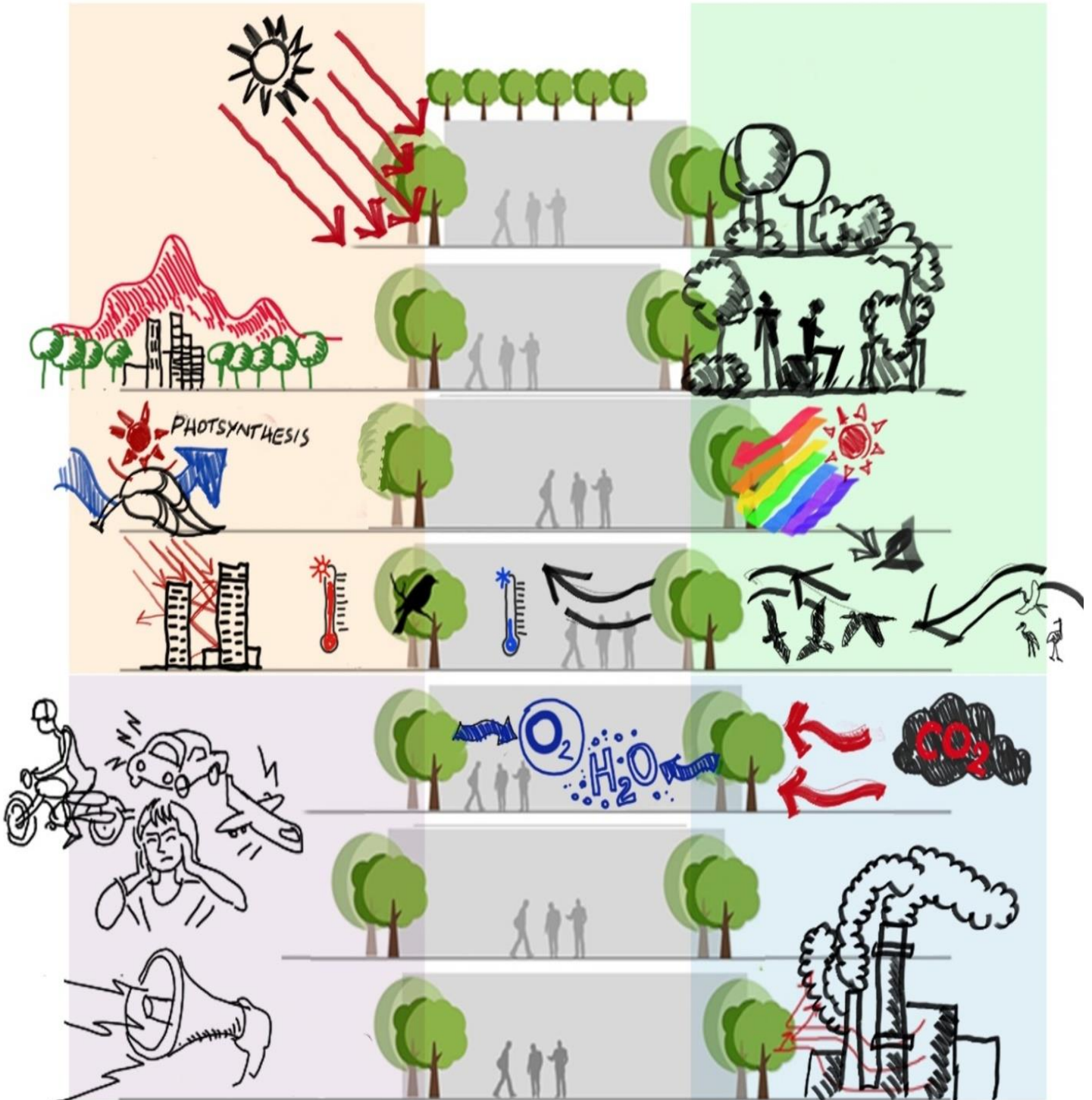
Visual issues- The visual quality of sky risers has created with the materials such as glass, steel, cement, cladding, etc. It looks dry and dull without soft landscape. Windows without green background do not create a fresh feeling and it always creates a grey feeling and aesthetic imbalance.

Air issues – Most of the city area are having polluted air, because of large number of vehicles and other human activities. In this

situation, sky rise interiors have also affected by this polluted air and most of the time, interior spaces are not using fresh air as interior oxygen level goes down and carbon dioxide level goes up. In this type of situation, people feel uncomfortable which results in *sick building syndrome*.

Benefits of vertical garden

- Reduces urban heat island effect and cleans outside air of pollutants and dust and offsets the carbon footprint of people and fuel emissions
- Cleans interior air space by removing VOCs and other harmful toxins like benzene and formaldehyde
- Acts as a sound proofing barrier
- Soil and plants are a natural filter that can clean the water that flows through the wall
- Insulates and cools the building envelope, as well as protecting it from the elements
- Creates habitats for birds and beneficial insects, increasing biodiversity
- Can be used for growing food in urban settings, creating sustainable and local control of food sources
- Increases real estate value
- Reduces sick building syndrome in the workplace and boosts employee morale
- Opportunity for building passive cooling methods



Vertical landscape issues and benefits-03

5. Conclusion

The purpose of this research was to highlight the benefits of vertical landscape in creating a better living environment in the urban vertically developed building interior spaces. Currently urban areas are having many vertical developments and with these we have faced many environmental and spatial issues. As a result of this scenario, building developers have to improve interior spatial quality by using lot of energy in converting it into a livable and working friendly interior space. But applying the vertical landscape for these buildings, in the meantime we can save lot of energy by improving building interior thermal quality, interior acoustic quality, interior visual quality and interior air quality. In this sort of scenario; vertical landscape plays a major role by uplifting interior spatial quality. So this analysis has emphasized that the vertical landscape is having many benefits in urban vertical development.

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7 Acknowledgments

I would like to extend my thanks to many people, who have so generously contributed to the work presented in this research.

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Biophilic Railway Stations: Re-imagine the Nature of Transit Design

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Abstract

Across the world railway stations, transit centres and transport interchanges are rapidly evolving from purely functional transit spaces to new urban centres and destinations, resulting in activity hubs and gathering places. These stations generate high footfall creating life and vitality, and form the centre of daily routines for many urban dwellers. Train stations are places of connection, they are gateways to the city, and can be one of the most exciting places in an urban environment to experience. Some stations make great destinations with shops, restaurants, museums and exhibition spaces. New architecture for railway stations acknowledges the functions of transit; whilst the heritage of place, culture and the surrounding urban spaces can provide excellent public areas to celebrate our innate human connection to nature. Similar to the grandeur of old railway stations, new majestic spaces with biomorphic-inspired monumental elements can include the fundamental pattern language that underpins the principles of Biophilia.

Rail transport infrastructure, especially railway stations, significantly contributes to the quality of human life, sustainability and the economy of urban centres. Station buildings play a major role in efficient and vibrant places, and can be at the forefront of innovation and modernity. Due to the current unprecedented levels of global urbanization, cities and their governing entities are investing in more sustainable public transport systems. The rationale for this investment is to aid reduction in greenhouse gas emissions and, assist economic efficiencies in goods and people movements across and within cities providing better forms of transport, whilst assisting in the creation of improved sustainability and healthier urban environments. New major transit projects massively impact the city fabric, but also provide opportunities to reshape urban environments to include innovative biophilic design.

This paper investigates the opportunities that new transit hubs and railway stations and their associated infrastructure can provide for creating more sustainable and healthy urban environments, through the lens of Biophilic Design. In the foreword of a recent study *Creating Healthy Places* (2017, p9), Professor Tim Beatley raises the question, “*might we re-imagine the very nature of a transit trip? Could it be not simply a trip to work or a travel to the high street, but perhaps a visit to the forest, a chance to hear and celebrate native birdsong, or a chance encounter with a butterfly. Perhaps food production becomes part of transit design, so that one picks a tomato or a desert plum on the way to catch the train. Why not a transit station in a forest?*”

This paper explores the patterns of Biophilia and its application to railway stations. It further benchmarks old and new examples of railway stations across the world against Biophilic patterns, and reflects on the *Creating Healthy Places* (2017) study recently completed for the Metro Tunnel Project in Melbourne, Australia. It concludes with recommendations of key principles to be considered for Biophilia-inspired railway station design that can assist in advancing the larger vision and agenda of ecologically sustainable and Biophilic Cities.

Keywords: Biophilia, Biophilic Design, Biophilic Cities, Railway Station Design, Healthy Cities

1. Introduction

Railway stations and rail transport infrastructure contribute significantly to the economy of urban areas, improving quality of life due to availability of public transport, and increasing the sustainability of cities. Station buildings can play a major role in achieving efficiency and creating vibrancy, and are often at the forefront of innovation and modernity. These buildings are also the hubs of many inner city and suburban precincts, acting as transit centres and transport interchanges which are evolving rapidly from purely functional movement spaces to new destinations and gathering places. Some stations make great destinations with shops, restaurants, museums and exhibition spaces, and railway stations can be the gateways to the city [17, p159]. These stations generate high footfall creating life and vitality, and are the centre of daily routines for many urban dwellers [16].

Due to the current unprecedented growth in urbanization, cities and their governance

entities invest in more sustainable public transport systems to aid the reduction in greenhouse gas emissions, improve economic efficiencies in goods and people movements in and out and across and within the cities, provide better forms of transport, and assist in creating sustainable and healthy urban environments.

Core to the investments in rail infrastructure is the provision of railway stations. These provide opportunities for a new architecture that acknowledges the functions of transit and the heritage of place and culture, while the surrounding urban spaces can provide excellent public areas to celebrate our innate human connection to nature [21].

Similar to the grandeur of old railway stations, new majestic spaces with biomorphic-inspired elements and the principles of Biophilic Design can include the fundamental pattern language [1] that underpins the principles of Biophilia: humans' innate connection with nature.



Figure 1: Grandeur of old railway stations with biomorphic-inspired elements: Antwerpen Central Station. Image Credit: Laurent-Jonathan Meyvaert, 2008.

2. The Innate Human-Nature Relationship

In the *Biophilia Hypothesis* (1986), Edward O. Wilson notes that humans need daily contact with nature to be healthy and achieve longevity. His reasoning was that humans have co-evolved with nature and are part of nature, noting that biophilia is “the innately emotional affiliation of human beings to other living organisms. Innate means hereditary, and hence, part of ultimate human nature” [10]. Biophilia supports the proposition that environments around humans need to include the essentials of

nature to provide us with psychological and physiological health:

Over thousands of generations the mind evolved within a ripening culture, creating itself out of symbols and tools, and genetic advantage accrued from planned modifications of the environment. The unique operations of the brain are the result of natural selection operating through the filter of culture. They have suspended us between the two antipodal ideas of nature and machine, forest and city, the natural and artificial, relentlessly seeking, in the words of the geographer Yi-Fu Tuan, an equilibrium not of this world [19, 21].

Affiliation with nature continues to be critical in modern-day human health and wellbeing literature and practice [7], and has been strongly identified as a valid concern by the health sciences. In the research area of human health and wellbeing, a growing body of research reveals that exposure to nature continues to result in positive health benefits in a wide range of sectors; at work, home, recreation, community areas and even within the urban environments where people work and live [3, 9].

While humans may have an inherent affiliation with nature, the benefits as a result of contact of nature depend on repeated exposure to the elements that generate the biophilic effect. This biological tendency needs to be nurtured and developed to become embedded in contemporary metropolitan environments [9, 12]. One method to develop this affiliation is to design places that facilitate the biophilic experience and repeated connections with (real and surrogate) nature in peoples' daily lives. Dubos acknowledges this opportunity as being the need to re-establish an in-depth and loving relationship between humans and nature:

The relationship between humankind and nature can be one of respect and love rather than domination ... The outcome ... can be rich, satisfying, and lastingly successful, but only if both partners are modified by their association so as to become better adapted to each other ... With our knowledge and sense of responsibility ... we can create new environments that are ecologically sound, aesthetically satisfying,

economically rewarding ... This process of reciprocal adaptation occurs ... through minor changes in the people and their environment, but a more conscious process of design can also take place. - Rene Dubos, The Wooing of the Earth; cited in Kellert & Calabrese, 2015 [11].

Alexander (1977) strongly argues that this affiliation to nature is needed, and that the fundamentals of a 'more conscious process of design' are necessary. In 'A Pattern Language' (1977), Alexander states:

People need contact with trees and plants and water. In some way, which is hard to express, people are able to be more whole in the presence of nature, are able to go deeper into themselves, and are somehow able to draw sustaining energy from the life of plants and trees and water. - Pattern 173 'Garden Wall' [1, p806].

This indicates that psychological benefits for us as humans are deeply rooted in the connections with nature. The fundamental benefits of physiological and psychological wellness due to biophilic exposure are further explored by Kellert (2005), with findings demonstrating numerous health benefits and a better quality of life [8, 12]. These benefits can be achieved if we design and plan our built environments to include the considerations of Wilson's biophilia, more specially identifying the structures and patterns that occur in the form-making processes of the living systems of nature, and design and plan with a regenerative process that unfolds living environments of place [14, 18].



Figure 2: Healthy psychological benefits are rooted in the connection between humans and nature.
Image Credit: Aporlo, 2011.

3. Biophilic Design

To be able to apply the context of biophilia in our daily lives, the concept of Biophilic Design promoted by Kellert et al (2008) and further interpreted and celebrated by Newman (2012) and others, particularly Beatley in *Biophilic Cities* (2010), must be able to help us establish and nurture healthy and living environments in our cities that supports healing and wellbeing [2, 5, 12].

To establish whether biophilic design can achieve this goal of healing and wellbeing, we first need to identify and understand the meaning of biophilic design. Biophilic design

is the deliberate attempt to translate an understanding of the inherent human connection to natural systems and processes, known as ‘Biophilia’ into the design of the built environment [12]. Salingaros (2013) explains that biophilic design involves ‘deep connections’ to nature that include links to geometric structures and patterns that occur in the form-making processes of living systems, resulting in the ‘biophilic effect’ [18, p8].

Further, biophilic design:

... seeks to create good habitat for people as a biological organism in the built

environment that advances people's health, fitness and wellbeing [11, p6].

4. Codes and Patterns

Widespread application of biophilic design in practice requires some codification and agreement by practitioners on which design elements produce particular replicable biophilic results [5]. Browning et al (2014) propose 14 Patterns of Biophilic Design (Table 1) within a framework that relates human biological science and nature to the design of the built environment [3]. Their 14 Patterns build upon the inquiries of biophilic researchers over a number of years:

... developed from empirical evidence and interdisciplinary analysis of more than 500 peer-reviewed articles and books [3, p62].

As noted by Downton et al (2017), this research offers both tools for understanding

design opportunities [4], and avenues for the application of design as a way to enhance health and well-being at both the individual and societal level (Ryan et al 2014). According to its authors, inspired by Alexander (1977), the term 'pattern' is used [1, 3]:

... to propose a clear and standardized terminology for biophilic design; to avoid confusion with multiple terms (metric, attribute, condition, characteristic, typology, etc.) that have been used to explain biophilia; and to maximize accessibility for designers and planners by upholding familiar terminology [3].

Using this strategy, and to apply biophilic design to the built environment in its simplest form, Potteiger & Purinton (1998) and Browning et al (2014) include the following design principles aligned with 'biophilic patterns' that can guide design decisions [3, 13]:

Table 1: Principles and Patterns of Biophilic Design

Biophilic Design Principles	Patterns of Biophilic Design		
	Nature in the Space	Natural Analogues	Nature of the Space
Design Narratives	Visual Connection with Nature Non-Visual Connection with Nature Non-Rhythmic Sensory Stimuli Thermal & Airflow Variability Presence of Water Dynamic & Diffuse Light Connection with Natural Systems	Biomorphic Forms & Patterns Material Connection with Nature Complexity & Order	Prospect Refuge Mystery Risk & Peril

Of particular interest to the *Biophilic City* concept is the realisation that some biophilic

effects can be achieved with no physical or tangible link to 'nature' or living systems at all [4]. Indirect experiences of 'nature' or

living systems, which may include artistic representations of nature, virtual reality and other illusions of nature can also generate biophilic psycho-physiological responses. Biophilic effects are measurable in environments at a distance from immediate interaction with nature, such as hospital rooms, when people are exposed to images or illusions of nature such as artificial sky. These kinds of illusory, or virtual, systems are part of a range of design tools available to the biophilic designer [4, 5].

The inclusion of an additional pattern, *Pattern 15 – Virtual Connection to Nature* (Table 2), is predicated on the observation that virtual experience of nature can result in

some of the same beneficial effects as ‘real’ experience with human physiological and psychological evidence pointing to stress reduction that lowers blood pressure and heart rate; cognitive performance improvements through mental engagement and attentiveness; and emotions, moods and preferences that positively impact upon human attitudes and overall happiness - Brown, Barton & Gladwell, 2013 cited in [4].

These 15 biophilic design patterns have been recommended to be used in the design of railway stations in *Creating Healthy Places* [4] as follows:

Table 2: Biophilic Design Patterns, Narrative and General Principles

Biophilic Design Pattern	Biophilic Design General Principles
1. Visual Connection with Nature A view to elements of nature, living systems and natural processes	Ensure visual access to real presentations of nature throughout the station complexes in preference to simulated nature and non-nature representations
2. Non-Visual Connection with Nature Auditory, haptic, olfactory, or gustatory stimuli that engender a deliberate and positive reference to nature, living systems or natural processes	Enhance opportunities for sensory connections (audible, smell, texture, temperature) to nature throughout the station complexes, in preference to urban simulated or constructed representations
3. Non-Rhythmic Sensory Stimuli Stochastic and ephemeral connections with nature that may be analysed statistically but may not be predicted precisely	Instil patterns of nature’s movements and seasonality throughout the station complexes, using real or artistic representations where necessary
4. Thermal & Airflow Variability Subtle changes in air temperature, relative humidity, airflow across the skin, and surface temperatures that mimic natural environments	Consider sequential changes in thermal and airflow variability to refresh spaces and to enable comfortability throughout the station complexes
5. Presence of Water A condition that enhances the experience of a place through the seeing, hearing or touching of water	Use water as a static, dynamic and or variable design element to achieve multi-sensory experiences throughout the station complexes
6. Dynamic & Diffuse Light Leveraging varying intensities of light and shadow that change over time to create conditions that occur in nature	Use mixtures of dynamic, diffuse and changeable lighting arrangements and patterns (including illuminance and colour) to evoke movement, time, seasonality, while maximizing solar access throughout the station complexes
7. Connection with Natural Systems Awareness of natural processes, especially seasonal and temporal changes characteristic of a healthy ecosystem.	Use natural systems (weather, hydrology, geology, terrestrial and aquatic wildlife, diurnal and seasonal patterns) as design inspirations throughout the station complexes
8. Biomorphic Forms & Patterns Symbolic references to contoured, patterned, textured or numerical arrangements that persist in nature.	Ensure biomorphic patterns legibility and interest in floor/ceiling/roof/wall places and furniture detail throughout the station complexes
9. Material Connection with Nature	Consider the richness of material colour, warmth, authenticity and tactility throughout the station complex

Material and elements from nature that, through minimal processing, reflect the local ecology or geology to create a distinct sense of place.	
10. Complexity & Order Rich sensory information that adheres to a spatial hierarchy similar to those encountered in nature.	Prioritise pattern compositional and order use enabling stimulation, interest and legibility, including artwork throughout the station complexes
11. Prospect An unimpeded view over a distance for surveillance and planning.	Provide a sense of arrival, prospect, for each portal 'gate', concourse level and platform level for the station complexes
12. Refuge A place for withdrawal, from environmental conditions or the main flow of activity, in which the individual is protected from behind and overhead.	Provide opportunities for retreat, contemplation, waiting, meeting, refuge, for each portal 'gate', concourse level and platform level of the station complexes
13. Mystery The promise of more information achieved through partially obscured views or other sensory devices that entice the individual to travel deeper into the environment.	Provide a sense of journey in pedestrian environments that ensures sightlines, permeability, and variability in edges and planes
14. Risk/Peril An identifiable threat coupled with a reliable safeguard	Lessen personal risk in preference to safety but do not let safety considerations override Biophilic Design opportunities and principle execution
15. Virtual Connection with Nature: A view to a simulacrum of natural elements, living systems and natural processes	Provide virtual connections with nature viewed through mediated means or evoked by simulacrums of nature, living systems and natural processes. Examples include artificial skies, animatronics and portrayal of nature via virtual reality

Using these 15 patterns can potentially support and enhance the design of railway stations as noted by Beatley (2017), stating that "Nature in cities, we increasingly recognize, is not something optional, but absolutely essential to leading a happy, healthy and meaningful life. And this extends to the design of every element in the city, including transit stations." - cited in Downton *et al*, 2017, p9 [4].

5. Creating Healthy Places - A Case Study

With partnership support from the Melbourne Metro Rail Authority (MMRA), a research team from Deakin University prepared and developed an international technical benchmark study on biophilic design and rail transport infrastructure – *Creating Healthy Places* (2017), to identify

the potential opportunities to consider biophilic design in the new Metro Tunnel railway stations [4].

Creating Healthy Places (2017) offers biophilic design insights and performance guidelines towards the enrichment of each of the proposed Metro Tunnel Project (MTP) railway stations to provide opportunities for biophilic design to be incorporated in the design process. It also offers avenues and principles that may better address the Project's sustainability alignment, and achieve certification of the railway stations under the Green Building Council of Australia-Green Star Rating system by supporting the potential targeting and achievement of a 6 Green Star rating for the railway stations [4, p3].

This research project specifically focuses on two key outcomes:

- Interrogation of the biophilia (and urban design quality) possibilities of the 5 new MTP railway stations (Arden, Parkville, CBD North, CBD South, Domain) in terms of their underground concourse areas and vertical circulation area, as well as their above ground plazas, entrances and integration with the larger streetscape and immediate environments, and;
- Contributing practice-rich knowledge and exemplars to inform the Metro Tunnel Project as to key opportunities, issues and ideas for biophilic design formulation of the overall project [4, p13].

The approach taken for the potential application of biophilic design to the railway stations was to firstly align the biophilic design principles and 15 patterns (14+1) with the *MMRA Sustainability Policy*, secondly, with the *MMRA Urban Design Strategy*, and thirdly, through a design narrative that matches the patterns with general principles of station design in a priority hierarchy. Finally the ‘Biophilic Design Toolkit’ was applied to provide a summary of recommendations for each station, using 17 actions or recommendations for the application of the biophilic design patterns [4].

6. The Toolkit

The ‘Biophilic Design Toolkit’ is a simple method to align 17 identified biophilic design recommendations/actions (Table 3) to support the application of the 15 biophilic design patterns to railway station complexes and environments (Figure 3). To demonstrate the possible outcomes, the ‘toolkit’ was used to assess exemplar projects indicating the biophilic toolkit qualities evident in the projects [4, pp88-94].

An example of the application of the 17 recommendations (Recommendation 1: Adopt a Biophilic Design Program), is indicated in the following Figure 3.

Table 3: Summary of 17 biophilic actions/recommendations as indicated in the biophilic design toolkit - adapted from: [4]

Biophilic Design Toolkit		
1	Adopt a biophilic design program for all railway stations	○
2	Make judicious use of planting, green roofs and walls	○
3	Maximise use of natural light	○
4	Apply controlled air movement	○
5	Make creative use of water	○
6	Manipulate the soundscape & olfactory landscape to reinforce biophilic effects	○
7	Incorporate biomorphic forms and images	○

8	Use materials as natural analogues	○
9	Create distinct spatial environments	○
10	Layer texture & modelling over undifferentiated planar surfaces	○
11	Explore transitioning of biophilia effects	○
12	Use signage and wayfinding to raise public awareness of local nature	○
13	Apply fractal design techniques	○
14	Use public art to achieve biophilic effects	○
15	Avoid abstraction	○
16	Make visible and incorporate the skyline	○
17	Make visible and incorporate the local pre-European/pre-industrial environment	○

‘THE BIOPHILIC DESIGN TOOLKIT’ SUMMARY OF RECOMMENDATIONS					
Design Tool		Urban Design Strategy	Urban Ecology Strategy	14+1 Patterns (see Chpt 2.3)	Exemplars (see Chapter 5)
1	Adopt a Biophilia Design Program	Designs must be sustainable Site responsive, responding to specific local conditions inclusive of built form, landscape, topography and orientation.	1.2 Objectives: Principle 1 Connect people to nature Principle 2 Create a diverse, connected and resilient ecosystem Principle 3 Demonstrate local and global leadership	All	Dingpu Metro Station, Taiwan. Atocha Railway Station, Spain. Low Line Lab, New York City. Stockholm Metro, Stockholm. MetroNapoli, Naples. The Eden Project, England. Gardens by the Bay, Singapore. Paris Metro, Paris. Park Güell, Barcelona. Cheonggyecheon Stream, Seoul.

Figure 3: Example of the Biophilic Design Toolkit Application - Recommendation 1. Source: [4]

7. International Examples

There are very few examples of railway or metro stations that have been designed with the specific intention to evoke biophilia qualities for their users. There are, however, stations that have been designed with

elements that are intrinsically biophilic. There are also public sector/infrastructure buildings, urban spaces and landscapes that are strongly biophilic. One notable example of a public infrastructure project is Singapore’s extraordinarily successful and well-visited ‘Gardens by the Bay’, where the specific intention to evoke biophilia is,

arguably, the primary driver of the project. Two examples of railway stations identified in this paper include the Stockholm Metro Stations (Figure 3) and the Atocha Railway Station (Figure 4).

Stockholm Metro Stations

The Stockholm Metro is a good example that demonstrate how local character, culture and place-making are celebrated in the distinctiveness of the underground railway stations in contrast to otherwise typically generic and placeless metro station environments [4, p91]. The Stockholm Metro is one gigantic art gallery. More than 90 of

the 110 stations feature artworks created by some 150 artists. For the price of a Stockholm Metro ticket you can see sculptures, mosaics, paintings, art installations, inscriptions and reliefs from the 1950’s through to the 2000’s at most metro stations [6].

Using the Biophilic Design Toolkit, an assessment of the Stockholm Metro Stations indicates that the design adopts a biophilic design program (or partially), includes biomorphic forms and elements, use materials as natural analogues, create distinct spatial environments, and makes strong use of public art.

Biophilic Toolkit Qualities	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	○						○	○	○	○	○		○	○	○		



Figure 4: Biophilic patterns in the Kungsträdgården underground metro station, Stockholm. Image Credit: Julian Herzog, 2016 [6].

Atocha Railway Station

The Atocha Railway Station’s concourse includes a 4,000m² covered garden arranged in neat garden beds. Around 260 species and over 7,000 plants improve the internal ambience, climate and environmental air quality of the station.

Using the Biophilic Design Toolkit, an assessment of the Atocha Railway Station indicated that the design also adopts a

biophilic design program (or partially), includes biomorphic forms and elements, maximises the use of daylight, makes creative use of water within the station complex, and manipulates the soundscape and olfactory landscape to reinforce biophilic effects. Further, the station demonstrates the creation of distinct spatial environments and makes the skyline visible from within.

Biophilic Toolkit	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Qualities	○	○	○		○	○			○							○	



Figure 5: Atocha Railway Station, Madrid, Spain. Image Credit: Yulia Grogoryeva, 2014.

8. Discussion and Conclusion

This paper proposes a fresh design approach to city infrastructure that demonstrates how biophilic design can bring together the realms of the built environment and nature so that we as humans can experience the wellbeing benefits of biophilia. The Biophilic Design of railway stations provides opportunities to re-imagine the nature of transit design and can assist in the enhancement of urban environments, including the possibilities for extensive vegetation, improvement and enrichment of ecological systems and their communities, and strengthening connections between humans and nature [4, 5].

The *Creating Healthy Places* (2017) study indicated that biophilic design can deliver visual, aural, and thermal stimulation(s) in urban environments, whereby such environments can become living laboratories as exemplars of what future Biophilic Cities could be [4]. However, the designing of cities and urban environments needs to be undertaken with the awareness that the inclusion of biophilia is not only limited to the provision of vegetation, but that biophilic design is a scientifically-informed design method that involves a raft of variables and attributes including environmental features, natural shapes and forms, ecological patterns and processes, light and space, considerations of place-based relationships, and the psychological and physiological evolved human-nature relationships as part of a holistic design solution.

Key to achieving this vision is the use of the *15 Biophilic Design Patterns* [4], supported by a *Biophilic Design Toolkit* applied to city infrastructure design and planning that includes *17 biophilic*

recommendations/actions, as well as an accompanying biophilic design narrative [4, 5]. This paper concludes with the following recommendations to be considered for Biophilia-inspired railway station design, which can assist in advancing the larger vision and agenda of Biophilic Cities:

- The need to include the principles of biophilic design in large infrastructure projects of cities to improve the biophilic city agenda;
- Adopt a biophilic design programme for new rail infrastructure projects (similar for other city shaping infrastructure projects);
- Go beyond standard railway station design and use the 15 patterns of biophilic design to inform the architecture, planning and urban design of the stations and their surrounding urban environment and precinct;
- Adopt the 17 actions and recommendations of the *Biophilic Design Toolkit* to integrate the biophilic agenda as a fundamental part of the design programme;
- Make biophilic design a key requirement in the sustainability policies and standards of city planning; and
- Include biophilic design outcomes in the performance requirements for infrastructure design and delivery.

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Biophilic city, vertical city, forest city? Towards an Architectree

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Abstract

Recently, the concept of biophilia has been used frequently in landscape architecture design, architecture design, and urban planning theory and practice. Biophilia is an important vinculum between the human world and the natural world. However, is it expectable adding biophilic elements without a limit? From a Chinese perspective recognizing the Chinese idiom, “月盈则亏，水满则溢” (full moon will turn wane, full water will turn overflow), meaning that everything has its appropriate scale. The other understanding of this term is that everything should keep balance in the world. In this sense, the authors believe that for a balance between nature and cities biophilic design should has its own scale that can be divided into the primary biophilic scale and regional biophilic design. In addition, the issue, how to do biophilic design in high-density building area, also caused the space value conflict.

This paper will analyze the biophilic scale and space value conflict for discussing and considering the Biophilic City strategy, Vertical City concept and Liuzhou Forest City project. In so doing, a question about how to deal with vertical green space in future cities is raised and a concept of Architectree is proposed.

Keywords: biophilic city, vertical city, forest city, vertical green space, architectree

1. Introduction

In recently, Biophilic design, derived from “biophilia”, is widely spreading in landscape architecture, architecture, and interior design and urban planning. Biophilia, popularized by Edward Wilson in 1984, represents an innate affinity that human have with nature and is a sort of relationship between human and nature both in psychological and physical. Biophilic design aims to create the space of

human activities that has more connections with nature. In 2014, Terrapin Bright Green published ‘14 patterns of biophilic design’, which summarized and introduced the details of these patterns. In this sense, the Hanging Garden of Babylon (or Nineveh) might be the first biophilic exemplar in the world. According to the record of ancient literatures, the Hanging Garden almost conform all the patterns of biophilic design. From Hanging Garden to now, more than 2000 years have passed but little advance in technology and theory has occurred. Despite this, Singapore

is playing a lead role in advancing biophilic urbanism as cross-compared in Figure 1.

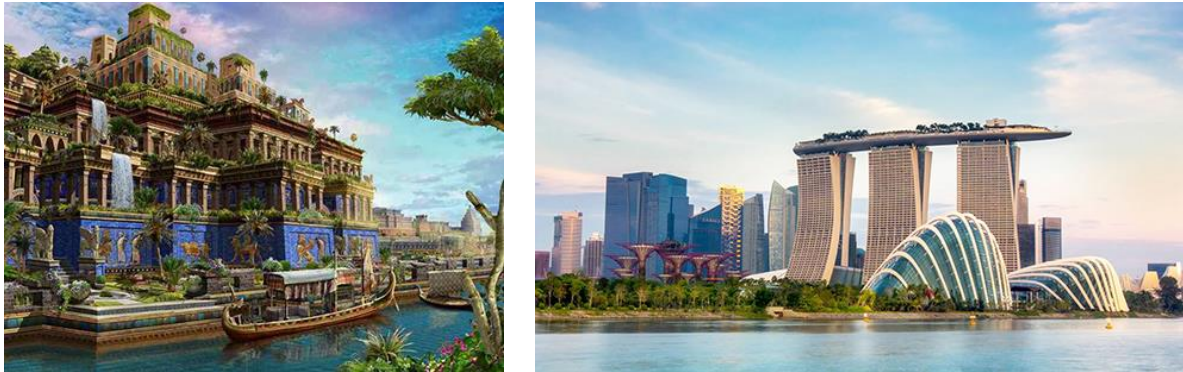


Fig. 1. The Hanging Garden, Babylon/Nineveh & Marina Bay, Singapore

This paper seeks to answer several questions about concepts of biophilic city, vertical city, and forest city and what is the relationship between them. The questions raised are as follows:

- (1) Why people should consider biophilic scale in biophilic urbanism and how to define it?
- (2) What is the method of keeping balance in Vertical City and Liuzhou Forest City?
- (3) What is the largest challenge in biophilic urbanism and other theories of urban planning or architecture design?

Finally, this paper proposes a concept of “architectree” for trying to heal the urban ills and to keep balances between nature and city, green value and land value, psychological and physical, aesthetic and functions, human and other creatures.

2. Biophilic elements in theories

In order to find out that how biophilic elements relevant to theories of urban, following urban planning theories (Figure 2) are listed:

a. *Garden City*

The theory of Garden City provided a comprehensive planning that includes areas of residence, agriculture, and industry, and this concept aims to solve the overcrowding and create a self-sufficient city. According to the central parks, gardens, and grand avenues in Ebenezer Howard’s planning, people can realize the necessity of green space had already existed in this great planner’s mind. [1] The Garden city focus on dividing functional areas in cities and allocating their location reasonably, so that the proportion of vegetation factors in the concept is relatively small. Despite this, green

spaces were planned in different areas as buffers and connectors.

b. Contemporary City and Radiant City

Le Corbusier provided an idea of Contemporary City, which is a project of urban planning that, would accommodate 3 million people, in 1922. As the blow four basic principles which developed by Le Corbusier,

- (1) Relieve the congestion of central districts,
- (2) Increase the population density of central districts,
- (3) Improve traffic flow,
- (4) Increase planted areas.

He indicated, “We must plant trees!” just after he analyzed mental health in a situation of people walking down the street in a future city.

The Radiant City is another urban planning theory of Le Corbusier; this concept is more like a complete version of the Contemporary City. Le Corbusier said that materials of urban design are sun, sky, trees, steel, and cements, and he defined the goal of the radiant City is like “sun in the house, a view of the sky through large window, trees people can see from their house”. [2] The Contemporary City and the Radiant City aimed to provide a new urban form with reasonable management and convenient traffic and the importance of plants began to be valued in this form.

c. Eco-city

Eco-city theory comprehensively expounded how people should build

cities in balance with nature. Richard Register expressed his idea of building cities and nature coexist as the completely sustainable human settlement with zero carbon emissions and renewable resources. Eco-city emphasize sustainable application and have a higher natural participation. [3]

d. Shanshui City

Qian Xuesen, a Chinese great scientist, first proposed Shanshui City theory in 1990. The term “Shanshui” means mountain and water, and Shanshui City is a future city concept based on Chinese traditional landscape and natural philosophy. In this theory, the city is located beside the mountain and waterscape like lake, river, and bay; therefore, Shanshui City values the merging of city and nature. However, Shanshui City are more of a concept compared to other future urban theories, because the urban planning rely too much on geographic location in this theory.

In conclusion, the urban planning movement (Garden City), the urban form design (Contemporary City & Radiant City), the future city demand (Eco-city), and the natural city concept (Shanshui City), they are all inseparable from the nature and related to nature in varying degrees. Through the study of Garden City, Contemporary City, and Radiant City, people can know that the tree plays an important role in these theories but the buildings are still the dominator in the city. Eco-city theory began to advocate the transformation from nature in cities to cities in nature and stressed the equal position of

natural elements and architectures. Although the landscape city is confined to geographical location, experts can continue to research its

concept extendedly and apply it to the appropriate cities to make it a sort of Biophilic urbanism.

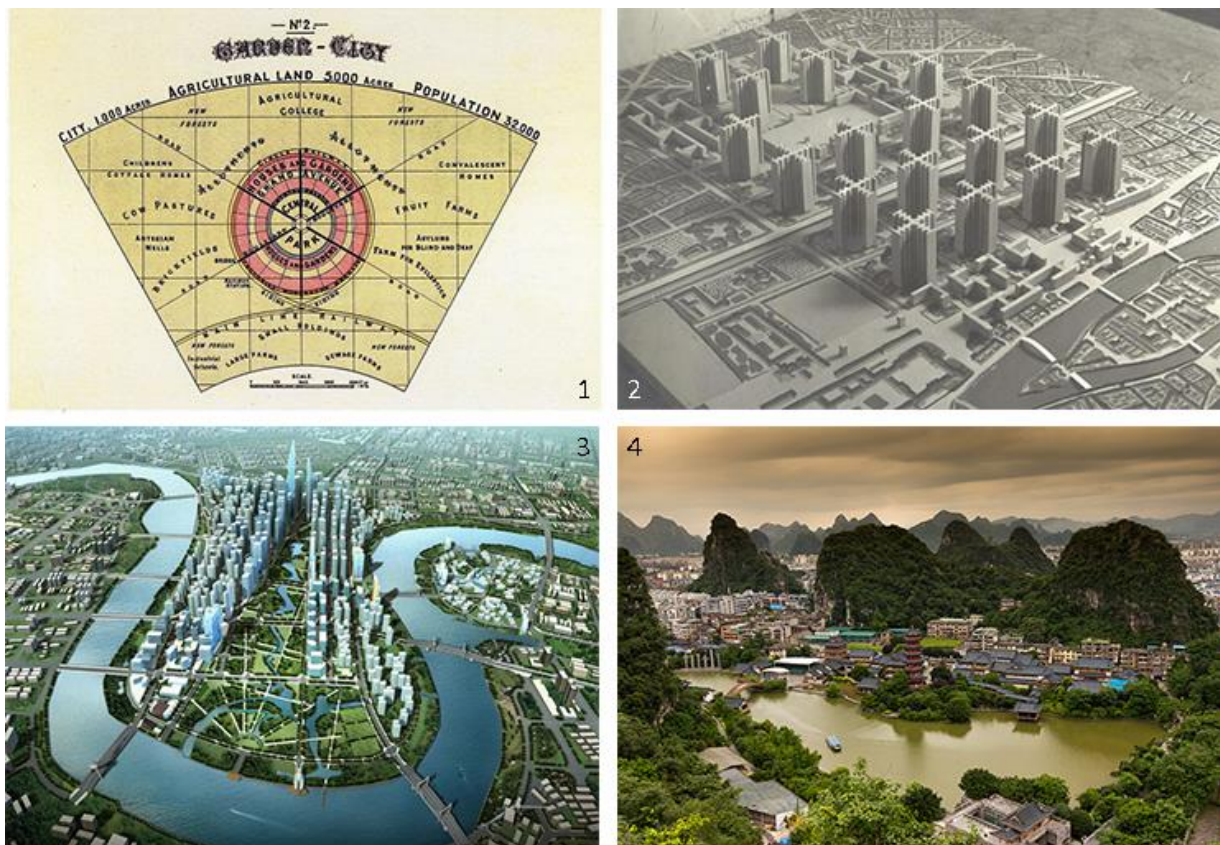


Fig. 2. Urban Planning Theories (1.Garden City, 2.Contemporary City, 3.Eco-city, 4.Shanshui City)

3. Biophilic scale and Space value conflict

Whether or not the Hanging Garden had really existed in the world, according to the description in literatures and records people could see a comprehensive artwork. However, the altitude and scope of modern cities have already exceeded the limits of Babylon; in this case, people should consider more issues in planning and designing the

cities with high-density skyscrapers and population.

3.1 Biophilic scale

For thousands of years, there is an old saying in China that "full moon will turn wane." This idiom comes from the famous Chinese ancient book "Book of Changes", "Sunset after midday, full moon will turn wane", meaning that the sun began to go west after it reach the highest point of the sky, the moon

will become crescent gradually after full moon night. After that phrase evolved into a “full moon will turn wane, full water will turn overflow,” which means that everything has scales and limits.

Thinking from this proverb, the authors proposed even biophilic design also has its scale and limits. Could a biophilic space full of natural elements? Could we call it nature if this space exists and satisfied infinitely close to 100% natural environment? In scientific sense, a complete nature is without any human factor; in philosophical sense, the only difference between artificial nature (artificial nature environment that people create by using only natural substances, no any device) and original nature is whether humans are involved, such as the relation between wild corn and agricultural corn. Conversely, the space cannot be called biophilic space if it have no nature. Another considerable situation is that should people make different biophilic design principles in cities of different regions?

According to above contents, there are two biophilic scales; one is the primary biophilic scale and the other is the regional biophilic

scale. Primary biophilic scale involves quantitative change, sequence change, and form change that can influence human psychology. Assuming biophilic rates can be modified, the enhancement of biophilic qualities can easily be escalated on all built environment projects. As depicted in Figure 3, scales of 3%, 20%, 50%, 100% of biophilic evidence on building facade offer the question, which one is more suitable for daily streetscape viewing? Regional biophilic design warrants the need to consider its regional/climate, seasonality, vertical limits, user ranges, etc. This scale involves qualitative changes to the built environment. Different climates, different plant species, different seasons can vary considerably whether the city is in the tropics, Mediterranean or temperate climates. Regional biophilic scale also relevant to primary biophilic scale. Considering that different plants show different states and colors in different seasons and regions, if we estimate a suitable scale of 70% plants-covered on a building in Singapore, then the number might be change to 40% in Beijing and 50% in Melbourne.

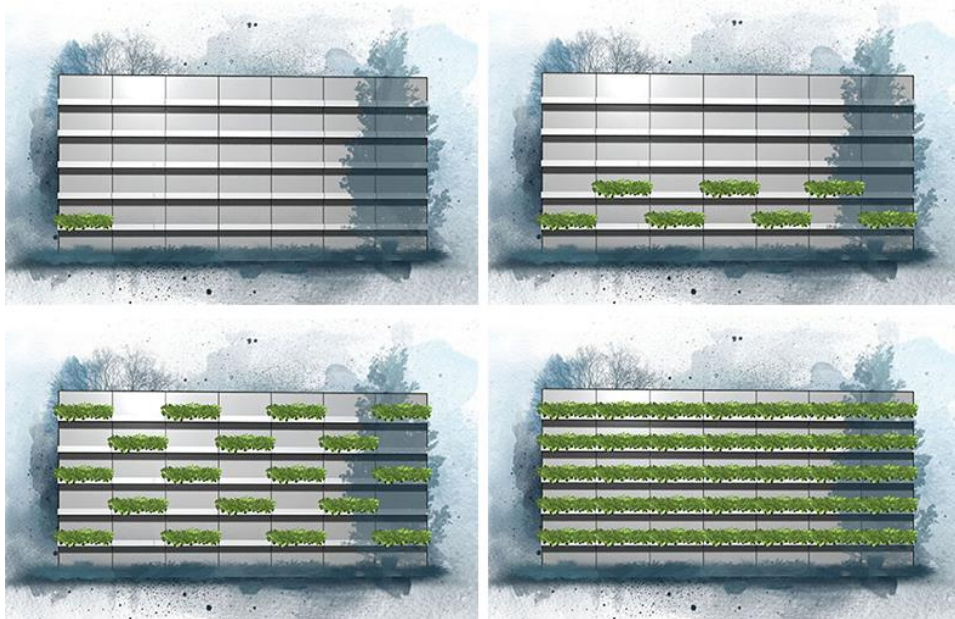


Fig. 3. Primary Biophilic Scale presents on building façade

3.2 Space value conflict

The value of land/space results in a conflict between land space value and green space value. The closer to the city centre, the higher the land space value. At the same time, the green space value is constant. The value of a street tree in CBD is equal to the same one in suburban area. In this comparison of the two values, the space value conflict is raised.

Space value conflict is the reason why people fail to see green space in the CBD of a city.

For example, using a 10,000m² allotment in Hong Kong CBD, faced with a choice between a 40-storey apartment that could bring about USD\$160 million versus a park with minimal economic benefit less health values, the government and business people will choose the apartment option because of economic gain. Figure 4 depicts a high urban density for people, and Figure 5 illustrates what a future Melbourne could look like if growth was concentrated in the inner city without middle suburban infill.



Figure 4. Urban building density in Hong Kong

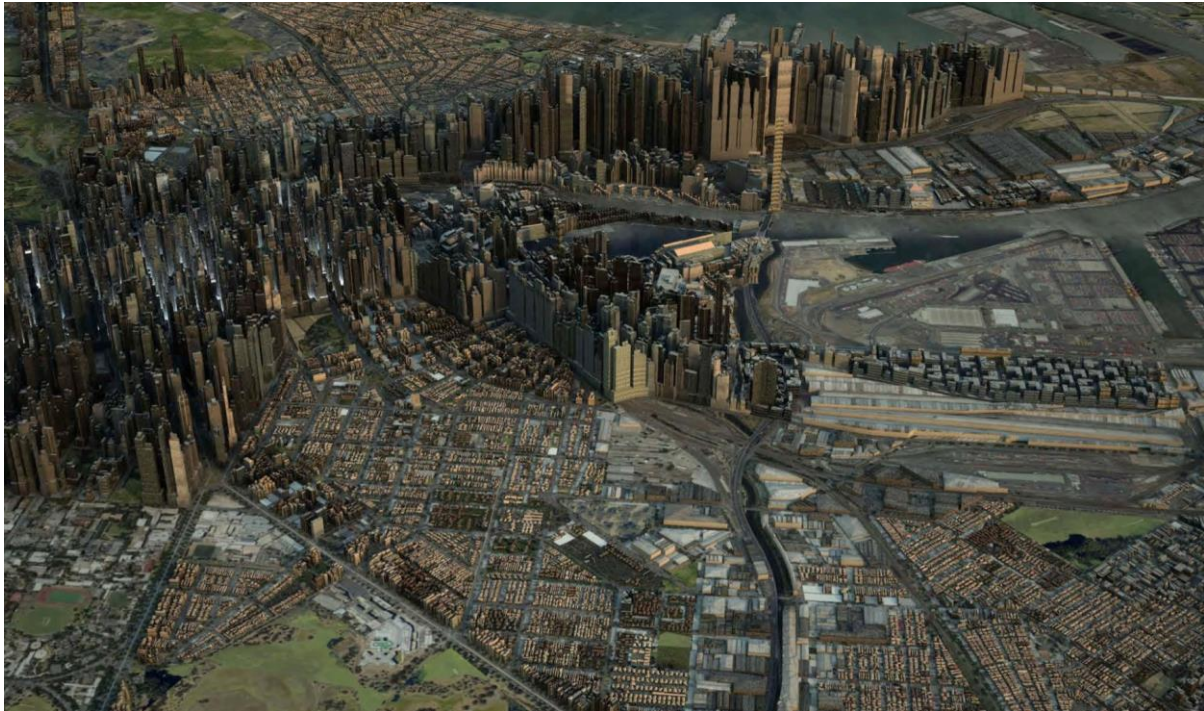


Figure 5. Melbourne growing pains

4. Cases of Biophilic, Vertical, and Forest City

4.1 Biophilic City

In Singapore, architects, planners, and other design practitioners made seven main programs or projects between buildings. To create more green spaces (The Singapore Green Plan 2012). [4] To create linear parks or tree-lined road and make them to link the residential areas, commercial areas, and green areas (The Streetscape Greenery Master Plans). A 300 kilometers of green connectors' network cross over the entire island so that people could walk or bicycle through parks in the city (The Park Connector Plan). Earnestly implement green walls and

green roofs all around the city since 2003 (Hort Park biophilic R&D). Naturalised the concrete canals, build up green land to replace the concrete watercourse, replant trees to cover the demolished boundaries of the canals (The ABC of water management). Made the communities green, made both public and private places more close to natural (Community in Bloom). As a start of developing gardens around the Marina Bay, a biophilic landscape architecture has built in public open space (Gardens by the Bay). Newman, P also provided seven case studies of biophilic design. In conclusion, these cases are all completed through one or several fallow designs: green wall, green roof, green balcony, green campus, and interior biophilic design.



Figure 6. The Vertical City

4.2 Vertical City

King and Wong provided a Vertical City (Figure 6) based on skyscraper development, this concept is a multi-skyscraper city that the highest building could reach over 1 mile, and the ground area covers 0.5*0.5 mile. [5] This concept includes about ten skyscrapers, 4 to 5 platforms consisted of skybridges connect each building, and a large base ground area at the bottom as a city central business district. The skyscrapers have cordless elevator system, garbage classification transport tubes, high-level wind power system, and transparent solar panels. Skybridges connect skyscrapers as the pathway from one to the others make the high-rise transport more convenient. In addition, huge width of these bridges could offer space for soccer, tennis, walking and jogging, for planting areas and recreation areas, for children outside-activities' areas. This emerging concept aims to enhance land utilization to response the growth of city population, reduce the pollution and CO₂ emissions to improve city environment, narrow the horizontal space of the city to save the time of working and living and food transportation.

4.3 Forest City

Liuzhou Forest City (Figure 7) is a program that could host 30,000 people and 40,000 trees. Buildings in the first Chinese forest city would be covered by plants and trees, including apartments, schools, hospitals, and office buildings. [6] The planning of this program, based on the “vertical forest” project in Milan, is the sustainable residential buildings with a vegetal system, which includes 800 trees, 4,500 shrubs, and 15,000 plants distributed on balconies of the building façade, therefore, Liuzhou Forest City could be treat as a program made of Vertical forests. Once completed, this terrific city could absorb almost 10,000 tons of CO₂ and 57 tons of pollutants per year and contribute nearly 900 tons of O₂ to this new city. Liuzhou Forest City also could decrease the average air temperature, create noise barriers and improve the biodiversity of living species, generating the habitat for birds, insects and small animals that inhabit the Liuzhou territory. Although the whole program showed the determination of architects and governments to change the urban environment, what we should get a clear understanding of is the “forest” is still built up with reinforced concrete and municipal pipelines.



Fig. 7. Liuzhou Forest City

4.4 Conclusion

Biophilic City, Vertical City, and Forest City: one strategy, one concept, and one project. Biophilic City or biophilic urbanism focus on increasing connections between citizens and nature in order to strengthen stress reduction and keep the city's health and resilience. According to Newman (2014), the main methods of Singapore to achieve biophilic city is green wall, green roof, green balcony, green campus, interior biophilic design, and green connector. From the perspective of space availability, green campus and green connector have less limitation than the others do. From the scope of cities, biophilic design would encounter many obstacles work with skyscrapers in high-density building areas

like CBD. At present, the vertical green space is a relatively suitable solution for the space value conflict,

Vertical City aims to Increase vertical space utilization for more natural space and agricultural land. The Vertical City like a huge super high-rise complex with functions of housing, employment, education, recreation, health care, and other services. It provides a new urban form from horizontal development to vertical development. As the other new urban form, the Forest City increases the number of plants, especially trees, and greatly increase the rate of greening. The common points of the Vertical City and the Forest City are that they would reduce population pressure and the energy consumption, improve the city environment,

and more green space is created (enhancing the three-dimensional greening rate). However, their common disadvantage is that people cannot determine whether people are attracted to the new cities because they have no same characteristics as the long-time-existed cities, such as fame, historical, local cultures, opportunities, high-quality education, metropolitan atmosphere, commercial diversification, etc. In fact, implementing the program like Vertical City

5. Architectree

Architectree could be a concept of tree-like architecture for future. It has the most realistic natural properties that can be incorporated into the urban environment. Architectree seeks to craft an equitable balance between the natural world and human civilization, and between economic and green space benefits. Applying the Primary Biophilic scale, cities could plant architectrees in different areas and blocks to enhance human values and wellbeing. Architectree can imitate different tree species to adapt to different climatic conditions. For example, the architectree of Chinese Red Pine can be used in Beijing, the architectree of the Queensland Kauri in Brisbane, and the architectree of Sequoia sempervirens in Los Angeles.

Architectree could be an ecological and sustainable architecture model, which could be more than 200m tall and located amongst cement constructions, its branches and leaves could cloud other lower buildings nearby it. As an ecological architecture, it can offer shelter to residents and isolate outdoor noise. As a sustainable architecture, its canopy of leaves can convert light energy to electric

and Forest City in China may need to take certain risks. According to the report of China Household Finance Survey and Research Center (CHFS) of Southwestern University of Finance and Economics on June 10 in 2014, the overall housing vacancy rate in China's urban areas in 2013 was 22.4%. [7] Same as these two concepts Utopian Cities also have lofty goals and ideal plan. Unfortunately, the development theories and practices of many utopian cities ended in failure in history. energy and its root system can collect and store water underground.

Architectree could be tree(s), which could absorb CO₂ and product O₂. It can reduce air pollution, light pollution, noise pollution, and soil contamination. It can mitigate smog and improve air quality. It could improve city ecosystems, and cloud streets using natural elements. It could provide a better city environment for the mental health and wellbeing of both human and animal citizens.

5.1 Similarities

There are hundreds of plants in the world, why trees are most suitable to be imitated for architectures. Firstly, in human subconsciousness, myths, legends and religions, trees are a symbol of origin, positivity, hope, protection, and life, etc. Secondly, excluded herbaceous plants and fungus because of lacking strong and sturdy characters. Thirdly, the height and volume of the tree can satisfy a shelter for animals and human. At last, there are several similar structures between trees and buildings:

1. Root/foundation.
Support the trunk/construction and make the tree/building stable, in addition to these, the root system can

absorb moisture in the soil and dissolves the ions therein, and has the function of supporting and storing synthetic organic substances. The roots purify the earth, reduce soil contamination, and prevent soil erosion.

2. Trunk/superstructure.

As main body of tree/building on the ground, trunk/superstructure afford the shelter to residents. In addition, there are vessels and sieves of xylem and phloem in the bark, the surface of trunk. They can transport moisture and organic matter to the branches and leave by transpiration.

3. Canopy/roof.

Canopy/roof on the top of the trunk/superstructure, can withstand the effects of wind, frost, rain, snow, solar radiation, temperature changes and various unfavourable factors on the building.

5.2 Challenges

As a concept of future architecture, Architectree will face a number of challenges in materials, technologies, construction, management, etc. Materials, closer to the nature of trees, are required to build the superstructure, canopy, and root system of Architectree. Technical expertise is need to explore energy conversion issues including devices that can extract energy from photosynthesis without negating the biological functions; a water supply system that can drain water for using by humans

from the water absorbed by the root system. Prefabrication offers a viable choice to build an Architectree. However, what procedures need to be understood to enable sound connections between vessels and sieves, and the step of placing root system underground. Finally, Architectree has all the disadvantages of a tree: diseases and pests, fire risk, root damage, and falling objects, etc., so the maintenance of the entire Architectree to be discussed. We might need to train and hire more gardeners in our future cities.

6. Conclusion

Above all, to a future living place, what people require is a city that could cooperatively organize green spaces and vertical spaces. On this basis, cities also should satisfy functional requirements like sustainability, safety, entertaining, education, hospital, resilience, etc. However, the concept of Architectree, which aims to stand on a balance point between natural world and civilization, between economic benefits and green space benefits. As a biophilic element, Architectree provides more green space value without affecting the land space value. Architectree could be built in blocks, to improve city environment penetrating into the city.

As a concept has both the vertical space benefits and green space benefits, authors will research the impact of architectree in a city in next stage, and the future available materials, technologies, construction methods of “architectree”.

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Disconnect from nature is apparent in high-rise apartment dwellers – how can we bring nature to apartment buildings?

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Abstract

Introduction/Aim:

The biodiversity of our surroundings is continuing to decline worldwide in many high-density urban areas due to the conversion of nature to the built environment. A reasonable case can be made to assume that people living in high-rise apartment buildings built in place of greater biodiversity have a reduced exposure to soil, plants and animals. It has also been shown that urban populations worldwide are increasingly disconnected from nature. What might be the consequences and can this trend be reversed using greening strategies? The research reported in this paper evaluates the efficacy of one such strategy, which involves growing plants on balconies in high-rise apartment buildings located in urban areas. The aim of the research is to measure nature relatedness and health differences between apartment residents with plants on balconies and without.

Methods:

Eighty-seven respondents have provided health and/or lifestyle survey information as part of a 12-month study in the metro area of Perth, Western Australia, which investigates the relationships between high rise apartments, environmental biodiversity and the human skin microbiota. Preliminary data analysis of the health surveys, and the lifestyle survey factors 'nature relatedness' and 'visits to green spaces', was calculated using Qualtrics and SPSS. Nineteen respondents had plants on their balconies, and 68 had no plants. Mental health of respondents was captured using the SF36 survey. Nature relatedness attitudes, perceptions and experiences were captured using the 21-question Nature Relatedness Scale; and frequency of visits to green spaces and gardening was captured using a set of scale questions regarding frequency of respondents' visits to different types of green spaces and respondents' participation in gardening.

Results:

Interim results indicate that although the majority of high-rise apartment dwellers agree that they are not separate from nature but are a part of it, they do not have high nature relatedness. Forty-four per cent of respondents visited local parks less than once per month, if at all; 38% never visited bushland areas; and 46% never went to national parks. However many had preferences for green spaces to be around them, with over 80% of respondents saying that they would prefer a park and street trees around their apartment buildings. Almost half (45%) of health survey respondents stated that they experienced emotional problems that interfered with social activity, and 61% felt worn out at least some of the time. Statistically a significant difference was found between the two groups of respondents and the frequency of visits to green spaces. Respondents with no plants were found to visit green spaces less often than those with plants on their balcony.

Conclusion:

High-rise apartment dwellers with no plants appear to be further disconnected from nature than those with plants on balconies. The consequences of limited contact with nature may be a reduction of beneficial ecosystem services, and this may lead to various health issues such as higher stress levels. For whatever reason apartment dwellers cannot access nature, most have a desire to be near nature and we should look for ways to bring greening strategies to apartment buildings.

Keywords: Nature relatedness; high-rise apartments; biodiversity; disconnect, ecosystem service, green spaces, stress, wellbeing

1. Introduction

This paper is part of a broader longitudinal study of high-rise apartment dwellers in Perth, Western Australia that is investigating the links between occupant lifestyles, stress, physical and mental health, nature relatedness and the diversity of human skin microbiota. Participants living above the third floor in high-rise apartment buildings have received either real or fake indoor plants and are being monitored over a 12-month period. The study includes administering health and lifestyle surveys before and after the intervention. Data has been captured and analysed from surveys administered before the intervention.

Environmental biodiversity is a holistic expression of the natural environment that surrounds humans [3]. Environmental biodiversity provides a range of ecosystem

services that include health benefits; however biodiversity (trees, plants and all other living species) is continuing to decline worldwide in urban areas due to the conversion of natural areas to urban infrastructure [12]. In Australia singles and couples spend less than 25 minutes per day outdoors, which underscores a disconnection between people and nature in high-density urban areas due to both declining biodiversity and modern technology [6-8].

Biophilia is a human's innate need to connect with nature [9]. Research conducted over recent decades has suggested that environmental biodiversity is good for our health [7]; however, this does not appear to have filtered through to urban planning and developmental policies in many cities [28], including Western Australia where this study is located [29]. Disconnection from nature relates to the loss

of essential microbes for human microbial diversity, which may cause dysbiosis and compromise our immune system [8]. An interdisciplinary call to action between planners, landscape architects, ecologists and health professionals is warranted. This is becoming a matter of urgency because the number of high-rise apartment buildings is rapidly increasing along with the incidence of chronic diseases in our highly urbanised world [4].

Modern high-rise apartments are near major transport hubs and city centres, and are a less expensive form of housing for many. Some of the downsides are that affordable apartments may be placed in suburbs with industrial or commercial outlooks, built with no greening infrastructure, or in new estates that have no green space. What happens when the demolition of older housing and private gardens make way for a high-rise building that takes over the entire building envelope? Does policy allow for any of that greening to be put back? What might it mean for high-rise residents to have little greenery or soil around them? How do they connect with the natural world? Some strata companies will not allow plants on balconies because of possible paintwork damage from pooling of water, and even deny occupants the ability to have plants indoors because of possible moisture problems. Unfortunately some modern apartments in Australia and elsewhere do not have windows that open for ventilation, but only a sliding door to a balcony and a mechanical ventilation system. If the mechanical ventilation system is not used the apartment can be affected by moisture issues. In addition, if an indoor

environment lacks good outdoor airflow, the microbial population will mainly consist of the occupant's own microbial clouds and the built synthetic environment, and this has the potential to cause dysbiosis [1, 3-5].

This paper focuses on nature relatedness and why a connection to nature is important for human health and shares the results of preliminary findings. This paper will also discuss wellbeing of high-rise apartment dwellers in relation to green spaces, and look at how wellbeing might be affected by disconnection from nature. Finally, recommendations reveal how we might consider moving towards a biophilic city, a city that recognises the need for daily contact with nature, the ecosystem services provided by nature, and by prioritising nature in its planning and development policies [32].

This paper presents the preliminary results of lifestyle surveys from high-rise apartment respondents with plants on their balconies and those without plants. The relationship between nature relatedness, visits to green spaces, and health is presented, and the paper asks the question 'what might be the consequences and can this trend be reversed using greening strategies?'

2. Green Spaces and Wellbeing

Studies from many sources and countries over the last 30 years have shown that there is a positive link between environmental biodiversity and health [10-12]. The creation of large biodiverse areas such as parks and green belts has been shown to improve the mental and physical well-being of people living in urban areas, but due to

scarce resources it is increasingly difficult to create 'immune-friendly' green areas in rapidly growing megacities.

Because of the threat of biodiversity loss, subsequent ecosystem impairment and the role of environmental microbiota, researchers propose that living in high density urban environments may lead to an inability to adapt to microbe-poor environments which is termed 'immune adaption syndrome' [13]. People living in high-rise apartments may not have access to parks due to land scarcity, which is a further disadvantage for biodiversity exposure and may negatively affect wellbeing [12].

A mixed methods study that examined the role that neighbourhood green space played in influencing residents' self-reported health found that green spaces were important for people to relax in and get away from the noise and busyness of the city. Respondents who perceived nearby green space to be useable were more likely to report better general health than those who did not [14].

Recent work has shown indirectly that individuals in urban environments are at a disadvantage in processing stress compared to those in rural environments [2, 15, 16]. The results of a study identifying and describing eight perceived sensory dimensions in green urban spaces conducted by Grahn and Stigsdotter [17] confirmed the need for urban green spaces to be considered as part of future urban planning in order to mitigate stress and public mental health. In an urban neighbourhood study, stress was found to be a full mediator of the relationship between the quantity of streetscape greenery and mental health, and a partial mediator of self-rated health. Residents with higher amounts of

streetscape greenery reported better mental health, less acute health complaints and stronger social cohesion [18]. Similar results have been found in studies conducted in England [19], Denmark [20], and Sweden [21]. Von Herten et al. (2015) suggested that the benefits of nature in coping with stress should be better acknowledged, and that this research might contribute to new measures to reverse rising trends in the prevalence of conditions such as chronic inflammatory disease.

3. Benefits of the indoor and outdoor natural environment

Loss of biodiversity impairs many essential ecosystem services including the role of environmental microbiota [13]. There are already trillions of bacteria in high rise buildings, but only a limited number flows in through open windows and air conditioning from the outdoor environment. Most of the bacteria, fungi and viruses come from people who inhabit buildings [3]. The home environment then creates new habitats for numerous microbial communities that may be quite foreign for the human skin to adapt to, and may not be beneficial for health. The biodiversity hypothesis theory states that an environment with diverse microbiota modifies and enriches human microbiota, which is a necessity for the development and maintenance of the human immune function [11, 23].

Beneficial bacteria on indoor plants, and in the soil they are contained in, are an important addition to an apartment, stabilising the ecology of the built synthetic environment. Plant-associated bacteria could help to avoid outbreaks of pathogens

by enhancing biodiversity, which may enhance the immune system [24]. Indoor plants will also purify the air, reducing the emissions of volatile organic compounds such as formaldehyde [5].

Outdoor plants and soil have an abundance of ecological communities compared to indoor environments, and a higher diversity of microbes, and they therefore increase the numbers of insects, birds and other fauna. Outdoor plants such as trees and shrubs also have a role in high density urban areas by shading buildings and streets and assisting with stormwater runoff and nutrient dispersal [25]. Rooftop community gardens may have social and health benefits as well as providing an ecosystem service. For residents interested in gardening, there are also mental health benefits [26]. Green roofs and living walls are a new concept for Australia, and must be formulated both for Australia's climate, and for the best ecological systems [27].

4. Preliminary findings from a PhD study in Perth, Western Australia

SF36 health surveys and lifestyle surveys comprising of 150 lifestyle questions were distributed and received over four seasons from high-rise apartment dwellers in the metro area of the city of Perth, Western Australia. The responses were inputted into Qualtrics software for analysis. Not all respondents elected to be part of the broader 12-month study, thus 87 lifestyle surveys and 81 health surveys were received. The 21-item Nature Relatedness (NRS) scale has been shown to differentiate between groups of nature lovers and those who do not participate in nature experiences [22, 30].

The NRS Scale was used within the lifestyle survey in addition to eight questions regarding time spent visiting different types of green space and a question regarding time spent gardening.

The results indicate that many high-rise apartment dwellers agree that they are not separate from nature but are part of it. However, these individuals do not have high nature relatedness scores (Table 1), nor do they visit green spaces frequently (Table 2). However many had preferences for green spaces to be around them, with 89% preferring a balcony garden and 83% indoor plants. Around the apartment building 93% of residents would strongly like a park, 87% street trees, 81% a rooftop community garden and 75% vertical gardens. Respondents in the broader study collectively live in 37 apartment buildings, and of those 37 complexes 24 had no landscaping. Nine complexes had a community garden.

The nature relatedness (NRS) and green space data were analysed using SPSS (Version 25). Collectively the components of the scale measure the affective, cognitive, and experiential relationship with the natural world, with a higher score indicating a stronger orientation towards nature [22, 30]. These scores are a strong predictor for visitation to green spaces [22].

Total scores and descriptive statistics were computed for each of the NRS factors. For the total green space mean and the gardening variable descriptive statistics and a total score were computed by averaging across the items. Spearman's correlations between variables were calculated and it was found that nature relatedness was not

significantly related to the majority of lifestyle variables.

Tables 1-2 present the descriptive statistics and Cronbach's alpha reliabilities of the combined key study scale variables.

TABLE 1

Descriptive statistics of the nature relatedness measures of high-rise apartment residents with no plants (n = 68) and plants on balconies (n = 19). Five-point Likert scale ranging from one (disagree strongly) to five (agree strongly).

NRS Measure	Group	Range	M	SD	α
Experience	<i>Plants</i>	1.90-4.86	3.38	.86	.548
	<i>No Plants</i>	1.19-5.00	3.30	.78	
Perspective	<i>Plants</i>	2.98-4.88	3.77	.66	.722
	<i>No Plants</i>	2.14-5.00	3.73	.65	
Self	<i>Plants</i>	2.38-4.84	3.71	.72	.834
	<i>No Plants</i>	1.98-5.00	3.53	.68	
Total	<i>Plants</i>	2.79-4.86	3.64	.66	.648
	<i>No Plants</i>	2.11-5.00	3.52	.52	

Note. NRS = Nature Relatedness Scale M= Mean SD = Standard Deviation

TABLE 2

Descriptive statistics of the visitation to green spaces mean scores of high-rise apartment residents with no plants (n=68) and plants on balconies (n = 19). Seven-point Likert scale ranging from one (never) to seven (daily).

Measure	Group	Range	M	SD	α
Local Parks	<i>Plants</i>	1.00-7.00	4.47	1.90	
	<i>No Plants</i>	1.00-7.00	3.75	1.80	
Bushland Areas	<i>Plants</i>	1.00-4.00	2.37	1.07	
	<i>No Plants</i>	1.00-7.00	2.04	1.34	
National Parks	<i>Plants</i>	1.00-4.00	1.89	.88	
	<i>No Plants</i>	1.00-5.00	1.65	.82	
Farmland	<i>Plants</i>	1.00-3.00	1.58	.61	
	<i>No Plants</i>	1.00-3.00	1.29	.55	
Beach	<i>Plants</i>	1.00-6.00	2.53	1.12	
	<i>No Plants</i>	1.00-7.00	2.34	1.28	
Farm (Animals)	<i>Plants</i>	1.00-2.00	1.47	.51	
	<i>No Plants</i>	1.00-3.00	1.21	.51	
Sports-field	<i>Plants</i>	1.00-5.00	2.32	1.4	
	<i>No Plants</i>	1.00-7.00	2.18	1.5	
Camping	<i>Plants</i>	1.00-2.00	1.42	.51	
	<i>No Plants</i>	1.00-3.00	1.32	.56	
Gardening	<i>Plants</i>	1.00-5.00	2.20	1.36	
	<i>No Plants</i>	1.00-7.00	1.50	1.2	
Total	<i>Plants</i>	1.00-3.22	2.25	.63	.748
	<i>No Plants</i>	1.00-3.56	1.92	.59	

Respondents with no plants had an aggregated mean score that was below the NRS mean population norm of 3.65 [22],

and though respondents with plants scored higher, when a Mann-Whitney test was applied there was no significant difference (.785). However there was a significant difference between the two groups that showed that respondents with plants visit green spaces more frequently than those without (.036). The limitation for the comparison was the smaller sample size of respondents with plants on their balconies compared to respondents with no plants.

The SF-36 is a short questionnaire with 36 items which measure eight multi-item variables including five items on mental health [31]. Of the 81 study participants who completed a SF36 health questionnaire, 45% stated that they experienced emotional problems that interfered with social activity, and 61% felt worn out at least some of the time. There were no statistically significant differences in the figures for individuals with plants on balconies and those with no plants.

5. Conclusion

Existing evidence shows that being around or viewing nature enhances health for the human population living in high density urban areas in cities around the world. Nature relatedness can vary between individuals and appears to be inherent rather than related to lifestyle. A reasonable case can be made to assume that people living above the third floor in high-rise apartment buildings have a reduced exposure to soil, plants and animals than dwellers in low-rise and single-unit housing.

High-rise dwellers with no plants in their immediate environment appear to be further

disconnected from nature than those with plants on their balcony.

Based on this study of the Perth population, people in high-rise apartments with no plants visit green spaces less than people with plants on their balconies. This result may be applicable to other apartment dwellers living in other cities in Australia (and elsewhere). High-rise apartment buildings are increasing as available building space in inner city areas diminishes, and this looks to be the way of the future as the human population increases.

Ecosystem services such as parks, community gardens, rooftop gardens, living walls, green roofs and internal green spaces are critical to human health from both a mental and a physical perspective for high-rise apartment dwellers [9]. Landscape architecture in conjunction with government development policies is paramount to enabling ecological justice and accessibility to nature, as well as providing the right microbial balance for high-rise apartment buildings.

Possible recommendations to help planners move towards a biophilic city are as follows:

1. Green space strategies need to become a focus for developmental planning revisions;
2. Developers need to be made aware of the need to put back a percentage of greening when designing high-rise buildings on small blocks.
3. Ecological justice needs to be taken into account so that greening of suburbs does not escalate real estate

- and push lower socioeconomic people out;
4. Greening of unused blocks of state land in suburbs where there is a shortage of public green spaces will benefit residents;
 5. Reuse of unused industrial spaces may make neighbourhoods safer and more welcoming in addition to providing nature benefits;
 6. Public transportation may also need to be addressed, in order to facilitate more visits to bushland areas or national parks.

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DO WE REALLY NEED TO CHOOSE BETWEEN NATURAL, HORTICULTURAL AND AGRICULTURAL PLANTS FOR OUR CITIES?

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Abstract

Green is beautiful, ecology is smart and horticulture is the past? Two housing projects developed in Grenoble, a French city located in the Alps, offer a unique opportunity for a cohabitation between endemic local plants, with fruits and vegetables, and horticultural bushes and flowers. Both of these projects are telling: we don't need to choose between ecology and gardening to be sustainable!

The first project is located in Seyssins, a small city in the Grenoble suburbs, between the river Drac and the Vercors mountain foothills. The project includes 55 flats, among which 30 are dedicated to social living, rented flats, comprised mainly of families, and 25 flats sold to individual owners. Overall, there are over 150 adults and children living in this housing project. Together, they share a vegetable garden, an orchard and a collective roof garden. In addition, each family is given a small private garden or a large terrace. The top roof is covered with extensive meadows mainly constituted of the identical plants found growing in the rocky soil of the mountain adjacent the apartments. Rainwater is collected in tanks and used for watering the vegetable garden and the roof garden. The gardeners are themselves the residents, some of them owners, others tenants. All together they manage the vegetable garden with the residents' association, which also provides and takes care of the gardening amenities (equipment and locale), the citrus trees integrated in the mail box room used as greenhouses, the watering installations and the orchard. Four years after the residents' arrival in their new flats, this project is a success, putting forward its multilayered biodiversity (an influx of birds and insects) and its social development.

The second project is still under construction in the south of Grenoble, near the city's main ring road. 150 flats will be built, among which, 20% are reserved for social housing families, 15% for student housing and 15% for retired residents. The housing is organized in terraces from the 4th floor up to the 11th floor. It integrates a large roof garden with a greenhouse, a vegetable garden and a small orchard. The rain water used for watering the roof garden is collected in a succession of extensive roof gardens with dry meadows. A wet forest garden is planted in the heart of the housing project. It is also the final area to collect and infiltrate all

the rainwater, coming from each successive terrace, the water circulating from terrace to terrace, partly hidden in the roof structure, partly left to trickle down in the open.

Both of these projects are resilient in the face of climate change. They participate in mitigating the climate change impact in city housing, for summer comfort, as well as for winter wellbeing, with the added bonus of minimizing flooding risks and protecting the ordinary biodiversity of our cities.

Keywords : climate change resilience; green cohabitation; multilayered biodiversity; wellbeing

Introduction

At a time when sustainable development is at a high, how can we concretely integrate into projects environmental, socio-economic and heritage aims, on one hand, in our daily private practice and, on the other hand, in our confrontation with an educational and teaching practice among students in universities or other. The educational experiences hereafter concern mainly the thoughts and reflections experienced at the Grenoble School of Architecture, Grenoble being the “capital” of the French Alps. And it is particularly on the questions that address biodiversity, stemming from the experience in our planting choices, tested through our agency’s landscape projects, that on this occasion, the Singapore IFLA Congress, we wish to take stock of the reflections on this matter, as a professional and a teacher.

In Europe, wilderness, in the ecological and scientific sense of the term, has almost disappeared. Today, there is almost no territory left anymore where man has not intervened in the last 300 years. There are, however, “some” natural spaces, in the common sense of the words, that we know, are not managed either by man, nor by farmers, forest rangers or gardeners. In France, if these spaces are still relatively numerous on faraway mountainsides or

certain islands, agriculture and forestry, more or less intensive, widely dominates our territory.

At the same time, biodiversity has never been so much in danger, including the ordinary urban biodiversity such as insects, birds and small mammals. As an example, in 2018 the Paris Natural History Museum and the French League for the Protection of Birds issued a report revealing that a quarter of all breeding bird species, are today in danger in France, their population decreasing around one third these last fifteen years.

Among the many explanations that are put forward, there is the major decline in insect numbers and the evolution of agricultural practices that are leaning evermore towards intensive or industrial methods. Moreover, Europe in general and France in particular, have observed that the new fauna biodiversity refuge is actually becoming our cities. Foxes, wild boars and other small mammals have become a common sight in our urban spaces, cities adapting to new forms of cohabitation. More recently, a wolf even returned into Berlin.

In this context, every new project comes with newfound responsibility for our society to develop new biodiversity shelter spaces (without losing sight of improvements to agricultural methods). It is also urgent to

change our methods and approaches to the project in matters of landscape design.

We created our landscape agency over ten years ago, and for the equal amount of time we have searched to develop our approaches, and our ambitions for the project, making them continually evolve. Whether in our studies or in project management, each of our projects aim to protect not only the local biodiversity but also aim to develop it further. This also includes any concerns in the preservation of plant substrates and stormwater management.

Our design practices and methods must continue to accompany our environmental ambitions, improving them, especially in matters of spatiality, space ambience, function and use comfort, all in the name of general interest. Throughout our studies and projects, plants and flora in general remain "the raw material" at our disposal. But beyond the preservation of regional endemic flora and fauna, we refuse to have to choose between local flora and horticultural and productive flora.

And so, at our small scale level, we continue to test plant associations, stemming just as much from field observation as from literature research. We proceed to follow their evolution, with fauna and flora considerations, but also in matters of functions, uses and esthetics. There is, for us, a form of filiation with the landscape architects', Piet Oudolf and Noel Kingsbury, ecological and phytosociological approach.

For now the reality is other. After our projects are completed, the biodiversity established, we, unfortunately, remain unable to set up scientific follow-up protocols, having no internal scientific expertise. We simply wish to participate in the collective ambition to create more sustainable living spaces, with conditions allowing our fellow countrymen to live a more sustainable life in these spaces. This is the type of experience we wish to share with the 2018 Singapore Landscape World Congress and, most especially, through the displaying of two of our recent projects

Living within a kitchen garden, a co-ownership project in the heart of a garden in Seyssins

Seyssins is a small municipality in the suburb of Grenoble, itself a metropolis of about 450 000 inhabitants.

The city launched a housing project, comprised of 55 intermediate flats, at the heart of what used to be a large garden, complete with orchard. It was partially constructed on an underground concrete parking structure. The site was previously occupied by community and family oriented allotments and represents a strongly sloping terrain of approximately 8 500m².

Oriented due west, the project stands at the foot of the Vercors Mountain, a vast calcareous and jagged mountain range. The region benefits from a continental climate, with a high level of exposure to sunlight (approximately 2066 hours/year) with heatwave summers and an average rainfall level (approximately 934 mm/year,

including a few days of snow) stretching out over the entire year, with more intense rain periods in the spring and the fall.

1.1. Architectural and landscaping project

The project is organized around five buildings each arranged perpendicularly over a shared underground parking (see ground plane, fig.1 and section, fig.2). Among the 55 flats, 30 are dedicated to social housing and the 25 others were meant to be sold to individual owners. The social real estate developer, after construction, kept on managing 30 social housing flats and sold the others, social housing in France needing to be overseen by appointed public bodies. In this case, the city of Grenoble named “Grenoble Habitat” as developer and administrator.



Fig.1. Ground plane



Fig.2. Site section

Each flat has a direct access (as would a house, even though this housing building is known as “intermediate housing”) to a large terrace or a private garden, while smaller flats have access to bigger collective terraces.

The building constructions are organized in a staircase profile that allows grand viewpoints on the three mountain ranges surrounding Grenoble.

The architectural and landscape design was developed in association with GTB Architects, a Grenoble architectural firm. Their design was drawn in a way so that all tenants and inhabitants could share and manage collective spaces such as vegetable patches, fruit trees (including citrus trees), the gardening tool shack and rainwater tanks (see technical cross section fig. 3) as well as a fully equipped common open air space with tables, benches, playgrounds, bicycle storage and a parking lot.

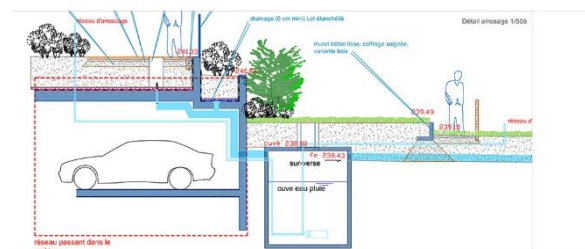
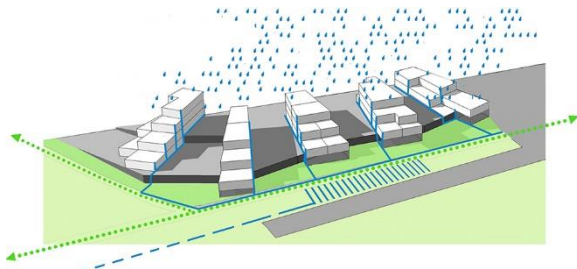


Fig.3. Detail section – cross-section through parking and cistern system

Gardens are located either on the concrete structure or on the original topsoil (the former topsoil being reused after careful storage while construction was underway).

All the rainwater is stored in 4 tanks for summer use and specially directed to the kitchen gardens and the collective terrace



(see hydraulic principle, fig.4). The excess water is collected in a wide ditch located on the property limit.

Fig.4. Stormwater management

The project also hosts about ten birdhouses for common birds and three bat houses (pipistrelles, see photos, fig. 5 and 6).



Fig.5. Birdhouse

Fig.6. Bat houses

The project is situated near a tramway station that puts the inhabitants at a 25 minute ride from the city center.

There is also a shared vehicle in the car park.

The housing complex is itself at the junction between the city and a vast urban park, a natural urban reserve, the Green Alley of Seyssins.

Pedestrian's and bike's access to the different buildings is situated along the park pathway.

The public limit is itself put at a fair distance by small vegetable patches and terraces.

The project's design spanned from 2011 till 2013. The construction itself started end of 2013 was completed in the spring of 2015, as the plantations were done.

1.2. Plant selection

The project proposes various plant selections, ranging from endemic dry meadows of the Vercors plateau, the mountain range closest to Grenoble, to the

more classic horticultural selections for vegetable plots of land.

We planted, from the top roof to ground level, the following plants selection:

- On the invisible technical top roof, an extensive vegetation of sedum.

- On the collective roof garden we developed a traditional intensive roof garden, of various melliferous perennials, of bulbs and small shrubs. This terrace garden is cultivated upon 60cm of quality topsoil and a drip irrigation system connected to one of the water tanks (see photo, fig.7).



Fig.7. Collective roof garden

- In continuity with the flats' wooden terraces, a semi intensive vegetation of dry meadow is planted on a 25cm substratum (70% volcanic rock, 30% compost) and limestone mulching. The plant selection (46 species of perennials, annual flowers, bulbs and grasses) was chosen among floral lists of the Vercors natural protected zones, in a 3 or 4 km radius (see photos, fig. 8 and 9). Each terrace of the housing

itself integrates a large pre-vegetated planter containing aromatic herbs and vines planted next to the sun shades architecturally positioned and designed for better climbing.



Fig.8. Extensive green roof just after planting

Fig.9. Extensive green roof after one year

- The main terrace, inserted between the buildings and slotted over the parking, is also a roof garden. There is at least 1m² of topsoil reused from the site. This terrace garden is made up as a normal everyday garden complete with orchard trees. (see photo, fig.10).



Fig.10. Hedges and private gardens

- Planters as well as the carpark walls, east of the residences, are planted with shrub trees and vines, on at least 80cm of topsoil. (see sectional drawing before).



Fig.11. The carpark “green wall”

- The low level terraces, propose vegetable gardens managed by the residents. The surrounding hedges are planted with small flowering shrubs and fruits (currants and blackcurrant mainly).
- Small landings and immediate surroundings in access to the homes, in the drier and sunnier environments, are planted with Mediterranean plant species and fruit trees.
- The wide ditch collecting rainwater is planted with shrubs, grasses and perennials, supporting vast amplitudes of humidity, from temporary submersion to temporary drought (see photo, fig. 12).



Fig.12. Wide planted gap separating private domain and the public path rainwater ditch.

- Prior to the residents’ incoming, the vegetable plots of land, awaiting the future gardeners, were sowed with a “green fertilizer” (*Synapis arvensis* and *Phacelia tanacetifolia*).
- The mailbox rooms have also been designed as unheated greenhouses, each of which is planted with a variety of citrus tree.

Counting trees, shrubs, climbing plants, perennials, bulbs and grasses, about 212 different species were planted. Amongst them 19 different tree species and 15 fruit tree varieties.

1.3. First feedbacks

The Seyssins project reflects, on the one hand, the research and the observations in regards to a typical plant project and, on the other hand, the experience in regards to a social project. It was the object of intense public consulting and inquiry beforehand, a request strongly driven by the municipality

and the real estate developer. The aim was double.

The first goal to achieve was to allow future residents, homeowners and leaseholders, with low income, to get to know each other before having to share common spaces in the same building. Several information meetings were then organized in order to present the project as well as a visit, in situ, during construction.

The second goal aimed to further implicate future residents in the green space management. Indeed, the real estate developer was investing on large amounts of plants (over 14 000) that would become each and everyone's responsibility whether caring for or only watering them. The challenge was won and the residents up to par. Around 150 people took the gardening project in hand, terraces and gardens alike, even going to the extent of adding new species.

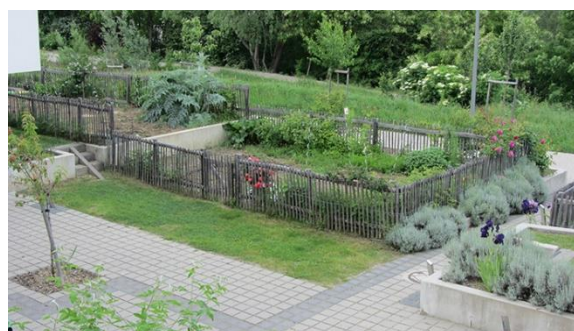
According to all, numerous insects have invested the gardens and the first birds, and even some bats, have also started to call Seyssins home. It is necessary to note that certain residents seemed cautious in the beginning, maybe even frightened, at the idea of cohabitating with bats.

We estimate today that approximately 70% of this initial biodiversity is still present on site, and this, nearly 3 years after having planted. In order to paint a full picture, we must also state that ruderals (notably the *Docus carota*) have slowly started to dominate rooftop intensive plants

The more shaded areas (northern face) have had greater difficulties developing to

maturity. Certain plant replacements were made, introducing, at the same time, various new varieties.

The garden management in general has been put into the hands of a non-profit association comprised of a group of residents (homeowners and leaseholders). This association is the privileged speaking partner with the residents for all site management questions. Every aspect of management is maintained without any



chemical products (see Fig 13).

Fig.13. Vegetable patches, plots

2. A garden building

The second project is in Echirolles, a southern suburb of Grenoble.

The building construction only just started in September of 2017. The



project provides for 150 flats, partly designed for low income social housing, homeownership, housing for seniors and student housing, and was the brainchild of the SCAU Architects agency. The Safilaf was the developer.

2.1. Architectural and landscaping project

The housing project took on a triangular shape,

, a green grass space, complete with fruit trees, allowing for picnics and calm relaxation. (Fig 14 through 17).

An intermediate terrace acts as a liaison area, linking the upper functional parking terrace to the street level interior garden. From the 11th level down to the 5th level, the flats open up to the South onto large rooftop terraces, terraces extended further by semi extensive dry meadows. The rainwater collected from these terraces cascade down from storey to storey. It is then recovered into cisterns in two gardener's sheds, each of which are located on the parking roof's extremities. (Fig 18 and 19).

Fig.14. Ground plane

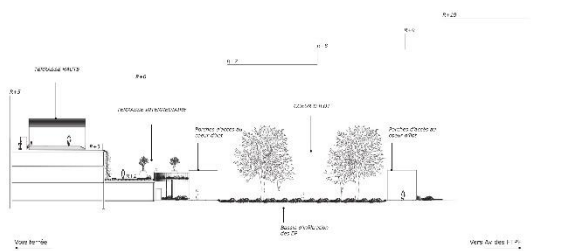


Fig.15. Project section



Fig.16. Illustrated general view (illustration: SCAU Architects)



Fig.17. Illustrated interior view as seen from the community shared terrace (illustration: SCAU Architects)

2.2. The landscape design

This project is the logical follow-up to the previously cited Seyssins project. It draws lessons from Seyssins, all the while introducing new methods of experimentation or testing.

One can then see, from the ground up:

- Dry meadows on impoverished substrates planted on semi-extensive green roofs. Contrary to the previous project, the more vivacious ruderals were entirely eliminated from plant lists.
- A garden roof atop the parking facilities, both horticultural and productive. It is the future playground and resident gardening area (Fig.20 and 21).

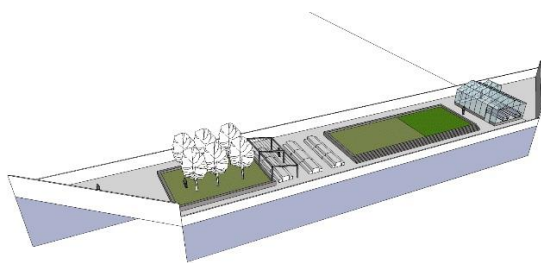


Fig.20. 3D view of the community collective terrace

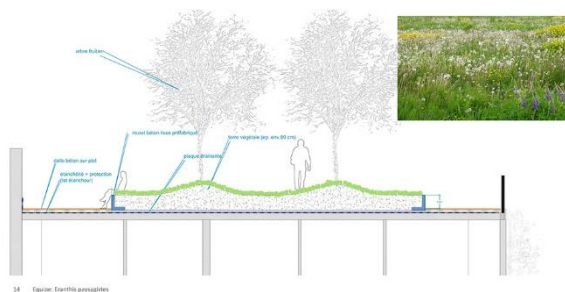


Fig.21. Section illustrating the terrace orchard

- The intermediate terrace is made up of potted multi-trunk trees, ground covering plants but also climbing plants on the parking wall. This terrace has the distinctive feature of

leading overhead rainwater from summit terraces to the interior central garden below.

- An interior central garden was imagined as «a small piece of wilderness»: a number of trees, green spaces, typical forest undergrowth (a collection of different ferns).

Accumulated, there are more than 13 500 plants, from more than 65 different species.

Conclusion

We have researched varied sources, studied many works, all in order to verify if any information existed concerning horticultural plants that would attract less wildlife in general, and insects in particular, than endemic plants. There are notably several studies on green roofs and green walls, which prove that a flora offering food, in particular flower or fruit nectar, indeed attracted fauna, and that insects and birds that are dependent to a unique species of plant were rather rare. Our own project feedbacks seem to confirm these studies. Floral diversity, including horticultural species, favoring melliferous and/or fruit species, is the key. Sterile horticultural species without nectar, which would disorientate some insects, in particular bees, have been eliminated from all our floral assortments/palettes. It is also necessary to note, that in these urban environments, more or less windy, strongly allergenic plants were avoided.

So, whether it be the Seyssins project, where regular visits allow us continued observation

on the evolution of plant diversity, or the Echirolles project, soon to be constructed, or any other future agency projects for that matter, we realize more and more that we are but at the beginning of our comprehension and mastering of these complex living environments.

This is also the reason that makes our profession so enthralling and captivating.

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Translation: Ginette Saint-Onge, Catherine Combe

The role of Landscape Architects in building Biophilic Cities

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Abstract

Decision-makers around the world are grappling with the implications of rapidly growing cities and are seeking to foster healthier living amongst sedentary populations with chronic 'lifestyle' diseases and an increasingly aging population. Design solutions that address these concerns have the potential to improve standard of living, reduce public or insurance health spending and enhance ecosystem health. The field of biophilic design offers strategies for addressing these concerns while also delivering health, lifestyle and ecosystem benefits.

The theory and related design principles of biophilic design span more than three decades of action research over a variety of geo-political, built environment and climatic contexts. Over the last five years, Conrad Gargett has participated in a multi-faceted action-research partnership seeking to deepen understanding and better integrate biophilic elements towards healthy cities and citizens. Collaborative research has included several projects investigating healing gardens integrated into a Queensland hospital, including an evaluation of garden-visitor experiences (reflective journals and surveys), a review of the design journey (archival analysis and interviews), and evaluation of micro-climate conditions of the gardens (monitoring).

This paper will draw on these projects to identify key roles and influencers necessary to successfully implement biophilic urbanism projects, suggesting strategies for biophilic design to tackle complex 21st Century challenges within a rapidly changing built environment. It will provide an insight into strategically embedding 'biophilic services' to address public and environmental health, and climate change impacts. It highlights the need to commit to social responsibility and critical design thinking to nurture human and environmental health, reflecting our innate human need to connect with nature.

We conclude that landscape architecture has a significant role in influencing the design of resilient cities, as leaders in embedding 'biophilic services' through systems thinking and interdisciplinary collaboration. In particular, Landscape Architects can ensure that 'functional biophilic design' is an integral part of the city's fabric, contributing to designing spaces for people that feel intrinsically familiar, towards aesthetic, intellectual, cognitive and spiritual satisfaction. Finally we highlight the need for capacity building in the landscape architecture community, to embed biophilic services within projects.

Keywords: *Landscape architecture; Biophilic Cities; Health and Wellbeing*

1. Observing the critical role of Landscape Architects

Decision-makers around the world are grappling with the implications of rapidly growing cities and increasingly sedentary and aging populations with chronic ‘lifestyle’ diseases such as type 2 diabetes, cardiovascular disease, and obesity (Willet et al, 2006;WHO,2003;WHO,2005). They are concurrently grappling with climate change related impacts including increasing temperatures and frequency of extreme weather events, the spread of certain tropical diseases, and sea level rise (IPCC, 2014).

As cities continue to develop and densify and develop around the planet, it is imperative that design solutions address these social and environmental concerns. Indeed prompted by these concerns we can go beyond ‘survival’ to ‘thrive’ (Cooper-Marcus, 2016), collectively improve standards of living, reduce insurance health spending, enhance ecosystem health, and foster built environments that are resilient to the impacts of climate change. We propose the strategic integration of nature into urban environments as being a critical component of such efforts. Amongst global calls to action, we highlight the call for landscape architecture leadership by the Hon Hilary Benn, Secretary of State for the Environment, Food and Rural Affairs, U.K.:

“...you bring together the skills, knowledge and passion that we need for the 21st century in the way that engineering shaped the 19th century. We need you in the fight against climate change. You can show people how it can be done. Your Institute

has established a record to be proud of – whether greening gardens or greening the 2012 Olympics, from being leaders in the design of cleaner, greener neighbourhoods to pioneers of green energy and green infrastructure projects.”

Within this paper we use our collective lived experiences over the last five years to highlight the social and environmental responsibilities of landscape architects to improve public health and urban resilience to climate change impacts, towards nature-loving – i.e. biophilic (Beatley, 2000) – outcomes. We propose that landscape architects can champion the integration of what we call ‘biophilic services’, defined as, “the benefits yielded from intentional interventions in the built environment, providing conditions and processes through which one or more biophilic elements yield direct or indirect, implicit or explicit, quantitative or qualitative enhanced well-being” (el Baghdadi and Desha, 2016).

Over the last five years, Conrad Gargett has participated in a multi-faceted action-research partnership with Griffith University, Queensland University of Technology, University of Queensland and Queensland Health, to explore the role of biophilic design in city health, and to better integrate biophilic elements to positively impact cities and citizens. Collaborative research has included several projects using the healing gardens at the Queensland Lady Cilento Children’s Hospital as a case study to better understand the social and environmental impact of biophilic design, particularly within a sub-tropical hospital context. This included an evaluation of end-

user experience (reflective journals and surveys), a review of the design journey (archival analysis and interviews), and evaluation of micro-climate conditions of green space (monitoring).

Drawing on this collaborative journey and the concept of delivering ‘biophilic services’, in this paper we discuss leadership roles landscape architects can take towards delivering healthy and resilient cities. This includes embedding a holistic approach to development from concept through to project delivery. It also includes effectively using spatial data information to design purposeful and effective biophilic cities. We conclude with a discussion of the implications for design and master planning projects, and for professional practice, and several immediate actions to create more resilient cities through biophilic design

2. The role of Landscape Architects in delivering biophilic outcomes

The design and development of urban spaces and infrastructure is typically a multi-disciplinary process involving planners, urban designers, engineers, financiers, architects, landscape architects and the construction industry – among others. There has been growing recognition of the value of integrated, collaborative approaches that bring together these professions and key stakeholders early in the design and decision-making stages to achieve more holistic, sustainable outcomes.

In order to deliver biophilic services as an integral component of urban design and development, we propose that the role of

landscape architects in such collaborations needs to be elevated, to ensure the preconditions are achieved to deliver thriving natural features; and to ensure biophilic design principles inform the broader urban design. More specifically, the disciplinary training and experience of landscape architects support a central role for this profession in the following ways:

- Ensuring the overall design of the urban space or infrastructure is 'conducive to life' in a way that optimises the long-term viability and function of the vegetated and other natural features, including that they receive good light, air circulation, and water.
- Ensuring vegetated areas are well integrated into the rest of the design in a way that supports way-finding, use and maximises the value of those vegetated features. In this regard, the vegetated features are elevated to a central design consideration, rather than an afterthought.
- Integrating broader 'biophilic design' principles into the design of the space of infrastructure, including moving beyond 'nature in the space' (natural features), to also ensure ‘nature analogues’ (natural patterns, forms and materials) and ‘nature of the space’ (nature based design-induced experiences that promote positive emotions) are achieved in the design.

In this section we outline the role of landscape architects in addressing these identified issues, or *pain points* in the urban environment. From concept design through to handover – landscape architects can champion the integration of biophilic

services through the city as means of fostering improved urban design and ecosystem health, which lends itself as fittingly complimentary to urban related professions that are also contributing to sustainable urban design. Landscape architects play a crucial contributing role in improving urban ecosystem health due to their knowledge of landscape integration in the built environment.

Previous research led by the first author has discussed the myriad of biophilic services that are capable of improving liveability in our cities, through social, environmental and economic improvements (el Baghdadi, 2016):

1. *Social improvements:* Human beings are physically, neurologically and emotionally responsive to cues in their surrounding environment (Ulrich, 1984; Kaplan and Kaplan, 1989; Kellert, Heerwag and Mador, 2008). This further points to the prominent role of architectural and landscape design, which play a role in the sympathetic (and alternatively the parasympathetic) nervous system (Bengtsson, 2015) influencing people's health and well-being. Dating back more than 20 years, seminal work in this field has found that higher stress levels reduce the body's healing processes (Ulrich, 1984; Ulrich et al, 1991), this identifies the significance of designing spaces that make people feel better.
2. *Environment impact:* This method of planning is capable of providing local, state, and national governments with

options to mitigate climate change (Newman, Beatley and Boyer, 2009), alleviate UHI effect (Nieuwolt, 1966; Roth, 2002), integrated water cycle management (Xiao and McPherson, 2006), and promote healthy environments for increased biodiversity (Alvey, 2006).

3. *Economic impact:* Various studies have also presented the economic impact of integrating nature into the built environment. Some of which include: reduce absenteeism (Elzeyadi, 2011; Romm and Browning, 1994), increase productivity (Bergs, 2002), reduce building energy demand (Graffin, 2005), increase food security (City of Sydney, 2014; Smit, Nasr and Ratta, 1996), roof longevity (Banting et al, 2005), infrastructure longevity (McPherson et al, 1997), increase property value (Laverne and Winson-Geideman, 2003; Benson et al, 1998), tourism (Chiesura, 2004), catalyse economic development (Terrapin Bright Green, 2012; Skyrise Greenery, n.d.), reduce traffic incidences (Dixon and Wolf, 2007), reduce healthcare cost (Thayer et al, 2010; Bedimo-Rung, 2005), and increase employment (De Sousa, 2003).

With this in mind, Table 1 highlights key challenges within the built environment, benefits of biophilia, and the role landscape architects can play as champions in addressing these within the design of cities.

Table 1. Identified challenges and opportunities for the profession to contribute to solutions

[Insert Table 1 here]

3. Undertake holistic design for biophilic services

In this section we discuss the opportunity to go beyond including incidental green spaces in and around buildings, neighbourhoods and cities, to undertaking holistic design that nurtures human and environmental health reflecting the innate human need to connect with nature. In particular, we argue the importance of locally optimised solutions that are inspired by local context and with a view of delivering biophilic services to achieve optimal project outcomes.

The theory and related design principles of biophilic design span more than three decades of action research over a variety of geo-political, built environment and climatic contexts. Biophilic design or biophilic urbanism continues to evolve as a concept to offer more intentional solutions to urban-related issues (el Baghdadi and Desha, 2016), with landscape playing a prominent role in serving as a framework indicating where to urbanise and to not urbanise, as well as how to urbanise (el-Baghdadi, 2016). Biophilic urbanism represents the idea of integration of urban nature into cities and proffers a design principle to inform intentional and functional use of biophilic elements, such as city and pocket parks, linear green space, and green roofs and walls in the built environment (Beatley, 2000).

Landscape architects through their professional training, collaborative approach and trans-disciplinary working are well equipped to take a leadership role in this arena. True collaboration requires dense interdependent connections, a high level of trust and frequent communication. Negotiated shared goals are driven by mutual self-interest and an appetite for innovative design solutions demonstrating social responsibility. There is a commitment and accountability to network with the community and stakeholders. The commitment is long-term, often high risk with opportunity for high reward and product innovation. Figure 1 illustrates how collaboration works within the landscape architecture field; whereas, Figure 2 demonstrates the collaboration cycle.

[Insert Fig. 1 here]

Fig 1. The cycle of collaboration

[Insert Fig. 2 here]

Fig 1. How collaboration works

Noting the need for a more strategic collaboration process that contributes to effective biophilic design, we propose a more rigorous process which can ensure externalities are carefully identified, solutions have been presented and projects goals are met. Responding to the need for trans-disciplinary teams to understand and apply this knowledge, we have developed an emergent process (see Fig. 3) to demonstrate the role landscape architects can take in

contributing to biophilic design within the urban environment.

[Insert Fig. 3 here]

Fig 3. Strategic collaboration process to inform biophilic design

As shown in Fig. 3, the landscape architecture profession needs a more integrated strategy to ensure spatial data is used suitably within the design processes to deliver a project that not only addresses the project brief but also strategically contributes to the built environment. We argue that an impetus to formally integrate ecology into decision making may be needed to encourage a deviation from the ad hoc and aesthetically driven implementation of landscape design and biophilic elements. The research of biophilic elements and their corresponding services (el Baghdadi, 2016) identified that demonstrating net public good from investment in a biophilic element was found to be possible using a number of approaches that range from a value driven analysis to an externality analysis as well as an ecosystem services analysis. This means that linking externalities with the corresponding biophilic service responsible for addressing this externality provides landscape architects with the necessary guidelines/scope to complete projects, whilst simultaneously address climate change consequences.

The three main components from Figure 3 are discussed below:

IDEA: Project Concept Design Using Spatial Information Technology

Spatial information technology offers opportunities to increase the visibility and appreciation of the urgency of the challenges facing cities by highlighting the deficit of current approach to urban developments. Utilising spatial information to identify externalities across the built environment provides impetus for recognising the systematic use of biophilic services throughout the city, or for a particular project, to help facilitate sustainable development. Ensuring landscape architects use spatial information appropriately during the project concept design stage creates opportunities to stimulate change in cities by converting an implicit recognition of externalities to an explicit conversation.

PLAN: Project Design Development Using Biophilic Services

Figure 3 highlights that an understanding of the taxonomy of biophilic elements along with their corresponding services offers opportunities to facilitate its effective use in the project concept design process for landscape architects. This is because this strengthens the project proposal by offering a menu of options tailored to address identified externalities, through spatial information technology, allowing landscape architects to consider this through the project design development stage.

ACTION & OUTCOME: Strategic and effective communication

Communicating findings clearly to the client and relevant stakeholder groups may inform and drive an agenda for change.

In comparing the current situation regarding ad hoc or aesthetically driven implementation of landscape integration, it is apparent that there is an opportunity to employ spatial information technology for communicating the role of biophilic services to encourage clients to accept a project proposal that not only addresses the project brief, but also contributes to climate change adaptation. Additionally, incorporating spatial information and biophilic services into the design process assists in communication in ways that are meaningful across disciplines which becomes important for effective collaboration across teams.

4. Implications for projects and professional practice

As climate change is now strongly influencing policy matters worldwide, landscape architecture should actively participate in the narrative to suggest strategies for sustainable design to tackle 21st Century related challenges due to ineffectual resource use and urban design. In this section we conclude with a discussion of the implications for design, and for professional practice, and several immediate actions.

Immediate action is required to demonstrate the interconnectedness of human actions, climate change and mitigating design solutions. Looking to nature for design solutions, adapting ecosystem services to the urban context and utilising nature's ability to adapt to a changing environment should be clues to the way forward. These design solutions have to

be evidence based, economical and require the support of local and world communities to be effective. In addition to technical knowledge, advocacy and leadership are required to inspire individuals, communities, industry and government to show social responsibility and take immediate responsible actions to support human and planetary health. It is clear that professional practice has much technical knowhow to contribute and has a responsibility to lead the discussion and the development of holistic design solutions.

Avoiding the potential for biophilic design to be regarded as no more than incidental green spaces in and around buildings, neighbourhoods and cities, landscape architects must intentionally consider the unique climate, landscape, and context, and design within this scope of natural elements as biophilic services to help address identified pain points in a city. This requires collaborative practice with architects, landscape architects, designers, engineers and other built environment professionals working together, accessing academic contribution to underpin evidence-based decision-making.

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Table 1. Identified challenges and opportunities for the profession to contribute to solutions

Identified challenge in Cities	Landscape Architecture role in prioritising green infrastructure
Environmental challenges	
Intensification of the urban heat island effect (Roth, 2002)	<ul style="list-style-type: none"> Opportunity to reduce higher temperatures, particularly in summer, leading to risks to human health in the built environment.
Water shortages (Xiao and McPherson, 2006)	<ul style="list-style-type: none"> Opportunity to mitigate reduced rainfall and increased evapotranspiration, affecting the vitality and productivity of vegetation.
Flooding (McPherson et al, 2006)	<ul style="list-style-type: none"> Opportunity to green the built environment and advocate wetlands to tackle increased rainfall intensity and increasingly frequent storm events
Rising sea levels	<ul style="list-style-type: none"> Opportunity to reduce impacts in coastal areas, including displacement of communities, social infrastructure, biodiversity and alterations to landform configurations.
Changes in biodiversity (Groombridge and Jenkins (2002).)	<ul style="list-style-type: none"> Opportunity to tackle new climatic conditions, particularly temperature and humidity levels with adaptive and resilient plant communities. Particularly, as some species increase in number and range whilst others decline, food provision, the spread of diseases and our enjoyment of a healthy and aesthetically pleasing environment all stand to be affected.
Decreasing air quality (Nice, 2012)	<ul style="list-style-type: none"> Opportunity to improve air quality through increased oxygen and humidity levels and the removal of air pollutants - formaldehyde, benzene, and carbon monoxide
Increased radiation	<ul style="list-style-type: none"> Opportunity to affect higher temperatures and possible increases in ultraviolet radiation, which could have consequences for human health and comfort.
Social challenges	
Social isolation	<ul style="list-style-type: none"> Opportunity to create public open space suitable for social interaction, community celebration and public events.
Decline in mental health	<ul style="list-style-type: none"> Opportunity to facility the human need for time in nature in the urban environment advocating parks and a myriad of green typologies in the city.
Increase of lifestyle deceases	<ul style="list-style-type: none"> Opportunity to counteract the impact of lifestyle deceases, such as type 2 diabetes, obesity and heart decease by growing fresh produce, promoting physical activity, by encouraging pedestrian friendly urban living and easy access to nature in the city in general.
Access for all	<ul style="list-style-type: none"> Opportunity to consider cultural diversity, physical and mental disabilities, gender specific consideration, safety and security in the user friendly design of public open space
Disaster recovery	<ul style="list-style-type: none"> Opportunity to create environments for social support during disaster recovery; access to essential services, a place where the community can get together; a place to improve moral and lift the spirit
The character of our landscapes (Louv, 2005)	<ul style="list-style-type: none"> Opportunity to preserve natural character of landscapes as a changing climate impacts upon environmental, cultural, social and economic factors which shape this character
Reduced access to nature and wilderness restoration (Louv, 2005)	<ul style="list-style-type: none"> Opportunity to reduce negative impact on mental and physical health
Congestion and longer travelling times	Opportunity to integrate green infrastructure, transport including public transport and services infrastructure to enable working and living in close proximity
Economic challenges	
Increased health spending	<ul style="list-style-type: none"> Opportunity for innovative design such as healing gardens to reduce hospital

	stay and health costs generally
More frequent disaster recovery resulting in an increase of repair/replacement of infrastructure	Opportunity to design resilient infrastructure based on system design
Increased spending to safeguard assets from raising sea levels	Opportunity to collaborate with the community and professionals to prioritise and spend money wisely based on evidence based design.

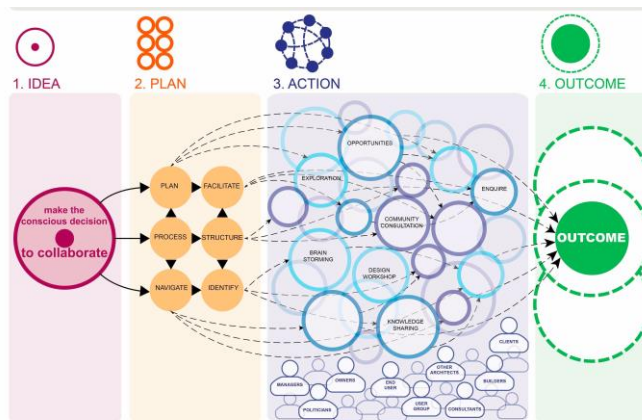


Fig 1 How Collaboration Works

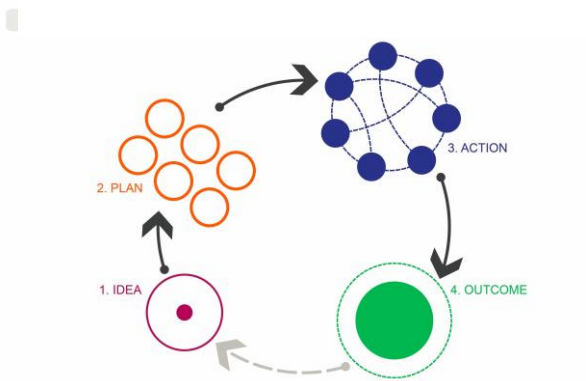


Fig 2 The Cycle of Collaboration

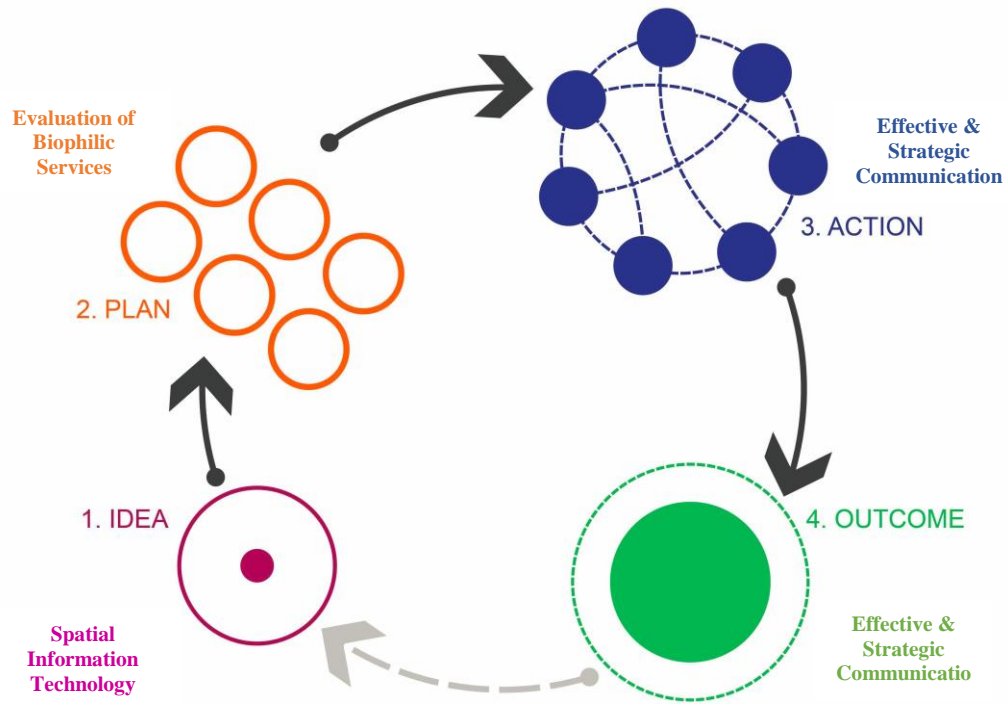


Fig 3 Strategic collaboration cycle to inform biophilic design

Building resilience: working across disciplines to foster 'nature and nurture' outcomes

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Abstract

Around the world, management and maintenance budgets for public infrastructure including parklands are steadily eroding with the increasingly expenditure on clean-up and restoration following extreme weather events. Without intervention, this trajectory of diminishing budgets has significant implications on the provision of community services and facilities. Community impacts of living with degraded and weather-impacted community-infrastructure, public open-space, and nature-reserves within our built environment call for a fresh approach. To combat these 21st Century challenges, innovative design approaches and design solutions are required. The authors propose the critical need for multidisciplinary teams producing transdisciplinary solutions, focusing on integrating biophilic design.

The paper draws on the authors' lived experiences and workshops with more than 150 industry, government and academic colleagues in the biophilic urbanism field (2016, 2017) to discuss emerging consensus on how to move forward. This includes overcoming existing barriers to mainstreaming living infrastructure, and overcoming emergent barriers associated with diminishing budgets and changing risk profiles of public open space in our cities and surrounds.

The paper findings have immediate implications for advocating for management and maintenance budgets to prioritise restoration and rehabilitation projects that address future climate forecasts. The findings also have implications for clarifying the role for landscape architects to be working with engineers, public health and healthcare professionals, to ensure that design solutions meet structural (e.g. water inundation), epidemiological (e.g. water-borne illness), and psychological (e.g. mental wellbeing) performance requirements in this rapidly changing climate. The authors intend that the paper also sparks dialogue about effective spending on resilient infrastructure.

Keywords: resilience; biophilic cities; health and wellbeing

1. Introduction

Climate change is a game-changer and a risk multiplier. Cyclones and other extreme weather events are becoming more severe and both recovery costs and times are escalating for communities [1]. It follows then that increasingly limited funds will need to be used strategically to ensure future healthy and liveable cities of the future. Dzau *et al* [2] aptly refer to the saying 'Never let a serious crisis go to waste' when describing the opportunities created by disasters to plan for what we want our communities to look like as they recover, where forethought and development of a shared vision can capitalise on rebuilding opportunities towards resilience in our built environments.

Indeed the built environment – where people live, work and play – presents a crucial setting in which to focus our efforts to build resilience in the face of more severe weather associated with climate change. Greening our cities and incorporating restorative landscapes into urban design is becoming a well-recognised strategy being espoused and adopted to varying degrees worldwide. This is not a new concept but rather renewed in vigour, in the face of climate change impacts.

In the 1800s Fredrick Olmsdead, the father of American landscape architecture, long advocated for green spaces where people could recover from pollution, co-designing many well-known parks including New York's Central Park. The intuitive rationale for urban greening is quite straightforward. Such landscapes provide a buffer to the ubiquitous biophysical and socio-economic stressors in highly urbanised environments such as higher temperatures,

air and noise pollution, congestion, social isolation, multi-media bombardment and busy, stressful lifestyles [3,4,5].

Moreover, access to green and blue space in urban environments has been associated with a wide range of health benefits through measurement and quantification [6,7], and several systematic reviews, including a comprehensive summary of the available evidence by the World Health Organisation in 2016. These health benefits include improved mental health, reduced cardiovascular morbidity and mortality, obesity and risk of type two diabetes, and improved pregnancy outcomes (World Health Organisation, 2016). Current research has clearly moved beyond observing associations, with a greater focus on elucidating their nuances and the mechanisms through which these benefits are derived by different sub-populations in different contexts [8,9].

The benefits of urban greening are attracting the attention of professionals from a wide range of fields, including landscape architecture. These professionals often present with quite different paradigms, perspectives, priorities, foci and depths of inquiry. Furthermore, for a multitude of reasons, each professional discipline tends to talk to audiences from similar backgrounds, values, and perspectives, using familiar jargon and referring to their profession's dominant paradigm. Silos between professional disciplines have limited the potential benefits of sharing insights between different disciplinary backgrounds [10,11]. In the case of city design, this has led to the default situation of piecemeal and rather disconnected urban design/redesign programs and the inefficient use of limited resources [12].

Within this context, this paper discusses the experience in using biophilic urbanism, which refers to the use of natural elements as purposeful design features in urban landscapes, to reach across multiple disciplines to address climate change issues in rapidly growing economies [13]. The authors present lived experiences in building resilience, through fostering communities of practice that work across professional disciplines to foster ‘nature and nurture’ outcomes in constructed spaces. In the following sections we summarise three events in Australia (2016, 2017) that brought together more than 120 industry, government and academic colleagues to discuss emergent challenges and opportunities for greening cities and fostering healthy, sustainable communities.

2. A Summary of Three Convergent Journeys

In this section we summarise three convergent Australian journeys of the paper's authors, spanning public health and green infrastructure. Although event participants did not overlap, there are significant reinforcing messages apparent in each of the communities of practice. The three event organisers became known to each other through a common colleague (Dr Dominic Hes, Director THRIVE Research Hub, University of Melbourne) over the course of 2016, and only began collectively discussing the barriers and enablers to mainstreaming green infrastructure in cities in late 2017. In the following section we highlight the insights gained from considering the three events together.

2.1. *Healthy Places, Healthy Communities International Symposium*

In November 2016, this one day International Symposium held was organised by the second author of this paper (Dr Roiko), with a team of four academics from different schools within the Health group at Griffith University on the Gold Coast who had fortuitously discovered a mutual interest in this transdisciplinary space. With the theme of ‘Cultivating Healthy, Sustainable Communities through Environmental Connections’, the symposium explored two main themes: Linking climate, environment and human health: Case studies to big data and Designing healthy, restorative environments.

Four internationally-renowned keynote speakers from diverse backgrounds shared their experience and insights: Prof. Michael DePledge (European Centre for Environment & Human Health, Exeter University); Professor Pierre Horwitz (Centre for Ecosystem Management at Edith Cowan University); Dr. Chinmoy Sarkar (HKUrbanLab, University of Hong Kong) and Dr. Shaneen Fantin (People Oriented Design, Cairns) They showcased exemplars of new ways of working that can produce major shifts in our knowledge about complex and multi-scalar health responses to the environment.

With the aim of initiating and building a broader network of professionals interested in building healthier, more resilient communities through connections with nature, this event was aimed at and attracted a diverse audience of around 70 academics,

practitioners, policy-makers, regulators and individuals from special interest groups. The participant profile is summarised in Table 1, and Figure 1.

Table 1. Profile of participants

Sector of Employment (Participants)	Gender (Male / Female)	Experience in the topic area (< 5 years/ > 5 years)	Geographic Region (Queensland / Other)
Academia (52)	(19 / 33)	(14 / 38)	(40 / 12)
Industry (6)	(2 / 4)	(2 / 4)	(4 / 2)
Gov. (13)	(6 / 7)	(5 / 8)	(8 / 5)

The symposium featured breakout sessions, panel discussions and, importantly, time for mingling and networking. The symposium also provided the stimulus for more intensive workshop discussions with a smaller, invited group of approximately 25 participants from government and academia over the following two days.

Over the three days, individuals from diverse backgrounds worked in small groups to explore themes introduced by the keynote speakers and their ideas were then shared with the larger group and recorded. Groups were also tasked with articulating a key research problem with two research questions and approaches to addressing them. Space precludes a discussion of this rich dialogue but several key findings that

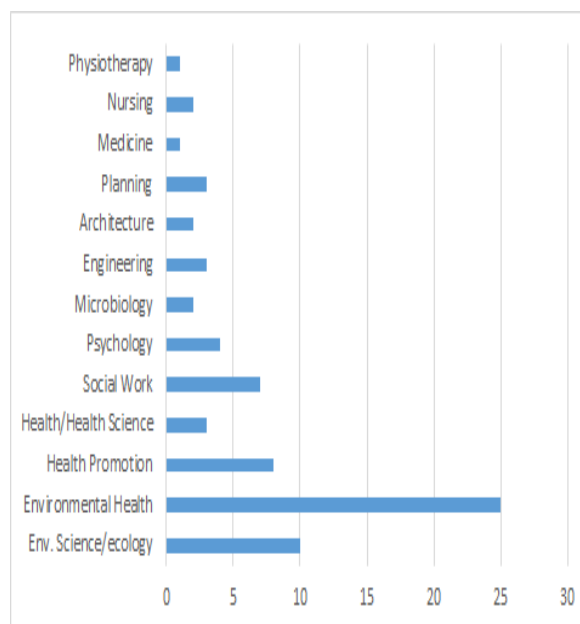


Figure 1. Disciplinary background of participants (Healthy Places, Healthy Communities International Symposium)

are directly relevant to the focus of this paper are as follows:

- We need to be cognisant of past, present and emerging challenges at the environment-health nexus and it is vital to bring indigenous knowledge and different world views and paradigms to the table.
- Everything is connected yet developing collective understandings and being funded to work together to solve problems is made difficult by fragmented organisational structures and discipline-focussed funding models.
- Researchers need to acknowledge communities and listen, employ mixed-methods of research and learn how to

communicate complex issues in effective ways that influence people.

- We need to be leaky at the boundaries, recognising that solutions and strategies come from many disciplinary perspectives.

2.2. *Biophilic Urbanism in the Tropics Symposium (BUTS)*

In March 2017, driven through direct requests from colleagues around Australia and emerging healing gardens research agenda (Nieberler-Walker, 2015, 2017, a national *Biophilic Urbanism in the Tropics Symposium* was convened in Brisbane (Queensland, Australia) to share what has been, and what could be in future. Organised by the first, third and fourth authors of this paper (Desha, Nieberler-Walker, el Baghdadi), the one-day event was hosted at the Griffith University Eco-Centre. The profile of the 39 participants is summarised in Table 2 by sector, and in Figure 2 by professional discipline.

Table 2. Profile of participants

Sector of Employment (Participants)	Gender (Male / Female)	Experience in the topic area (< 5 years / > 5 years)	Geographic Region (Queensland / Other)
Academia (27)	(10 / 17)	(18 / 9)	(22 / 5)
Industry (10)	(3 / 7)	(3 / 7)	(9 / 1)
Government (2)	(2 / 0)	(2 / 0)	(2 / 0)

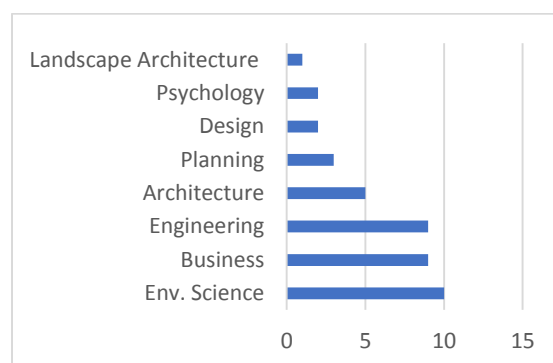


Figure 2. Disciplinary background of participants (Biophilic Urbanism in the Tropics Symposium)

Of interest to the authors is the relative lack of landscape architects attending the event, despite the snowball (word-of-mouth referral) approach to inviting participants to attend. Participants were predominantly from science, business and engineering backgrounds, who then provided reflections on the importance of all professions including landscape architecture.

Discussions spanned hearing about key activities in Australia and globally, and interactive sessions to discuss priorities going forward. With a facilitated panel on ‘Industry in Action’ followed by an interactive session on ‘Linking Biomimicry with Biophilic Urbanism in the Tropics’, the event was used to launch the Queensland chapter of the national *Biomimicry Network Hub*. The event also included an acknowledgement of the life and contribution of Professor Stephen Kellert (1957-2016), who over the course of his career inspired several of the attendees to take on leadership roles within the biophilic urbanism community of practice in Australia.

During the final session on ‘Looking Ahead – Vision for the Future’, participants distilled the ideas of the day into several key

actions going forward, related to embedding nature within urban design towards biophilic outcomes:

- To catalyse health and wellbeing in our interconnected living and physical systems
- To advocate that a resilient and thriving future is possible
- To leverage ecological intelligence and influence socio-ecological potential in cities.
- To bring the national community of biophilic urbanism practitioners together for the first time

2.3. Designing Cities that LOVE Nature – Community Event (DCLN)

In July 2017, Tim Beatley, (a colleague of Professor Kellert, fellow pioneer in biophilic design and author of *Biophilic Cities*), visited Perth, Western Australia. He offered to speak at a community event on the topic – *Designing cities that LOVE nature*. The fifth author of this paper (Söderlund) organised the event with sponsorship by the Australian Institute of Architecture (AIA) and Regional Development Australia Perth (RDA).

Although with a very short lead in time, and limited advertising, the event still attracted 71 attendees on a stormy winter’s night, signifying the interest in the integration of nature in cities. The attendees included architects, landscape architects, academics, local government, non-government organisations (NGOs), interest groups, activists and interested citizens, as shown in Table 3.

Table 3. Profile of participants

Sector of Employment (Participants)	Gender (Male / Female)
Academia (11)	(6 / 5)
Industry (19)	(8 / 11)
Government (15)	(5 / 10)
NGO (8)	(6 / 2)
Community(17)	(8 / 9)

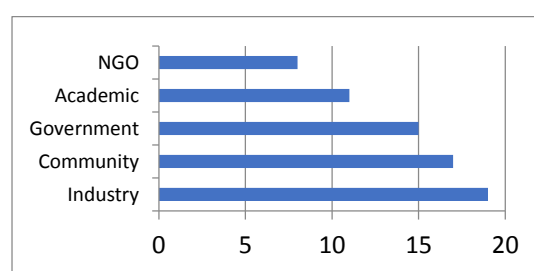


Figure 3. Disciplinary background of participants (Designing Cities that LOVE Nature)

A four-person panel facilitated by Beatley followed Beatley’s presentation. The panel consisted of two academics, one State government (Building and Finance) and one local government (city architect) representative. The aim was to expose and discuss emergent barriers to implementation of biophilic initiatives. The city architect talked about barriers such as cost, maintenance, wind and political will in implementing green infrastructure. Each of these was addressed by the panel. Audience questions and discussion was then encouraged.

The prime concern which emerged was the rapid loss of nature through infill and frustration was expressed both by local government and community about the lack of regulations, particularly regarding tree loss. Although participants had attended the event due to their interest, the passionate depth of concern and desire to retain and increase nature in the city was compelling.

Beatley suggested the formation of a Biophilic Perth group and there was immediate positive response with many hands going up followed by 52 people signing to the group and a steering committee of ten being formed.

The key learnings that can be summarised by the experience of this event are as follows:

- People from diverse disciplines can be united through a common goal and participate in constructive conversation.
- Across diverse disciplines there is a strong and passionate recognition of the necessity to urgently retain and increase nature in cities for liveability, particularly with rapidly changing climatic parameters.
- More cross-disciplinary collaborative conversations are needed, facilitated by supportive organisational structures and funding.
- Professional, government and research disciplines need access to community conversation in forums that acknowledge ‘the wisdom of the masses’ while communicating the complex issues.

There was a significant practical outcome from this event in the formation of Biophilic Perth as a branch of the global Biophilic Cities network. Represented within the committee is academia, local government, landscape architects, industry and NGOs, all in senior roles and/or with major businesses. The group has met regularly and held well attended events. A presentation and discussion event held in Fremantle, Western Australia in 2017 included senior academics and the Mayor. Since this event, the City of Fremantle joined the global Biophilic City network by signing a pledge committing to biophilic initiatives (April 2018). They are

the first Australian city to become a member.

3. Emergent lessons, challenges and opportunities

Looking across the events described above, the authors have independently reflected on and collectively discussed the connections and similarities across the professions’ consideration of urban greening. The first challenge in these discussions was to overcome professional-language barriers, where a variety of theoretical constructs have been used to discuss the role of nature in built environments. For example, addressing the distinguishing features of what it means to have successful ‘green space’, ‘public open space’, ‘recreation space’ etc, occurs differently for landscape architects, engineers, planners, designers, and health professionals.

In the following sections we discuss the variety of theoretical contexts observed during the three events, which span a number of key theories. This has helped to understand and connect language and concepts. We also describe three principles for professional practice that have emerged from discussions, towards fostering healthy and resilient outcomes in planning and design.

3.1. Relationships between theoretical contexts

Reflecting on dialogue at the three events described above over several online and teleconference sessions (August 2017 – March 2018), the authors have synthesised a map of key theories informing research and practice for resilient and healthy cities over the last 20 years, shown in Table 3. In this

case the ‘Built Design’ profession refers to professionals involved in the creation or modification of infrastructure spanning buildings, parks, services delivery (such as energy, water, and waste) and transportation systems. The ‘Public Health’ profession refers to professionals involved in protecting the safety and improving the health of communities, spanning education, policy making and research for disease and injury prevention.

[TABLE 3 – See Attachment]

As indicated, while a few key theories have crossed professional boundaries, there are several distinct and important concepts related to the topic area that are discussed in only one or the other community of practice. Notwithstanding the absence of a systematic literature review at this point, fundamentally across all theories the authors observe acknowledgement of a need for wellbeing – the opposite of stress [27].

It is clear from both professional discourses that we are poor in measuring wellness, in particular ‘Eudaimonic’ (psychological – purposeful and fulfilled) wellbeing, as opposed to ‘Hedonistic’ wellbeing (e.g. happiness) [see for example 28, 29, 30]. We do know that the burden of disease from mental health is increasing, and that well-being – or salutogenic – responses are not being delivered, resulting in lost opportunities and sunken costs of future maintenance and rebuild. This observation provides opportunities for future inclusive approaches to working across disciplines and across sectors to build resilient built environment solutions for communities.

3.2. Emergent principles for professional practice

From these learnings, three organisational principles are proposed for greening cities towards healthy and resilient outcomes, as described in the following paragraphs. These are intended to bring together the learnings from the built environment and health professional disciplines, to create and evaluate transdisciplinary solutions with urban greening outcomes that are technically feasible, economically viable, safe and conducive to wellbeing.

1. Leadership in multi-disciplinary work environments

This principle is concerned with the importance of leadership in walking the talk of collaborative work environments, including clarity around the intent of the planning or design, who should be involved, and processes to be used. Teams with representatives from multiple professions, and spanning industry and academia, with co-location, considering design as an iterative process. Leadership is critical in for example defining the extent of community engagement, the extent of plastic versus real plants, the boundaries of a whole of life analysis versus short term benefits, key elements of garden design, and the need for data capture including clinical analysis of patient responses to green infrastructure.

2. Collaborative enquiry enabled by technology

This principle is concerned with the importance of using technology to model, visualise and communicate opportunities for urban greening, helping to maximise efficiency and reduce costs. For example, using parametric design in curvilinear high-rise buildings, using drones for vertical

green wall maintenance, optimising irrigation systems in green walls taking into consideration the need of each plant in unique conditions for design, using algorithms to inform green infrastructure design, like data informs the strength of the building pillars and foundations, and using geospatial information to run place-based scenarios to guide decision-making.

3. Systems thinking towards transdisciplinary solutions

This principle is concerned with the importance of systems thinking, considering the world as interconnected and interdependent systems that create conditions conducive to life. As described by Acoroglu [31], this includes social systems (rules and structures such as education), industrial systems (manufactured and man-made components), and ecosystems (natural services such as air, water and food). An example of a solution informed by such thinking includes the Blue Health International Project [32], Healing Gardens [33, 34, 35], and normalcy [36].

4. Conclusions

There is an urgent need to overcome *existing* barriers to mainstreaming green – otherwise known as living – infrastructure, and overcome *emergent* barriers associated with diminishing budgets and changing risk profiles of public open space in our cities and surrounds. The three principles presented can guide strategic and adaptive actions to green our cities towards nature-loving – or biophilic - outcomes, including the adoption of nurturing ‘design for wellness’ – or salutogenic – approaches to design. Sustained multidisciplinary dialogue, a systems-based approach and

collaborative planning and design are critical to such success.

This vision for salutogenic solutions has implications for the way we design our built environment to accommodate unpredictable future impacts including catastrophic weather events. Design inspired by natural systems and their approach to resilience and recovery can lead the way. Our city designers and builders must collectively ask, ‘*How can we use natural systems and adapt elements of these natural systems to protect physical assets and provide us with an environment that helps us recover mentally and psychologically?*’

The paper findings have immediate implications for design professional bodies in advocating for management and maintenance budgets to prioritise restoration and rehabilitation projects that address future climate forecasts and population growth. For decision-makers in government, there are urgent implications in removing existing barriers to mainstreaming living infrastructure, and overcoming emergent barriers associated with diminishing budgets and changing risk profiles of public open space in our cities and surrounds.

For industry professionals, the obvious challenge is about optimising design for green outcomes, through evidence-based design. The knowledge required to design these integrated systems is complex and relies on interdisciplinary collaborations. This provides an opportunity for transdisciplinary professionals such as landscape architects to take a leading role. This leadership requires technical and practical knowledge and the ability to inspire others to work together.

The findings also have implications for industry in clarifying the role for landscape architects in urban planning, design and construction projects, working with engineers and healthcare professionals, to ensure that design solutions meet structural (e.g. water inundation), epidemiological (e.g. water-borne illness), and psychological (e.g. mental wellbeing) performance requirements; building healthy and resilient communities in this rapidly changing climate.

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Table 3. Mapping the theories and approaches informing urban greening research and practice

Key theoretical perspectives / approaches appearing in event dialogues	Event Context		
	HPHCIS	BUTS	DCLN
Prospect and refuge theory [14]: <i>Theory of environmental aesthetics based on an adaptive evolutionary perspective</i>		●	●
Biophilia hypothesis [15,16,17]: <i>The passionate love of life and all that is living; Love of nature</i>		●	●
Healing gardens [18]: <i>Defining the underpinnings for healing gardens</i>		●	
Salutogenesis [19,20]: <i>Supporting human health and well-being, rather than disease</i>		●	
Attention restoration theory [21]: <i>Direct and indirect physiological restoration</i>	●	●	●
Stress reduction theory [22,23]: <i>Positive health outcomes from exposure to nature, gardens</i>	●	●	●
Flight or flight response [24]: <i>Sympathetic nervous and endocrine systems, and adrenaline responses</i>	●		
Emotional congruence theory [25]: <i>How a person feels influences how and what a person sees</i>	●		
Reciprocity (see for example [26]): <i>When nurturing, the feedback is restorative</i>	●		

Key: '●' indicates the observed prevalence of theoretical perspectives by the paper authors and colleagues

HPHCIS: Healthy Places Healthy People; BUTS: Biophilic Urbanism in the Tropics; DCLN: Designing Cities that LOVE Nature

Research on the Influence of Green Space Intervention Affecting Depression Recovery: Effective establishment of a virtual scene model

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Abstract

With the booming of society, the tense pace of life has made people's tremendous mental pressure, which triggered many mental health diseases. Depression is not only a common psychological disease in the general population, but also a complication in the healing process of some diseases. At present, green space has been proved to play a crucial role in improving mental health through contacting, viewing and other activities. Therefore, the intervention of green space is potentially useful to cure depression. Using the patients with depressive tendency during the recovery from stroke as the experimental subjects, we study the spatial preference through depression scale and spatial scale in the first early stage. The design elements with the most influential and well-defined factors in green space design are finally determined for the rehabilitation of depressed patients. The results show that patients reject busy space subjectively, while are fond of tranquil space, which has significantly therapeutic effects on depression. Through data and literature, the research puts forward constructive elements and key points of designing effective virtual reality scene model. An evaluation is made of the ability of the information presented in landscape visualization model to meet criteria of credibility, salience and legitimacy when communicating with stake-holders and responding users. These focus on the need for applications of 3D visualization models to be more systematically evaluated, ideally as part of landscape planning exercises where the benefits of particular models for different purposes and audiences are examined across all stages of the decision-making process.

Keywords: Therapeutic Space; Mental Health; Depression Emotion Recovery;

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1. Introduction

According to the latest data from the World Health Organization, the global incidence of depression is 3.1%^[1]. According to incom

-lete statistics, the incidence of depression in China is as high as 5% to 6% and the incidence rate among urban population is between 5% and 25%^[2], which have been increasing year by year in recent years. Meantime, social events triggered by depression have caused the public to pay

more attention to their own mental health. At present, a plenty of studies have confirmed that long-term exposure to green spaces imposes a positive effect on depression^[3]. Therefore, actively improving urban green space plays a decisive role in promoting urban livability as well as public mental health. As Barton said: "Environment that promotes healthy activities is the highest ideal of environmental design^[4]."

Research on depression and green space at home and abroad mainly revolves two main aspects. On one hand, it clearly confirms the correlation between depression and green space. Judging from the quality of space environment alone, there is a significant correlation between the daily exposure of young people and the daily mood^[5]. There is a potential protective effect of green space on adult depression^[6]. At the same time, the poor housing environment and lack of green space are all related to the generation of depression^[7]. Mark S. Taylor et al. studied the relationship between tree density in the streets of London and the prescription rate of antidepressants. For each additional kilometer of street trees, 1.18 prescriptions were reduced for each additional unit of trees, confirming that green space has the effect of slowing down depression^[8]. The incidence of depression in people living in regions with higher NDVI is lower^[9]. In a study in the state of Washington, USA, it illustrates that the larger the urban green area, the fewer the number of consultations on anxiety and depression symptoms^[10]. On the other hand, based on the recovery of green space, the researchers explore the relationship between physical activity and depression in the green space and try to use it as a new means of treating mild

depression. The study indicates that although watching green for a short period of time has the effect of restoring depression, more effective plans need to be prepared through regular physical activities^[11].

Research on the relationship between depression and green space is currently focused on a qualitative level, clearly confirming that green space can improve people's depression, and long-term exposure to green space is able to reduce the prevalence of depression^[12-13]. In the past decade, many quantitative studies on space design and planning have adopted landscape visualization technologies, including photographs, paintings, and virtual reality models. One of the main advantages of using visualization research is that it provides a "common language" that all parties can communicate with^[14]. Stephen establishes landscape basic elements including terrain, vegetation, and water visual representation techniques through digital landscape models to solve abstract problems^[15]. Neuenschwand-er puts green space type maps and pattern designs into a parametric modeling and visualization chain, realizing the 3D visualization of the green space model as well as exploring the relationship with the ecosystem indicators^[16]. Leiqing Xu and others use VR scene to experience the influence of building interface and green virtual rate on the streets^[17].

From the arguments of the above article, we can find that the overall research results show that the urban environment has a measurable connection with depression. At the same time, the visual scene model is a necessary method for further research in the future. While there are still many problems to be solved in the study of green space with the

recovery of depression as the core: 1) The characteristics of spatial elements in existing green space are inconsistent and cannot be directly used as test scenes, making quantitative research unable to control variables and embodying key influences of elements. 2) Relying solely on photos or videos, the subject's actual experience is weak. The size and distance of the space do affect the emotions of the participants. Single visual experiences cannot change people's emotions and feelings apparently. Therefore, it is necessary to establish a virtual reality scene model according to the corresponding purpose of research in order to do researches deeply.

2. Methods

2.1. Procedure

The study first selected suitable subjects. Subjects are needed to have depression or obvious depression. Then, through the space scale and in-depth interviews, the necessary components in the scene model are identified. Because some of the questions in the space scale are more abstract and professional, it is necessary to add reference pictures. In the process of in-depth interviews, interviewing the interviewees about each image he has selected is to further explore the information while also ensure the authenticity of the scale. Use the literature to support the metrics that need to be quantified in the scene and give a reference range. The organizational principles of the model are proposed to provide a basis for the same research model of the scene, so that the follow-up can be continuously improved (Figure 1).

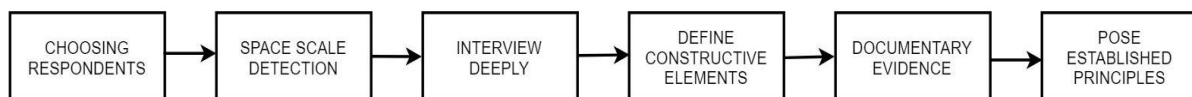


Fig. 1. Procedure Sequence.

2.2. Choosing respondents

This study uses the authoritative Hamilton scale in the medical field to determine the degree of depression of patients based on scores^[18]. Then, in-depth interviews are conducted on patients with more severe depression as well as a spatial scale is used to determine spatial features that positively

affected the patient's depression. As in the field of landscape architecture, spatial elements will change with the specific research purposes. So there is no space scale that fully meets the objectives of this study. Therefore, based on the necessary factors in the design of green space, the study focuses on the design of a spatial scale from the aspects of spatial characteristics investigation and the influence of spatial factors on the

effects of depression. Through the data collected, the reliability test and in-depth analysis are performed. Factor analysis is used to determine the design factors in the design of a quiet environment that can promote the recovery of depressed patients with the greatest influence.

In the course of the experiment, a total of 11 patients with scores of 8 points or more are screened through the Hamilton scale, and all patients are post-stroke depressive patients. Six of these patients scored 20 points or more and are diagnosed with severe depression. In the process of conducting in-depth interviews with them, focusing on their preference for spatial characteristics due to the fact that their results are representative.

3. Results

3.1. Research data

For the characteristics of spatial features, we investigated the type which is regarded as recreational space frequently and enjoyed by depressed patients. Nine individuals choose the green space in the community, while only one person like to go to the park since he is photographer. The distance to the green space is within walking distance. The type of activity in the space is only walking. Occasional meeting with acquaintances will have conversation activities, but they will not take the initiative to chat with strangers. There are two persons spending less than twenty minutes in activities. Six interviewees spend twenty to forty minutes and two people take forty to sixty minutes on physical activities. Good-looking flowers or trees of landscapes are viewed outside the landscape

and will not be entered. In the choice of the walking path, 60% of people like the deep path, and 40% of people tend to choose straightforward and clear road. For the waterscape type, 80% of people think that watching static water will relax themselves, and 20% of them feel relieved by watching flowing water (such as fountains and stacked water).

In terms of the spatial type preferences, ten subjects choose a tranquil space, and the research finds that they refuse lively spaces through interviews. If they run into this type of space in their lives accidentally, they will deliberately avoid it, otherwise they will feel distraught. For the description of the characteristics of tranquil space, 71% of respondents suppose that there should be sufficient lighting. 57% of people think that there ought to be a static waterscape and a large range of lawns. Everyone thinks that the space needs to be open and the line of sight is not obstructed.

3.2. Spatial features and characteristics

In the initial in-depth interviews and experiments in the space scale, we obtain more valuable results. The spatial preferences of depressive patients are measured more comprehensively, and the consistency in the selection of spatial features is demonstrated. Necessary factors in the green space include vegetation, roads, water features and activity venues. The characteristics of these types of spatial elements are clarified in the process of questionnaire surveys and in-depth interviews and are used to construct scene models. See Table 1.

Table 1 Data Analysis and related considerations

Spatial elements	Features of elements	Percentage of preference	Related considerations
Vegetation	Covering area of Vegetation	33%	20%
		33-67%	10%
		Over67%	70%
	Type of vegetation	flowers	50%
		lawn	40%
		Trees	10%
At the location of the vegetation	plant interior	25%	
	plant edge	25%	
	plant exterior	50%	
Green visual rate	5%	28%	
	10%	14%	
	15%	43%	
	20%	5%	
	25%	10%	
Road	Shape	Meandering	60%
		Straight and clear	40%
Waterscape	Type	Dynamic water	60%
		Still water	40%
Activities' Space	Type	Park	10%
		square	10%
		Community green space	80%
	Atmosphere	Tranquil	90%
		Lively	10%
	Scale	Intimate scale	10%
Medium scale		70%	
Far-reaching scale		20%	

4. Discussion

4.1. Key points of model construction

Through the determined spatial feature survey and detailed emotional experience interviews, the spatial model's pertinence and comprehensiveness can be better balanced. Different from ordinary standard spatial model design, interviews based on people's preferences and real emotions are more likely to make the model closer to the ideal experimental scene, which results that researchers can more accurately test the effect of the depressive healing of the designed green space. For the above spatial elements, the following points must be noted during the construction of the scene model:

1) For the design of vegetation within the spatial model, the planting layers must be focused. In the actual scene, many green space plants are designed to meet the standard green land coverage index and a large number of unapproachable ground cover plants are used in space. These ground cover plants are usually not seen. They are also completely incapable of healing the green plants. According to a study by Jiang Bin, the tree cover density ranged from 24% to 34% has obvious stress and emotional recovery effects^[25]. Meantime, the study presents that depressed patients like to watch outside the vegetation, rarely enter it. Therefore, in the model, in line with the above indicators, it is necessary to cleverly and rationally collaborate with the plant hierarchy to make it visible as far as possible.

2) When plants are used to surround the space, according to the results of the questionnaire, depressed patients prefer to enjoy flowers and lawns to make their mood pleasant. In the scene model, the proportion of flowers and lawns can be appropriately increased. The scale of the lawn should not be too large. Generally, it should be within

200 meters of the side, that is, the ratio of the width of the lawn to the height of the surrounding trees should not exceed ten. In this case, the vertical viewing angle of people will be more comfortable^[26]. When the height of the enclosing wall in the space is equal to the ratio of the distance between the man and the enclosure is 1:1, and the horizontal line of sight and the angle between the eaves are 45 degrees, a good sense of closure can be generated at this time^[27]. Thus, the plant height of the enclosing space is suggested to refer to this standard.

3) Combining the result that most depressed patients would like to enjoy a tranquil atmosphere, we are designing a virtual reality scene that can appropriately add birds, water features and music to reduce the noise made by humans. According to Germán's study, natural sounds can increase people's mood, especially the sound of water^[28]. Therefore, it is possible to mix slowly flowing waterscapes at appropriate locations. In addition, the roads in the space should be mostly open and semi-open. The path length should be 30m-50m, the width ought to be 0.9m-1.2m. What's more, the number of road turns should be 4-6 times to achieve the goal of tranquil atmosphere^[29].

4) The number and size of scenes in the model need to be considered. In the in-depth interviews, patients with severe depression are more likely to have large fluctuations in mood. Therefore, the experiment needs to be completed as soon as possible. Most patients will choose to relax in a small green space within 10 minutes of the house or downstairs. As a result, the designed model scene should not be too large and need to meet the green space specifications in the community appropriately. Professor Zhu Junzhen defines a garden space of less than 700 square meters as a small garden space in the Miniature Garden^[30]. According to the urban road greening planning and design specifications,

the width of residential green space should be greater than twenty meters^[31]. In the book <External Space Design>, Ashihara Shinyi points out that the most comfortable external space size is 20m*20m or 20m*25m^[32]. The size of the model scene can refer to the above specifications.

4.2. Application and improvement of scene model

The virtual reality scene model obtained in the research can be used to explore the value and function of green space health services. In the process of experiencing the model, the participants' actions and movements in the real scene can achieve almost the same results. Through interviewing patients with severe depression, Sims-Gould finds that patients with emotional disorders need to formulate physical activity plans based on potential preferences in the green or blue space, which contributes to the recovery of the condition^[33]. Therefore, this model can be used not only to verify the healing effect of this spatial interventional therapy but also to explore the influence of physical activity on depression. The spatial elements and characteristics in the study are selected according to the preference of the subjects with more obvious and serious depression, which are more targeted. In the later period of study, while increasing the sample, it is also crucial to add a person with normal mood or depressed mood as a contrast group to explore whether there is a significant difference in terms of spatial perception and spatial preference. Adjusting the scene model according to the research results makes the study more comprehensive and rigorous.

Although this research establishes a virtual reality scene model for environmental experience through experimental data, it can determine the basic features of the functional space for depression healing. However, as a

preliminary study of a small sample, the current research still has some problems. The quantitative evaluation of the research still requires more rigorous experimental control and full-sample experiments. 1) Since there are too many elements in the environment, and each element is depressive emotional influences. Therefore, follow-up research should focus on a single factor, exclude other factors from interference, clarifying the role of each kind of spatial element in depressive emotions as well as making future designs have accurate reference. 2) Some clear quantitative criteria for spatial elements need to be given. For example, green coverage is an important indicator of green space, but the traditional norms do not consider the healing function of plants, which leads to that existing indicators cannot be used directly. We need to re-explore what extent of green in the experiment is most helpful for people's depression.

5. Conclusion

On the one hand, the research grasps the basic spatial features that should be possessed by the green space with depression healing function, and define which spatial features can attract depression patients to relax. On the other hand, according to the results of the questionnaire and the literature, the main points of constructing the virtual reality scene model are put forward. The scene model can enable the depressed emotional patients to truly experience the space for further follow-up research.

The virtual reality scene model in the future research can be combined with technologies such as geographic information collaboration platform to create an overall outdoor design experience system while enhancing the realism of the scene. Researchers use GIS to simulate the lighting and pedestrian dynamics in real scenes, so as

to provide a better quantitative reference for planning and design.

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Study on Ecological Sustainability of Rainwater Garden Oriented by Soil Health

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Abstract

Soil health is an important property of the rainwater garden ecologically sustainable. And it is one of the important factors that determine the quality of rainwater garden. However, there are many problems in soil research, such as the multidisciplinary nature of soil research, the richness of soil health assessment methods, and the diversity of soil itself. As a result, our understanding of soil health is inadequate and there is a lack of quantitative criteria for soil health indicators. In this paper, we summarize the following aspects of research on the soil health of rain garden. The first is the effect of soil health in rain garden; the second is the influence factors of soil health in rain garden; the third is the assessment and management of soil health in rain garden. The study found that the efficacy of soil health in rain garden is reflected in five aspects: soil water permeability, water holding capacity, net water resistance, erosion resistance, and soil nutrients. The quantification criteria of soil health indicators are determined by the soil site conditions and the nature of the soil itself. In addition, the soil health index is not only an important factor in the ecological sustainability of the rain garden, but also plays an important role in the ecological sustainability of other disciplines such as urban planning, green buildings, and urban agriculture.

Keywords: Landscape Architecture; Rainwater Garden; Soil Health; Ecological Sustainability; Soil Health Index

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1. Introduction

The rapid growth of the population in the modern world has caused a shortage of water resources. At the same time, urban rainwater flooding and water pollution have caused huge environmental pressure on cities^[1]. In order to cope with urban stormwater problems, various countries have put forward relevant policies, such as the United States' Best Management Practices (BMPs) and Low Impact Development (LID), New York State's "Zero Water Inundated City" Program (ADC), and UK Sustainable Drainage System (SUDS), etc.^[2-3]. China vigorously promotes the construction of sponge cities^[4]. Due to the large geographical area of China, the construction of sponge cities will involve different site types, scales and environmental conditions, etc. Therefore, the construction of sponge cities will provide rainwater management and policies for other countries and regions. Formulation plays a role as a reference.

Green infrastructures such as rain garden, grass-grass groves, and biological retention ponds act as small "sponges" that use plant, microbial, and soil properties to remove contaminants from surface runoff and supplement groundwater^{[1][5]}. Due to the beautiful appearance of the rain garden, it is widely used in various countries and regions. The ecological effects of Rainwater Garden have been widely proven, but the construction of rain garden in recent years has raised the problems of high maintenance costs, poor ecological benefits, and low pollutant removal efficiency^[6-7]. Therefore, related designers and managers are paying

more and more attention to their ecologically sustainable construction and management issues. Nature-based solutions NBS (Nature Based Solutions) are now encouraged to improve the sustainability of rainwater storage systems by promoting ideal soil and landscape functions. The purpose of soil is to improve soil health and its ecological function. The landscape is mainly connected through the landscape, increasing soil moisture and reducing soil erosion, thus achieving sustainability^[8].

Soil carries many ecological functions such as water seepage in rain garden, reduction of runoff pollution, and reduction of surface runoff^[9]. If it is not maintained, a series of management measures must be adopted to restore and improve the soil function, which will inevitably increase the investment in rainwater garden production, and it will also pollute and destroy part of the rainwater garden ecosystem and environment^{[10][11][12]}. In order to effectively manage and use the soil health of rain garden, reduce investment, and maintain their ecological sustainability, it is necessary to analyze the ecological efficacy and influencing factors of soil health. In order to take correct soil management measures and maintain the ecological sustainability of rain garden^[13].

2. Rainwater garden and soil health research process and hot spots

2.1. Research methods and data sources

This article uses CiteSpace and Vosviewer analysis software, based on the Web of Science database, Rain Garden OR Bioretention and Soil Health as a search keyword. a total of 696 related documents, through analysis, objectively summed up the study of soil health in the rain garden area hot spots.

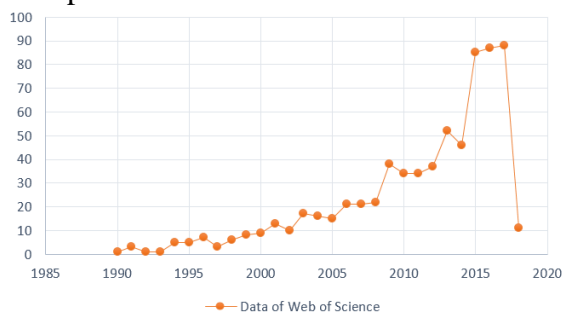


Fig. 1. Years of research literature inclusion and number of publications

2.3. Regional and research hotspots

From the analysis of the national time zone analysis chart (Fig.3). The U.S. has a leading academic role in the field of research on rain garden and soil health. And its achievements are significant and widely used. Followed by China, Australia, Germany, and the United Kingdom. From the perspective of keyword clustering analysis (Fig.4). The research hotspots at various time periods in the research area of rainwater garden and soil health involve Tree species, Bioretention Cell Design, Bioretention System Research, and Sustainability Comparison, etc. There are

2.2. Year of publication and subject research direction

From the perspective of the number of issued documents (Fig.1), the related research in the garden of rainwater and soil health started in 1990. And it has continued to grow substantially since 2015. Major research disciplines include Environmental Sciences Ecology, Engineering, Water Resources, Architecture, Agriculture, and Plant Sciences (Fig.2).

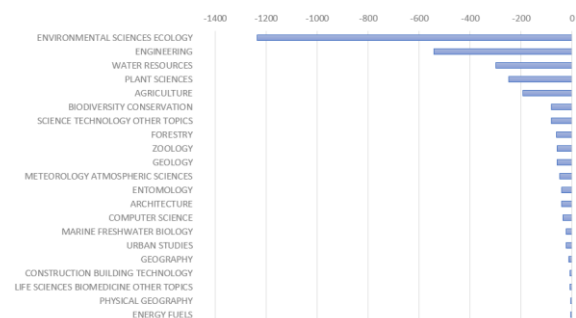


Fig. 2. Subject research direction and number of articles

obvious cross-cutting phenomena in related research.

2.4. The analysis of research frontier

Through the topic relationship diagram (Fig.5). The findings of the study focused on low-impact development, stormwater management and performance, which involved different manifestations (Rainwater garden, Bio-retention facilities, Green roofs, etc.); different influencing factors (Scale, Surface runoff, Soil, etc.); different effects (Rain collection, Adsorption, Water quality improvement, etc.).

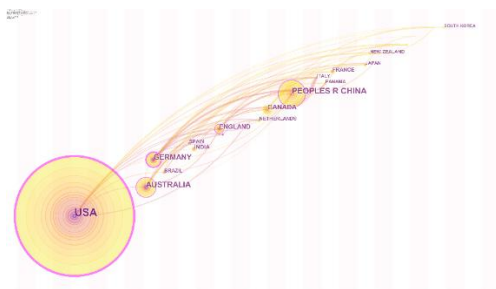


Fig. 3. National Time Zone Analysis of Rain Garden and Soil Health Sources

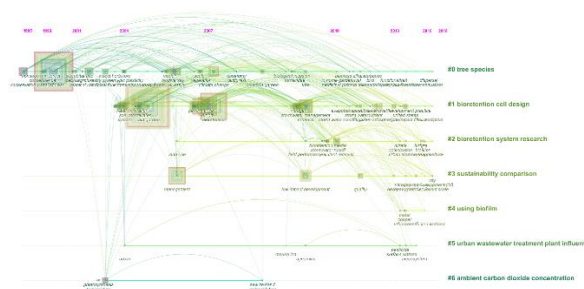


Fig. 3. National Time Zone Analysis of Rain Garden and Soil Health Sources

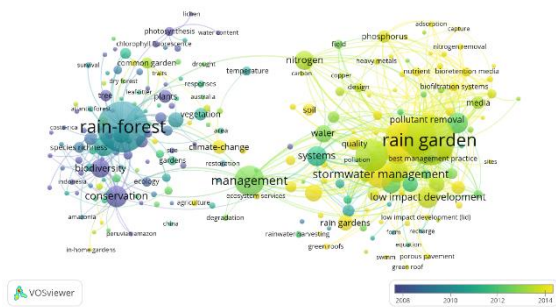


Fig. 5. Rainwater Garden Soil Health Research Frontier Thematic Diagram

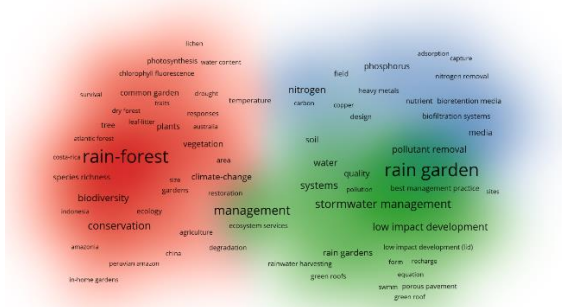


Fig. 6. Rainwater Garden Soil Health Study Cluster View

Discovered by the keywords clustering view (Fig.6). The frontier areas of Rainwater garden and soil health research can be summarized in the following three aspects: 1) The research on the efficacy of soil health in rainwater garden includes Retention, Adsorption, Pollutant Removal, Phosphorus, and Heavy Metals. 2) The

factors of the impact of rainwater garden on soil health include Land-use, Vegetation, Species Richness. 3) The hotspots of research on sustainable management measures for rainwater garden based on soil health include Stormwater Management, Low Impact Development, Green Infrastructure, etc.

3. Soil Health and Sustainability of Rain Garden

3.1. concept of soil health in rainwater garden

Soil health and soil quality are closely linked and both have similar meanings^[14-15]. Carter^[16] believe that soil health can describe the dynamic state of the soil in a

short period of time. Therefore, soil health mainly refers to the physical, chemical, and biological properties of the soil. To date, there is no unified standard for soil health^[17]. Broadly defined soil health refers to the ability of soil as a living system to maintain biological productivity, promote

environmental quality, and maintain animal and plant health and human health. In this sense, soil health and ecological sustainability are synonymous^[18 - 20]. In general, healthy soil should have the following characteristics: soil layer with sufficient thickness for plant growth, adequate but not excessive amounts of nutrients, excellent drainage, and certain resistance to adverse environments^[17], etc.

For the soil health of the rain garden, it is not exactly the same as the green soil type of healthy soil. It focuses more on the ecological efficiency of rain garden and on the sustainability and sustainability of the soil. It not only provides plants with space for growth and nutrition, maintains diverse biological communities, but also meets rainwater garden to store rainwater and reduce surface runoff. Purification of runoff pollution and other ecological effects^[9]. Maintaining the soil health of rain garden has important implications for maintaining the ecological sustainability of rain garden.

3.2. Ecological efficiency and influencing factors of soil health in rain garden

1) Soil permeability in rainwater garden and its influencing factors

Rainwater Garden can significantly reduce storm runoff. The merits of soil permeability directly determine the construction area and operating performance of Rainwater Garden^[21]. Therefore, determining soil permeability is the key to planning and maintaining the sustainability of rainwater garden^[22]. The soil permeability is affected by many factors, and the plant roots obviously help to increase the permeability of the soil and facilitate its self-recovery^[23]. Soil properties such as soil organic matter,

bulk density and agglomerate size also affect soil infiltration characteristics^[24-25]. It can be seen

that the permeability of rainwater garden soil not only depends on the structural properties of the soil itself, but also depends on its joint action with the rain garden plants, including root density, plant species, planting patterns, vegetation coverage^{[26][56]}, etc.

2) Soil Scour Resistance and Its Influencing Factors in Rain Garden

The rainwater garden can reduce the surface runoff velocity, and the erosion resistance of the soil can reduce the erosion of the rainwater on the soil and plants. Thereby realizing the process of natural penetration and natural purification of the rainwater garden^[35]. In terms of soil erosion resistance, soil use, planting methods, soil cover width and slope all have an impact on soil erosion^[27-28]. Precipitation and basic soil properties are the main predictors of runoff coefficients and sediment yields^[29]. For the rainwater treatment facility's soil, the slope of the terrain, the width of the cover layer of the soil, and its own properties all play a major role in combating the erosion of rainwater. But in terms of the interaction of the soil and the plant, with the increase of the plant root biomass, the soil Erosion resistance also increases^[30].

3) Soil Water Purification and Its Influencing Factors in Rain Garden

Rainwater Garden can reduce runoff pollution and achieve natural purification of urban rainwater. Soil, as an important component of rainwater garden, can effectively purify rainwater quality^[31-32]. The purification of pollutants in the soil mainly depends on the plant roots, and the

developed root system can enhance the removal of pollutants from the soil^[33]. Rainwater garden in terms of rainwater runoff purification, soil purification measures can be cut from the source, controlled in the middle, and processed by the terminal^[34]. This part is inse-

-parable from the plant root system. Heavy metal, flooding, waterlogging, and other contaminated rainwater runoff will have an impact on plant growth and soil properties. The plant roots can act as a pollutant adsorbent, filter, and retain^[35]. This in turn protects the stability of the soil properties. For some stormwater runoffs with relatively low concentrations of pollution, they are directly purified through the soil or mixed with other sand, pebbles, and peat to enhance the ability to remove pollutants^[36].

4) Soil Water Holding Capacity and Its Influencing Factors in Rain Garden

Rainwater garden can retain and save rainwater. Soil water retention capacity is an important indicator of soil moisture and plant growth. It affects the dissolution and transfer of nutrients in soil^{[63][37-38]}. The soil porosity and the average weight diameter of the soil aggregates are the main factors affecting the soil water holding capacity^[39]. Soil biochar produced at higher temperatures has higher water holding capacity^[40-41]. In terms of water

-r retention in rain garden, the nature of the soil is a direct factor, and rainfall, topographic gradients, and underground biomass are also closely related to soil water retention^{[37][42]}. The catchment area has a stee-

-per slope, a thicker soil thickness, and a stronger soil water holding capacity^[38].

5) Soil nutrient and its influencing factors in rain garden

Soil nutrients provide nutrient elements for plant growth and microbial survival in rainwater garden. And the ecological effects of the plant root system and its own function in rain garden have a direct impact on the clean water properties, water permeability, and erosion resistance of rainwater garden. Therefore, soil nutrients are important factors for ecological sustainability of rain garden^[43]. The soil nutrient in the rain garden is not only closely related to the nature of the soil itself^[44-45], but the runoff of the rainwater also causes the loss of soil nutrients, which is significantly related to the rainfall and rainfall height^[46]. In addition, the number of animals and plants on the site will also have an impact on soil nutrients^[47-48]. The distribu-

-tion pattern of plant roots in the soil profile is the determinant of plant nutrient acquisition^[49].

In general, soil is used as a rainwater infiltration channel for rainwater treatment facilities such as rain garden. Soil health is generally reflected in five aspects: soil permeability, erosion resistance, detergency, water holding capacity, and soil nutrients. Its performance is not only dependent on the structural nature of the soil itself, but also the interaction between the soil and the plants on the site, the slope of the terrain, rainfall and other conditions have important influence on the ecological efficiency of the rainwater treatment facilities.

3.3. Sustainable Rain Garden Soil Health Evaluation and Management

1) Soil health assessment status

The Cornell Soil Health Assessment evaluates traits, functions, and conditions of farmland soils^[50-51]. The existing two sets of landscape performance evaluation systems. LPS (landscape performance series) mainly focus on the water distribution, permeability, soil loss and erosion reduction of landscape soils^[52-53]. SITES (Susableable Sites Initiati -ve) pays attention to the environmental evaluation of landscape soil, including site selection, planning, design, construction, maintenance, etc.^[54]. From the standpoint of ecosystem flexibility.

2) Soil Health Assessment of Sustainable Rain Garden

Based on the existing soil evaluation system, the evaluation index is particularly

important for the evaluation of sustainable soil health in rain garden. The selection of indicators often depends on the ecological effects of soil, and the degree of ecological sustainability that the effect reflects. The quantification method of the indicator is also very important. If the method is not suitable, the result will be misleading. Since the health of the soil depends on the interactions of land use patterns, vegetation types, and soil structure, it cannot be directly measured. At present, the health status of the soil is evaluated mainly through indicators related to the nature of the soil^[55]. The soil health evaluation indicators of the rain garden can be divided into two parts: soil conditions and soil properties^[56-58]. (Table 1)

Table 1 Soil Health Assessment Indicators and Impact Factors in Rain Garden

Soil health efficacy	Soil site conditions			The nature of the soil		
	external conditions	Site characteristics	Site element	Physical properties	Chemical properties	Biological properties
Water permeability	Rainfall	Land use Slope Mixture composition	Planting methods; Vegetation Types; Vegetation coverage	Soil permeability; Soil bulk density; Aggregate stability	Soil pH; Nitrogen, phosphorus, potassium	Root Health Level; Soil organic matter
Water Purification	Rainfall	Mixture composition	Vegetation Types; Vegetation coverage	Soil texture; Aggregate stability	Soil pH; Soil conductivity;	Root Health Level; Soil organic matter; Microbial content
Scour resistance	Rainfall	Land use Farming methods slope	Planting methods Vegetation coverage	Soil texture; Soil particle composition; Aggregate stability	Soil pH; Nitrogen, phosphorus, potassium	Root Health Level; Soil organic matter
Water holding capacity	Rainfall height; Rainfall erosivity	Land use Farming methods	Vegetation Types; Vegetation coverage	Soil texture; Aggregate stability	Soil pH; Nitrogen, phosphorus, potassium	Root Health Level; Soil organic matter; Microbial content
Soil nutrients	Rainfall temperature	Land use slope	Vegetation coverage; Species richness; Biodiversity	Soil texture	Soil pH; Nitrogen, phosphorus, potassium	Root Health Level; Soil organic matter; Microbial content

3) Sustainable Soil Management of Rain Garden

Soil health management plays an important role in protecting the ecological efficiency of the soil. And it maintains the ecological sustainability of the rain garden.

Su Changhong proposed a soil management strategy based on the underlying mechanisms and processes of soil, including analysis of soil structure and properties^[59]. Soil organic matter has a certain influence on soil carbon and land management^[60], And frequent plant

-ing of carbon inputs is the main driving force for soil health changes^[61]. The research shows that the effect of artificial soil treatment is better than that of natural soil^[62]. And soil amendment can optimize the permeability and water purification of soil^[63-64].

Based on existing soil management measures, the identification of soil health in

rain garden can be tested, evaluated, modeled, and mapped. Based on these methods, the management of soil health in rain garden should be comprehensively considered from both the external environment of the soil and the nature of the soil itself, including slope, soil microbes and soil amendments.

laboratory. The relevant indicators to ensure the scientific accuracy of the data.

After countries such as the United States, Australia, and Germany successively proposed policies for rainwater management, China proposed a guide for the construction of sponge cities in 2014. Currently, the construction of sponge cities has been piloted in 30 cities, and the estimated annual investment cost exceeds 400 billion^[65]. So its importance is self-evident. The construction of the sponge city has alleviated most of the urban internal pollution and water environment pollution. In the existing related management policies and performance evaluation, relevant requirements have been put forward for water ecology, runoff control rate, and rainwater utilization rate^[66]. However,

there is no specific content for the soil. Therefore, based on the results of this study, it is suggested that the special content of soil should be added to the relevant management policies and performance evaluation systems for stormwater treatment in sponge cities, which can be considered from both the external environment of the soil and the nature of the soil itself. The external environment of the soil includes rainfall, slope, land use, species richness, vegetation coverage, etc. The nature of the soil includes the soil moisture content, agglomerate stability and other physical properties, soil

4. Conclusions and Outlooks

4.1. Discussions and Conclusions

From the study of this paper, soil health not only helps to achieve the ecological effects of rain garden, but also plays an ecological role and maintains its sustainability in rainwater treatment facilities such as grass-growing ditch, sunken green land, and biological retention ponds. When designing and maintaining the relevant stormwater treatment facilities, in addition to satisfying their aesthetics, the elements related to soil health should be considered in detail: 1) Focus on the site conditions of storm water treatment facilities, especially the terrain gradient, species richness and vegetation coverage, which have a greater impact on soil health. 2) If soil conditions on the rainwater installation site are not good, soil amendments can be used to optimize the soil or replace the soil. 3) Soil health indicators can be used to quickly estimate and predict soil data through scene simulations, software calculations, etc. However, due to insufficient data accuracy^[52], soil-related indicators can be tested in the laboratory to ensure that the data are scientifically accurate. The soil can be tested in the

pH, available phosphorus, available nitrogen, etc. Chemical properties, soil microbial content, organic matter and other biological properties.

4.2. Research Prospects

In the future research, in order to better achieve urban stormwater management. And to meet the ecological sustainability of rainwater treatment facilities such as rain garden, ecological retention pools, and roof greening. The landscape architecture must cooperate with disciplines such as ecology, botany, soil science, architecture, and urban planning. Pay attention to the relevant researches on the health of the rainwater treatment facilities. Focusing on the influencing factors of soil health, the quantification methods of soil health

indicators, the floating range and changing trends, and the management measures of soil health. These concerns about soil health will inevitably make up for the weaknesses in the design and construction of rainwater treatment facilities.

In terms of research content, ecological sustainability guided by soil health not only plays an important role in rainwater treatment facilities such as rain garden and grass-grooves, but also in urban planning^[67], green building^[68-69], urban agriculture^[70-71]. Other aspects are also important influencing factors. Designers and managers need new understandings and creations from the functions and impacts that soil health assumes and the people they serve.

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Research on the Urban Agriculture Community Planting Pattern of “online to offline”

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Abstract

For a long time, a unidirectional linear food system between urban and rural areas is exposing various shortcomings: the soil in rural is being eroded by the city, the transportation of food has been increasing carbon footprint etc. The proposal of urban agriculture has provided new ideas for urban planning and development. It promotes a sustainable, self-circulating food system to make urban development more flexible by conducting agricultural activities inside or on the edge of the city. Based on the research result of urban agriculture at home and abroad, being at a community level, the paper proposes growing vegetable by internet, a community construction pattern of urban agriculture under the “Internet+” era in China. And it also conducts questionnaire surveys as to this pattern with accepted by most respondents in the survey for self-satisfaction. Then we discussed the feasibility of the pattern according to the survey results, with a view to more evidences for explanation of the prospects and feasibility of studying urban agricultural community construction pattern in the context of the Internet.

Keywords: Urban agriculture, Community planting pattern, Internet, Participatory, Fruit and vegetable cultivation

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1. Introduction

1.1 Background

In 1977, the word “Urban Agriculture (UA)” was formally proposed by an American agricultural economist Allennis (Zhu et al. 2008). And Mougeot defines urban agriculture's as: an industry, located in or on the edge of urban areas, recycling natural resources while making full use of human resources and products within or around the city to produce or sell a variety of foods, non-food products, services for the city (Mougeot,2000).

During a long time, a one-way linear food system has been formed between urban and rural areas. However, with the rapid urban sprawl, the demand for agricultural production makes soil fertility decline and the food transport distance increase. In addition, as people's living standard gradually increases, they pay more attention on food with being eager to return to rural life for self-sufficient duo to more and more food safety problems. For above reasons, UA has been carried out globally (Biel, 2016; Drescher, Holmer et al., 2006), and supported and advocated by many actors from local community organizations and supranational institutions. The benefits attributed to UA practices, such as sustainable livelihoods, food security, re-claiming and self-management of the city, development of local identity and community empowerment (Barriga Valencia et al. 2011; Biel, 2016; Cantor, 2010; Certomà,2011; Drescher et al., 2006; Ernwein,2014; Gómez Rodríguez, 2014; Purcell et al. 2015; Turner et al. 2011) as well as promoting neighbourhood friendship, caring for vulnerable groups, etc. (Eva Schwab, et al. 2017)

1.2 States of Urban Agricultural Community Patterns at Home and Abroad

Since the 1960s and 1970s, more and more countries have adopted the bottom-up approach, which has further developed urban agriculture. Furthermore, people try to regain social connections through common production practices of food crops, and the popularity of network technology also makes this phenomenon become more popular (Sylvie et al. 2015).UA can make full use of various types of open green space, like horizontal space and even vertical space in cities, to exert its multiple functions as an ecological infrastructure.

As a country with less resource per capita, China's needs for UA are becoming more urgent. And there has been some practice in UA in China, but it is not in line with international standards. First of all, the boom of the agricultural suburbs around the city and the establishment of eco-agricultural parks are all only as leisure items to allow people to visit as spectators without reaching the community level and getting involved in people's daily lives. Secondly, the development of internet technology has led to the boom of a virtual public life and pushed people's lifestyles to change gradually. As various fresh fruits, vegetables with three-kilometre delivery service, it has established a new type of UA in production and sales for people who become accustomed to online shopping because of convenience.

The purpose of this paper is to verify the possibilities of building urban farming communities with "internet +", to find the construction pattern and development strategies, to bring food back to the city. The final goal is to reconnect people with the

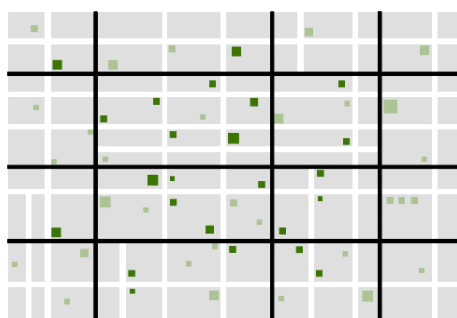
local food system to achieve regional community autonomy for agriculture, to promote a healthier lifestyle. It also makes sense for bringing a valuable pattern for the current community planning, transformation of old communities, and construction of ecological communities. (Liu, 2017)

2. Strategy design of UA "online to offline" community planting pattern

2.1. Concept

The community here refers not only to a community with a certain geographical relationship, but to a community with common interests and interests in a certain area. Exactly speaking, community gardens are defined as any land that can be planted by respondents. (Fig.1)

This paper starts from the community planting and proposes the concept of community planting pattern using the combining styles of online and offline. On the one hand, the online recruit volunteers to participate in the study and training of relevant knowledge, and residents and volunteers can be arranged to practice planting off the line. On the other hand, the fruits and vegetables planted off the line can be used to attract customers online to purchase the goods nearby and own it until the harvest to its mature. Through this pattern, unused land is used to reintroduce agriculture into urban life and to form a self-recycling food system.



a. A Independent community planting

2.2. Steps of pattern design

2.2.1. Investigation and interview

The research on UA potential is carried out for idle vacant lots in cities. UA can be developed in open spaces, public spaces, private roofs and private courtyards etc.

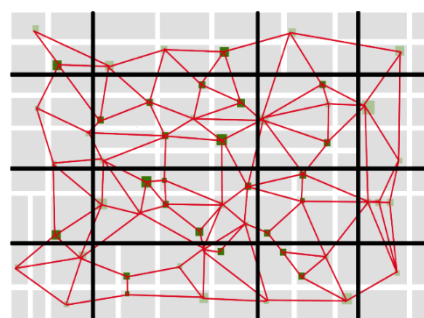
Interviews with local residents and volunteers, taking into full consideration of various needs, will provide reference for future work.

2.2.2. Establishing a self-circulating community system

Online pattern: The development of Internet technology has boomed a virtual public life, and this plan can use Internet technology to establish a network sharing platform to connect the entire communities in cities.

Offline pattern: It can combine schools, laboratories, public welfare organizations, etc., not only residents but also professionals, students or volunteers can be trained to join it, it can be used as extra-curricular projects or life experience projects to grow edible plants and harvest the gains after harvest, the gained edible plants can be donated to public welfare institutions or used for online and offline sales.

Business cycle: Residents can sell their own fruits and vegetables online or offline, and they also can get fresh agricultural products from urban agricultural land in the first place. (Gao, et al. 2014)



b. A Self-circulating Community Planting Network System with the help of internet

Public welfare cycle: Constructing links with public welfare organizations, setting up “care farms” for institutions, so that they can be involved in the process of community building, caring for vulnerable groups, helping the elderly and the sick in

2.2.3. *Establishing a self-circulating community system*

Different from the traditional community where material and energy are transmitted in a single line, the self-circulating agricultural community system has a complete material circulation and metabolism system through technical and spatial means such as agricultural planting, water reuse, rainwater collection, and biogas production and utilization. As a result, substance consumption and waste output are reduced to release the community's ecological pressure on the environment.

1)Online mode: The development of Internet technology has boomed a virtual public life, and this plan can use cloud technology to establish a network sharing platform and create “cloud-based dishes” to connect the entire community to cities through the Internet.

2)Offline mode: It can combine schools, laboratories, public welfare organizations, etc., not only residents but also professionals, students or volunteers can be trained to join it, it can be used as extra-curricular projects or life experience projects to grow edible plants and harvest the gains after harvest, the gained edible plants can be donated to public welfare

the community, and raising funds. The raised a certain funds can be used to maintain the system's operation. By doing these it can mobilize people's subjective initiative for joining.

institutions or used for online and offline sales.

Business cycle: After meeting their own needs, residents can choose to sell online or offline as urban agricultural activities have become a platform for communication between agricultural producers and consumers. Both sides can engage in online and offline contacts for consumers can either purchase suitable agricultural products from fields and workshops or even their own roofs at the first time to enjoy direct supply of fresh food from fields at home.

Public welfare cycle: Constructing links with public welfare organizations, setting up “care farms” for institutions such as welfare homes, health care centres, and so on, so that they can be involved in the process of community planting, caring for vulnerable groups, helping the elderly and the sick in the community, and raising funds. The raised a certain funds can be used to maintain the system's operation. By doing these it can mobilize respondents' subjective initiative for joining.

In response to this idea, related questionnaires are designed and a total of 402 questionnaires are distributed by way of online questionnaires. After excluding 50 invalid questionnaires, 352 valid questionnaires are accepted and the recovery rate was 86%.

3. Questionnaire results and analysis

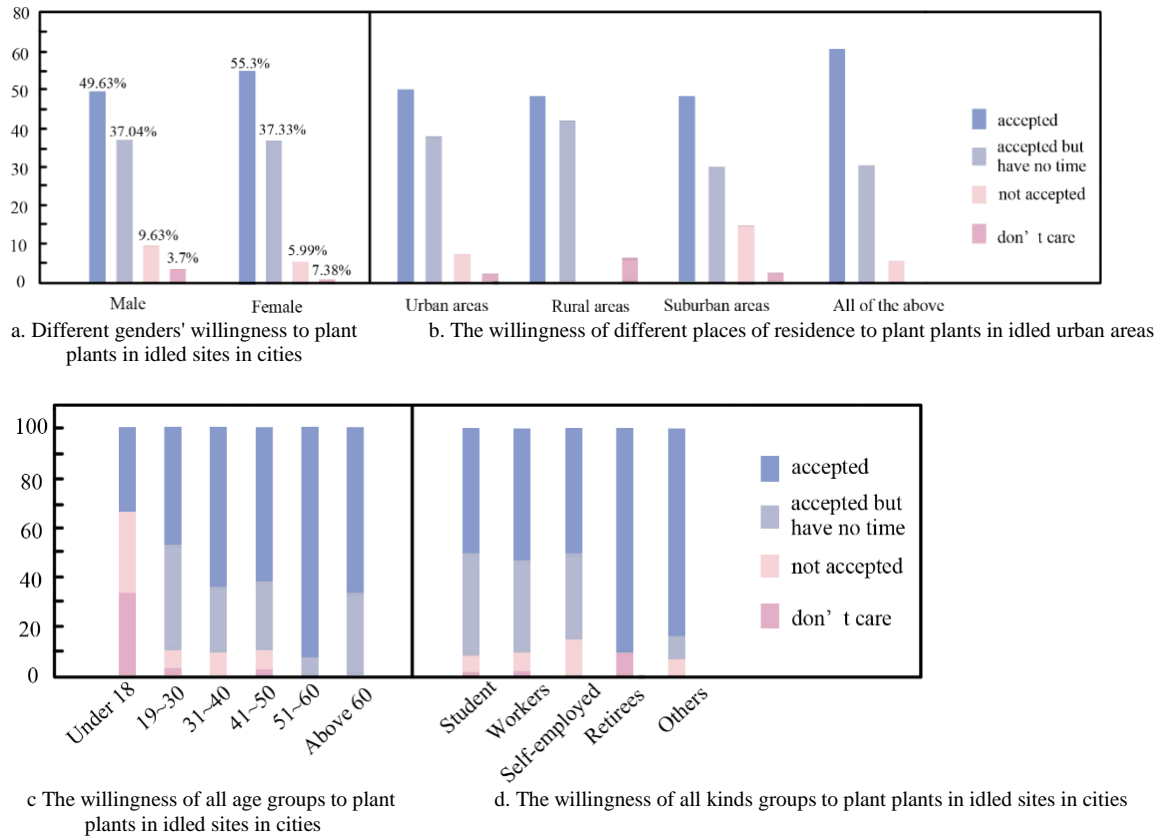


Fig. 2

3.1. Basic analysis

In the investigation and research of the UA "online to offline" community planting pattern, we finally find that 53.13% of respondents are willing to take part in this pattern, and 37.22% are willing to but have no time, and the rest of respondents are unwilling to or unconcerned.

3.1.1. Gender:

In general, respondents are willing to participate in community planting. Most of

the men and women are willing to participate it (Fig. 2a)

3.1.2. Place of residence:

More than a half of the respondents are willing to accept this pattern wherever they live in urban areas, rural areas or suburban areas (Fig. 2b).

3.1.3. Age

In the group of respondents over the age of 50, all of them choose "willing" or "willing but not having time". Their

participation is the strongest. In the group of respondents over the age of 18, their participation is the weakest. (Fig. 2c)

3.1.4. Occupation

More than half of all categories of respondents are willing to participate in it, especially for retirees and other members of the society. At the same time, a large proportion of respondents are willing to participate in it but they have no time, and this situation is more common among students, office workers, and self-employed. (Fig. 2d)

3.2. Analysis of respondents' willingness

3.2.1. Analysis of respondents who are unwilling to participate in the pattern

Among those who are unwilling to participate, the reasons for most of them are

“hygiene problems”, “food safety issues”, “worried about being picked at random”. And hygiene problems are the most noticeable. (Fig. 3b) In the case of solving these problems, there are 35.29% of respondents willing to participate, and this

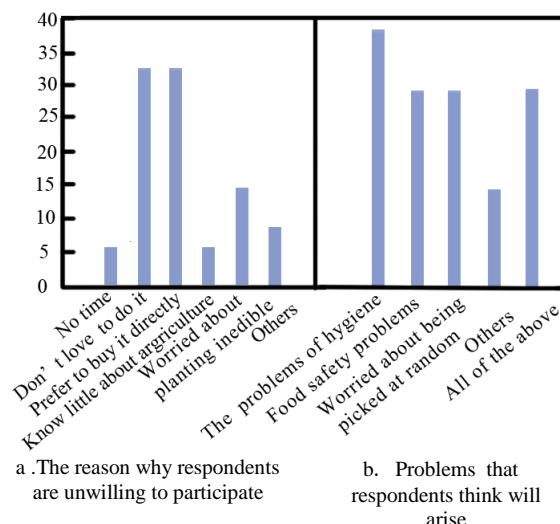


Fig. 3. Reasons for unwilling to take part in

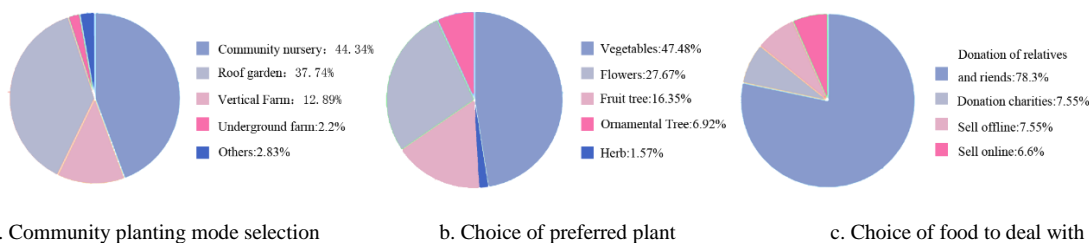


Fig. 4.

as follows: “not interested in it”, “do not like to engage in farm work”, “prefer to buy fruits and vegetables directly in the market”, etc, and a few respondents worries about that it is “unhealthy to eat fruits and vegetables planting in the city”, “do not even understand agricultural knowledge”, “worry that they cannot harvest after planting “and” there is no time”.(Fig. 3a)It is generally believed that UA will have

part of the respondents is a potential participant in the pattern.

3.2.2. Analysis of respondents who are willing to participate in the pattern

Among the respondents who are willing to participate in, the preference of community planting patterns is: community garden> roof garden> vertical farm> underground

farm> others (Fig. 4a), the preference of plants are: vegetables> flowers> fruit trees> ornamental trees> herbs (Fig. 4b). After satisfying their own needs and having more than enough money, most respondents are more willing to choose to give as a present to relatives and friends. The remaining small charities sell online or sell on the ground. (Fig. 4c)

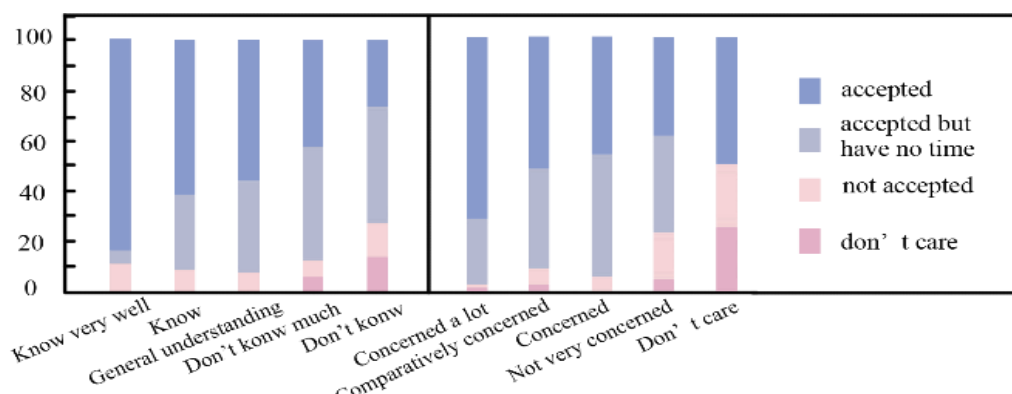
to the degree of the acceptance of planting in the vacant land in cities (Fig.5a).

The degree of understanding of traditional agricultural knowledge is significantly correlated with the choice of distance to buy vegetables ($P=0.036$, $P<0.05$)(Table 1). And the more understanding of traditional agricultural knowledge is, the more likely for respondents who do not care about the distance to buy vegetables. And vice versa.

Most respondents have paid much attention to food safety, in particular,

Table 1. Differences in caring about distance to buy vegetables under the different extent of understanding traditional agricultural knowledge

Knowledge of traditional agricultural (per respondents)	Whether or not in caring about the distance to buy food (per respondents)	Value of P
Understand a lot	19	0.036 (P<0.05)
Understand	38	
General understand	83	
Understand a little	71	
Understand nothing	11	



a. The degree of understanding of traditional agricultural knowledge

b. The degree of understanding of traditional agricultural knowledge

Fig. 5

3.3. Impact caused by the understanding of traditional agricultural knowledge and different food safety concerns

The degree of understanding of traditional agricultural knowledge is related

respondents over 50 years old are more concerned about food safety and pay more attention to their health. (Fig. 5b)

3.4. Analysis of other factors

3.4.1. Factors that affect the whereabouts of food

In the case of meeting respondents' own needs, 78.48% of them chose to give to relatives and friends. Most respondents admit to it that promoting neighbourhood friendship, caring for vulnerable groups; changing lifestyles; eco-friendly, shortening the food transport chain; giving residents certain rights to use land; food safety; reapplying and self-managing cities; reducing food expenditure (Barriga Valencia and Leal Celis, 2011; Biel, 2016; Cantor, 2010; Certomà, 2011; Drescher et al., 2006; Ernwein, 2014; Gómez Rodríguez, 2014; Purcell and Tyman, 2015; Turner, Henryks, & Pearson, 2011).

3.4.2 Factors affecting sales

The reasons that affect most respondents to buy fruits and vegetables are as following: freshness, safety, price, distance from home, taste, etc. Many respondents think that there are many factors, especially freshness. As for the purchase methods, most respondents are willing to choose to buy food in the market rather than buy food online for the reason is that they can more intuitively judge the freshness and quality of fruits and vegetables.

3.5. Importance evaluation

Aiming at the "online to offline" community planting pattern, five-point evaluations are carried out from the aspects of edibleness, participatory, innovation, design, and extensibility. In general,

respondents are most concerned about the freshness of fruits and vegetables in community planting, followed by the cultivation design of fruits and vegetables. (Table 2.)

1) Edibleness: it is generally believed that edibleness is great importance. And most respondents think that the freshness of fruits and vegetables is important, even 64.77% think it is very important. Respondents is also paying attention to the use of chemical fertilizers and pesticides, especially the former.

2)Participation: "Organization management", "sustainability "are all above 4 points, indicating that everyone is more concerned about actual benefits rather than entertainment benefits.

3)Innovation: "the instant feedback from the Internet's", shows the latest agricultural achievements in technology", "making friends according habits", and "fun games", scoring 3.99, 3.9, 3.73, and 3.4 points respectively, so it seems that most respondents think the freshness of fruits and vegetables is more important than them.

4)Design: The planning and design of the garden, the cultivation and design of the crop, and the average design score for the community activity of the plot are relatively high, indicating that we all care more about the interest and sense of design in practical farming.

5)Ductility: The scientific popularization of agricultural knowledge and the introduction of edible plantings scored 3.98 and 4.04, respectively, people considered they are important. (Table 2.)

Table 2. Importance evaluation

Type	No importance	Not important	general	important	Very important	average (five-point scale)	
edible ness	Freshness of fruits and vegetables	11(3.13%)	5(1.42%)	18(5.11%)	90(25.57%)	228(64.77%)	4.47
	Use of chemical fertilizers	16(4.55%)	20(5.68%)	83(23.58%)	99(28.13%)	134(38.07%)	3.89
	Use of pesticides	21(5.97%)	21(5.97%)	59(16.76%)	73(20.74%)	178(50.57%)	4.04
Participatory	Organization management	9(2.56%)	6(1.7%)	76(21.59%)	145(41.19%)	116(32.95%)	4
	sustainability	7(1.99%)	10(2.84%)	70(19.89%)	130(36.93%)	135(38.35%)	4.07
Innovation	Demonstrate the latest agricultural achievements in science and technology	5(1.42%)	22(6.25%)	82(23.3%)	138(39.2%)	105(29.83%)	3.9
	Instant Feedback on the Internet "Cloud Feeding" Community	5(1.42%)	9(2.56%)	73(20.74%)	163(46.31%)	102(28.98%)	3.99
	Making friends By hobbies	7(1.99%)	24(6.82%)	104(29.55%)	139(39.49%)	78(22.16%)	3.73
	Adding Fun games	15(4.26%)	53(15.06%)	116(32.95%)	112(31.82%)	56(15.91%)	3.4
design	Planning and designing of garden	6(1.7%)	9(2.56%)	50(14.2%)	161(45.74%)	126(35.8%)	4.11
	Crop cultivation	4(1.14%)	9(2.56%)	52(14.77%)	156(44.32%)	131(37.22%)	4.14
	Design for the community activity	6(1.7%)	9(2.56%)	68(19.32%)	156(44.32%)	113(32.1%)	4.03
Extensibility	Scientific popularization of agricultural knowledge	7(1.99%)	10(2.84%)	67(19.03%)	166(47.16%)	102(28.98%)	3.98
	About the introduction of edible crops	7(1.99%)	8(2.27%)	61(17.33%)	164(46.59%)	112(31.82%)	4.04

4. Discussion

UA is a kind of transforming movement. And It also sprouted as a response to slow food movements and greener lifestyles.

In terms of the effects of age, middle-aged and aged people are more likely to accept this pattern because they have more discretionary time and are lack of leisure life. People who understanding more about traditional agricultural knowledge, are more likely to pursuing higher quality of

vegetables and less care about the distance to buy vegetables. This group is more likely to become potential customers of this pattern. Most people take much count of food safety. For this purpose, community could regularly push some food safety knowledge to ensure that traditional agricultural knowledge will not be lost quickly, and it will also stimulate public participation in urban agriculture.

4.1. The role of the Internet

The Internet's involvement allows more respondents to have access to eat edible

plants grown in the community. According to our investigation, a large number of respondents are concerned about the freshness of vegetables. To some extent, the way of online distribution can shorten the distance and the time of delivering. After building their communities, a lot of respondents are more willing to share their fruits and vegetables to their relatives and friends instead of selling them after satisfying their own needs. The intention of privatization is obvious, and it indicates that most respondents choosing to create a community are not for living. Although it will greatly affect the construction of community networks, not all kinds of agricultural products need to enter the circulation chain in the pattern which is carried out under the condition of satisfying the residents' own needs as much as possible. However, with the development of technology and society, the increase in production and the promotion of public welfare will lead to the emergence of business cycles and public interest cycles. Based on a potentially viable business pattern, the development of the "online" is a means to achieve the sustainable developments of sustaining livelihoods and organizing structures. It makes people who have no time to plant but still are interested in and are willing to buy the community fruits and vegetables participate online in this "unique" way, and it also maintain and promote the development of community-building activities.

4.2. Promoting the healthy development of community

From the perspective of social benefits, UA is not only related to the healthy growth of food crops, it is more about the healthy development of community society. Some respondents said: "... we prefer to see a green garden in a once being deserted area near our home, which will let us feel more secure, "which proves that the community planting can create a sense of security and this arrangement leads to a high degree of security and long-term engagement that also meets individual needs. Most people who are willing to participate in the community planting pattern have chosen to give fruits and vegetables to their friends and relatives. This will promote friendship among neighbours, change their lifestyle, and enhance their well-being. In addition, UA has the functions of promotion, education and demonstration. By means of "online" line, the rapid spread of the Internet can expand the affected, lead low-carbon lifestyle, and restore the bond between modern respondents and nature, pay attention to vulnerable groups and care for public welfare.

5. Conclusion

UA community planting pattern of "online to offline" has been accepted by most respondents. A central idea created by this pattern is to encourage collective practice and community planting. This pattern is not a complete replacement for the local industrial food system, but a supplement to it, to provide alternative

forms of lower carbon, green, and more harmonious neighbourhoods. The meaning is not just planting and gaining edible plants in discarded areas, but more on the effects on social, public welfare, environmental, and time-effective effects.

Residents' wide participation and universal support are continuous motives with combining agricultural production with health and social services. The humanistic care in the community has extended to the online through the pattern. It not only realizes the integration of urban and rural

psychology and culture, but also in public welfare. As most respondents are willing to help and subsidize public welfare organizations, the forms will not only be food donations, they can also form the "care farms" in this way, which will be set up in the future to protect the physical and mental health of vulnerable groups such as children and the elderly, to form community interactions and community care, so as to promote the sustainable development of the community.

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Exploration of Biophilic System From Unnatural to Natural

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Abstract

Biophilic refers to the things related to nature and it is a eco word. City is the human habitats and most of them is designed on purpose, for the need or desire. It is the human-centered ego word. City itself is unnatural and because of the population increase, the urban sprawl, the resources development these unnatural urban systems are created more and more which occupied the existed natural landscape. The tendency of biophilic city just likes a kind of return in some extent. Human build the artificial environment while nature contain the ecosystem. With the city development the urban environment would become relatively closed, urban landscape is the intermedia for other creature in the urban system and it should be floating, dynamic and changeable space. The article would analyze the present urban landscape system in Hong Kong with the green ratio of 70% and public space of 85% but more than seven million population. Propose the landscape as the ecological island which would have the specific function like agriculture, commercial or even resident. As a result, the city would develop the new landscape system, the planned but natural free growth.

Keywords: artificial, ecosystem, landscape urbanism, urban farms, vertical landscape

1. Introduction

Bio-, as the geek words βίος, means life which covers every creature in the city. Wilson famously defines biophilia as “the innately emotional affiliation of human beings to other living organisms^[1]. Biophilic system is the system attracts people into the natural context. Biophilic city refers to that the artificial urban system contains the things related to nature. However, the city is planned of the human being’s will. The trees

are planned along the street as the belt and cannot self-grow like the trees in the forest. The community parks are built to serve the nearby residents and unlike the natural pound which can attract birds and different kinds of fish. The present urban ecological system is the unnatural one because our human as the clients designed it and make the system dominantly serves for us, which makes the biophilic scenario separated from the city. The metropolis is in this side while the nature is in the other side and between them has no connection. The biophilic system tries to

break the present urban system and set up the connection which should be the self-growth urban landscape attach the surface of the city between the natural system and the urban ecology.

Choose the specific Asian city Hong Kong as the site to analyze. Compared with Singapore, the two cities are all island with restriction and potential development. With more population, Hong Kong Special Administrative Region of the People's Republic of China as has the more complex urban planning. Most of the green space in Hong Kong is undeveloped mood and under the protection of the law. With the burden of the high density, these natural reserve or country park are distributed near the territory, the periphery part of Hong Kong. The center of Hong Kong is occupied by the busiest commercial urban activity. The infrastructure networks cut the skin of geological surface and the activity networks narrow the urban landscape space. The Figure 1 displayed the population density within the green space. A biophilic city is a city abundant with nature, a city that looks for opportunities to repair and restore and creatively insert nature wherever it can ^[2]. Based on the definition of the biophilic city, Citizens no need to build another structure and can utilize the nature as the pop-up space, like the space under the trees can be the emergency space or the space inside the grass can be the dump space. Apparently, Hong Kong is not a biophilic city so far.

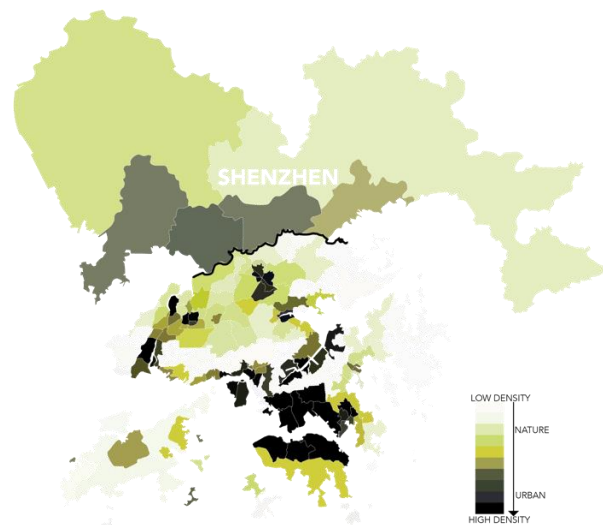


Fig. 1. The present density and greening in Hong Kong

This paper would focus on the present urban ecology system in Hong Kong, zoom in several specific urban green spaces, diagnose the reason why the landscape system is not fix the urban system and propose the future of biophilic Hong Kong.

2. The Present Green Space System in Hong Kong

Hong Kong consists of three parts, the Hong Kong island, the Kowloon island and the New Territory. Government sort the land open space into the urban areas, rural areas and countryside and coastal areas. Based on the Hong Kong planning standards and guidelines, the green space is defined as one type of open space for conservation function as the figure 2 showed. The prime function of this space is for conservation of the natural environment and for amenity and visual purposes. It is not countable towards the open space standard of provision ^[3]. The green space covering a total area of 443

square kilometres is classified as country park, coastal protection area, site of special scientific interest, green belt and conversation area. The planners separate the green space from the urban system in the beginning and the start point of the planning idea is still always the desire to control, control the development, control the growth. The following plots would find those different kinds of green space and explore the possibility of inserting biophilic system to them.

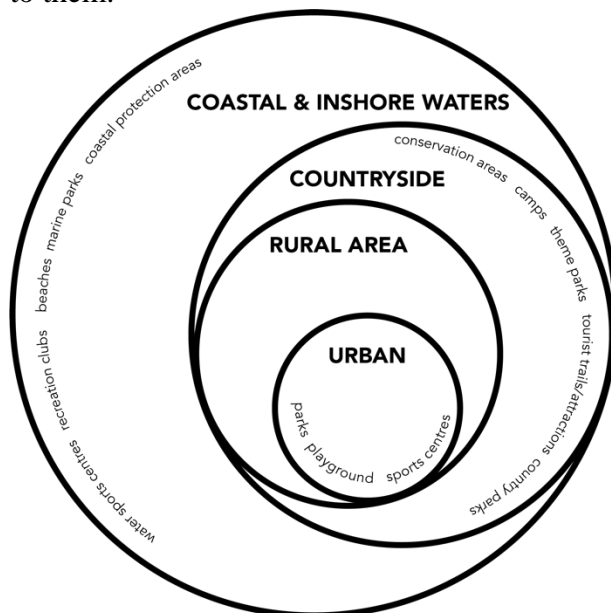


Fig. 2. The structure of Hong Kong open space

2.1 Country Park

Different kinds of mountains consist the Hong Kong hilly landscape and the country parks are always designated because of the mountains. The location of the country park is always on the boundary of the city as the main purpose of country park is shorten the distance for visitors to feel the rural and natural atmosphere. In 1976 the Country and Marine Parks Board, be cited as the Country

Parks Ordinance, was established to manage the leased land more easily and to provide a legal framework for the designation. There are totally 24 country parks in Hong Kong, 4 of them are in the Hong Kong Island and the rest are in the new territory. The country parks are very popular with different hierarchy of the society. Spending the whole day in the parks is always a good choice for the citizens. About 11.2 million visitors were recorded in 2014 and most visitors engaged in leisure walking, fitness exercises, hiking, barbecuing, family picnics and camping^[4]. The figure 3 showed the visitors of country park. With the increasing affluence of the population and the desire for better facilities for informal "countryside" activities and more effective management of the hill areas was required^[5]. Furthermore, the country parks take the responsibility of the education to encourage the public enjoyment of the green space. However, actually 22 of the country parks are created for the nature conservation which make a restriction the human activity. For now, the planning department prompt the trail program as the main target is minimising the human activity influence.

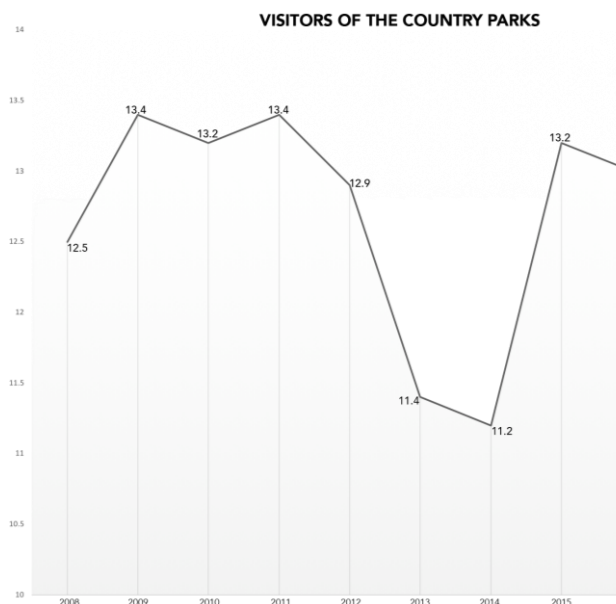


Fig. 3. The visitors (in million) from 2008 to 2017

Take Ma On Shan Country Park as an example. This park is located in the eastern of the New Territory covering an area of 2,880 hectares. As the urban landscape point, first this country park is in the metro line which connect several sleeping towns attracting more visitors. Second, the government has developed the space surrounding the park into the public housing area. With the human settlement developing, the park may focus on natural platform provision for more nearby residents by adding the new programs and cooperating with neighbour facilities. For park itself the hiking is the main function, which close the distance between human and nature also reduce the disturbance of wildlife. However, the single activity cannot fit the diverse residents, the old need the flat path to walk while the kids need some amusing elements. The community park, the sport centre and other supporting facilities aim to the issue of user diversity.

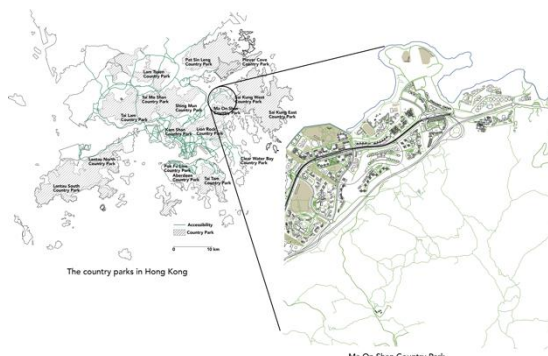


Fig. 4. The accessibility of country parks and location of the site

What if the country park itself can fix the diversity of the visitors and balance the need between urban and nature? What if divide the country park into the vertical layers to achieve the different functions? Moving the temporary residential area to the bottom layers of the park and the top layers could still be the reserve area. The middle layers can be the outdoors sports area, hiking path, rest pavilion and so on.



Fig. 5. The proposition for Ma On Shan Country Park

2.2 Marine parks

As Hong Kong is surrounded by the sea, the marine parks always located beside the country parks. The natural coastline provides the platform for the citizens to contact with the water. Hong Kong planning department puts this kind of parks into the category of coastal protection area of which the main aim

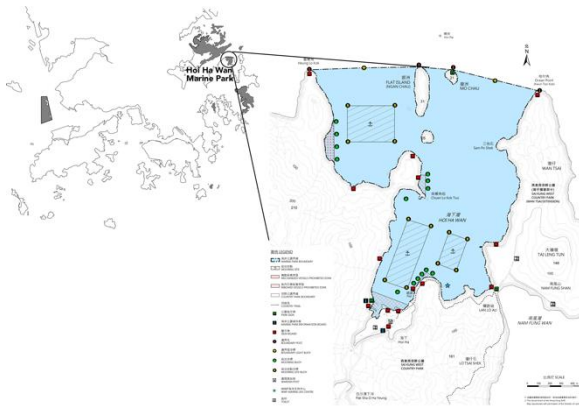


Fig. 6. The situation of marine parks and location of the site

is to protect the natural area and the nearby developing area against the effects of coastal erosion. The method of managing the marine parks is the zoning plan to divide the park to the different part and achieve the multiple function. The mooring site is the anchor function, to allow the ship to park in the and decrease the damage of coral. The core area and the inboard vessels prohibited zone are all the conserve function, to protect the marine lives and prohibit the fishing. The mechanised vessels prohibited zone is the diving function, to protect the divers and snorkelers by preventing the mechanised vessels entry. There are 5 marine parks which the total area is 3,380 hectares and the space for the human activity is around 700 hectares. The present planning is reasonable that the visitors may spend more time to arrive the marine parks so most of the visitors have strong purpose to do such activity.

Pick Hoi Ha Wan Marine Park as the urban landscape point. The site is almost in the boundary of Hong Kong, designated in July 1996 as the first batch of marine parks. The marine park of Hoi Ha Wan is situated at the entrance to the deep estuarine embayment of Tolo Harbour and because of the discharge of

the Hoi Ha stream at its head the mangrove stand here is also in estuarine waters [6]. Based on the planning policy is divided into four parts and visitors are permitted in the specific space doing specific activity. Although the large part of the waterfront is distributed for the boat and natural coral, coral communities at Hoi Ha Wan are still under threat of increased sediment loading, discarded fishing nets and cages, and hypoxic events [7]. However, the sea is the public space shared by all different kinds of species. What if apply the vertical thinking to the marine park? Aggregate the mooring site, develop the surface layer into the hydrophilic space and the undersea layers belong to the marine life.

2.3 The Green Belt

The ‘Green Belt’ (GB) zoning is not restricted to the rural area. It can be found in the new towns and urban planning area. This green belt policy is like designating a buffer zone to retain a large undeveloped area surrounding by the urban space, such as the parks mentioned above. The original purpose of green belt is creating an invisible border to prevent the improper urban sprawl and expand the scope of wildlife activity. Though there has never been any attempt to designate a continuous green belt zone to encircle any urban settlement or new town, green belt zoning of pockets of land is found in almost every statutory town plan wherever there are hills. For now, the green belt draws the boundary of the natural space and divides the natural space from the urban system, which drive the conflict between the green belt system with the rapid growth of urban population. Hong Kong government tries to

transform the green belt into the public housing to cover the conflict.

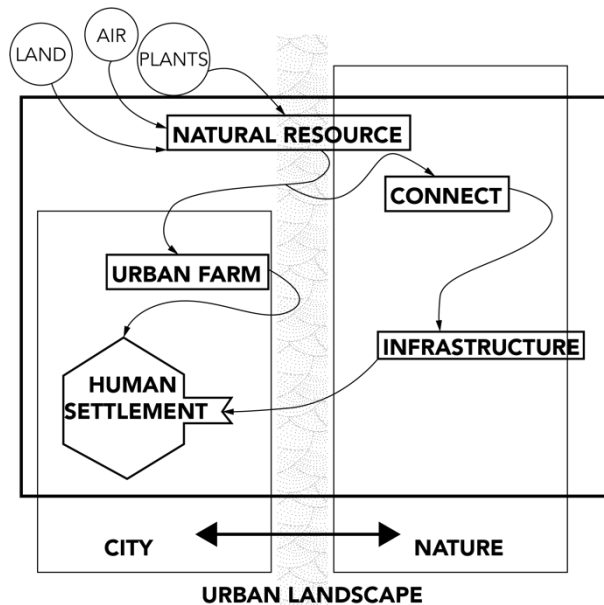


Fig. 7. The proposal of biophilic system

No matter the land is used as the natural reserve area avoiding human activity or as the urban development area erasing the natural elements, cannot fit the biophilic system. The green belt and other kind of green space are the context connecting the citizens and nature.

The green belt space is now allowed to application which change its function from the greening to the village housing. If the parks can be divided into the different layers, the buffer space do need between each layer. The green belt space has the potential being developed into the garden or urban farm to gather the nearby residents to do something together in nature.

3. The Proposal Biophilic System in Hong Kong

Focusing in the definition of the proposal Hong Kong biophilic system, this part would push forward the details. As the above analyzed, the parks, the green belt and other kind of the green space is separate from city's daily life because of the location or the policy. Landscape should be the intermedia connecting the rural area, the nature and the urban area, the artificial, like the figure 7 propose the city. Moving the city into the nature, let the landscape grow freely in the city and let the city develop freely in the nature.

3.1 The Boundary of the System

The Hong Kong has its physical boundary which divides itself from the other cities. Actually, inside Hong Kong there is another boundary which divides the city from the conservation area. The boundary protected Sai Kung part and Lantau south part from urban sprawl. As applying the biophilic system the first step is breaking the limitation. Hong Kong should be taken as the whole body. Thus, the general boundary of the system should be the city boundary and inside the city every different function in each district would form the fence naturally. Considering the present situation, the green belt space can be used as the dividing line, which could cooperate the surrounding area. The residential function can be surrounded by the urban farm green belt, the financial function can be surrounded by the outdoors resting green belt and the education function can be surrounded by the interaction garden green belt.

3.2 *The Internal Process of the System*

The process of the biophilic system drives urban ecosystem from the controlled, the planned level to more sustainable and self-organization level. Like the electric circuit in the transition of this point to other point, need go through the different node, different wire and press different button. For the urban to achieve the aim from unnatural to natural and sustain the internal process, the various parts of the city would be evolved. Obviously, the key policy directive would be those special nodes in the system.

Natural resource, playing the provider role in the ecosystem, is the first and foundation key to zoom in. Up to the sky, down to the earth, everything we can use is the resources. The food we eat, the air we breathe and the land we live are all from nature. City is a type of morphology for collective natural resources. The present policy of Hong Kong protects as much natural resource as possible, but the designation of the country or marine parks is based on the artificial ecology, which is the way created to see the world. In the proposed biophilic system the internal boundary is disappeared, the urban pattern would be reformed, and natural resource can be self-exchanged between the urban nodes. Nature is not only known as the provider but also as the urban space.

Human settlement including the working place, sleeping town and other function site, is for the individual sustainability. Doxiadis had proposed the human settlement is the system of natural, social and man-made elements which can be seen in many ways -

nature, man, society, shells, and network or economic, social, political, technological, and cultural [8]. Based on the science of human settlement, the principle of human settlement in this proposed biophilic system is maximization of the connection with the nature, minimization of the influence by the artificial works and optimization of the emergency space inside the natural environment.

Connect policy is the linkage between the above two key elements. The most common urban connection is the road, the highway, all the infrastructure the citizens can rely on. In the biophilic system the things which drive the citizens move the place to another place can all be considered as the connect. In this way urban landscape has the potential to be the intermedia that provide the access to the housing land, the farm land and working part. With such connect the Hong Kong belong to all citizens as well as the city itself.

3.3 *The Elements of the System*

Generally speaking, the elements can be classified into the provider and consumer. Consumer is the urban elements and the consumer absolutely is the natural elements. The present city consumer the resource and nature always one-way supply. Breaking the environment into the fragments, the biophilic system reprograms these elements and drags the provider and consumer into the same level and create the platform, such as urban farm or vertical green wall for the exchange.

4. Conclusion

Discourse of the biophilic city provide the new way to understand the city. Erase the fixed internal boundary. Create the new form origination like divide the vertical layers or insert the city into the natural space. Explore the possibility of transformation. The present role of each elements can be transformed even to the opposite side. Applying the biophilic system into the way of seeing Hong Kong can find more potential developing direction, city is the part of the system and can be break up into the nature and can be combined with reprogramming the nature.

Acknowledgement

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Urban Connector - Corridor landscape Planning of Benyamin Suaeb Street in the Centre of Jakarta through the circulations and social spaces

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Abstract

Corridor Landscape could develop into many functions. In the urban areas, the corridor landscape could enhance the quality of urban green spaces. Kota Baru Bandar Kemayoran (KBBK) is in the Central Jakarta area that developed as an environmentally friendly international trading city and has the potential to improve the quality of green open space in Central Jakarta. Urban green open spaces planning requires the existence of corridor landscape that has many benefits to improve the quality of urban landscapes, both in aesthetic and functional terms. Benyamin Suaeb Street is one of corridor that located in KBBK, Central Jakarta that consists of three parts, which are pedestrian way, vehicle way, and the median. Base on the history this street was Jakarta's big airport and have many potency to be developed. Now days, government already built the corridor but it was built without appropriate planning and give many problems in Kemayoran area. It is need to have study to solve many problems in this corridor. The purpose of this study is to planning the corridor landscape of Benyamin Suaeb. Methodologies that used are site survey, literature study, interview, and questioner base on the method of Booth (1983). The replanning formed by physical-biophysical, ecological and social aspect. All data from these aspects will be analyzed sensitively and can be used to do synthesize that produce a concept. The concept is Urban Connector, that connecting human and environment in sustainable urban space. The Benyamin Suaeb corridor landscape is connected by circulation pattern and social space that create an active corridor with more ecological aspects and a natural atmosphere for urban peoples.

Keywords: Planning, Landscape corridor, urban space

1. Introduction

The city of Jakarta as the Capital of the State of Indonesia experienced a very rapid development. This development process raises various problems, especially due to development without planning, therefore development should be balanced with a nature planning area. This planning of integrated with various aspects is done in order to create a functional and aesthetic sustainable environment. Planning as a process of detailing a planning idea must be accompanied by a maintenance plan as a guarantee of the site is sustainable.

Kemayoran is one area in Jakarta city which continues to grow. This area continues to be active in fixing the environment. Bandar Kemayoran area was once an airport area of DKI Jakarta Province. This area has an area of approximately 454 Ha, with the use of land that has changed from its origin, from an airport to various land use, include dense residential areas, high-rise apartments, star hotels to jasmine classes, markets, offices and business centers.

With the large number of residential and accommodation facilities in this area is inhabited by people from their own background. According to data from the Central Bureau of Statistics Kemayoran area has a population of 242,610 people with a population density of 33,463 inhabitants / km². With such a population, this region must be supported by adequate facilities and infrastructures so as to have a good influence on various aspect, especially social, physical and ecological aspects by plan the landscape Corridor of the area.

Construction of physical facilities and infrastructure can be planned in open space areas that have the potential to be developed in Bandar Kemayoran, one of which is on the green corridor of H. Benyamin Suaeb road. The green corridor that forms the landscape corridor has a length of 3.5 km and the width of each green corridor is 30 m, and the road median width is 4 m. The location is very strategic because it is in the middle of the area. Therefore the arrangement of this area will be carried out which begins with the planning process of landscape corridor equipped with green laying plan that exist in this corridor. This arrangement is expected to be useful for improving the ecological, social, ecological quality as well as supporting the functional and esthetic region image.

2. Objectives

The objectives of this study are as follows:

1. Implement sustainable work based on the Master Plan of Benyamin Sueb Street Landscape (North-South).
2. Obtain development plan and program of open space and green corridor gradually and continuously
3. Obtain the concept of arrangement of the green path landscape of Benyamin Suaeb Street and Working drawing which is in line with the vision and mission of Kota Kemayoran new town development

3. Research method

3.1. Research setting and time

This study was conducted activities conducted in Central Jakarta Kemayoran area with total area of 454 Ha on Jalan Benyamin Suaeb which is the main road in the area. The orientation map of the research

setting can be seen in the following Figure 1.

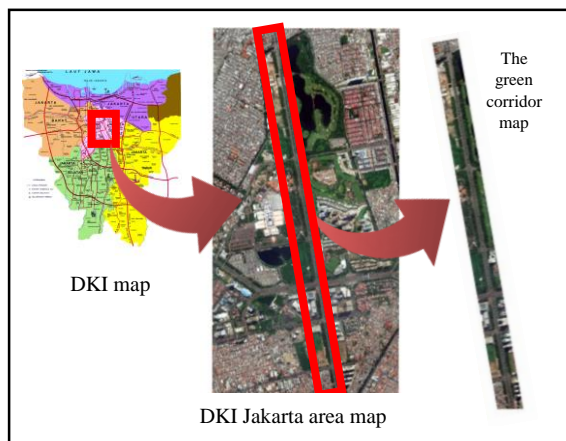


Fig. 1 Research setting

Source: <http://google.maps.com>

3.2. Research Method

The methods used in this study were as follows:

1. Inventory, is a direct observation or observation of the site at a certain time with different conditions. This activity aims to determine the general conditions directly on the site. Aspects that are inventoried aspects of physical, biophysical, and social.
2. Analysis and synthesis, the data obtained through the inventory will be analyzed based on the potential and constraints according to the development that will be done on the site, using descriptive analysis method and spatial analysis, including: physical, biophysical, and social aspects to generate the arrangement of zoning and the concepts.
3. Concepts, to be developed were basic concepts, planning concepts and development concepts. The concepts had been made into a reference in making the planning development. Developments

concepts are vegetation concepts, circulation concepts, spatial concept, activity concepts and ecological concept. The end result of this stage was the block plan of the concepts concatenation that had been made.

4. Planning Process

This stage is an advanced stage of the development concept. At this stage the concept of development is made in more detail by adding aspects of hardscape and soft scape created in the form of site plan.

4. Findings and discussion

4.1. General Condition

Benyamin Suaeb Street is divided into two lanes with a median road 4 m wide with an overall area of 1259.96 meters². It has a median road with length from north to south, which is 3.3 kilometers divided by traffic island with a diameter of 22 meters at each intersection. On the east and west of the road there is a green line with a width of 30 meters where on the edge of the green line there is a small and large drainage channels. The total area of 185,346.49 meter² green line, so the total area of planning is an area of 197,445.45 m². In general Kemayoran area is in relatively flat topography with slope of 1% and is at an altitude of 2.0-3.0 from sea level. The relatively flat topography condition allows the region to be developed. Types of soil located in Kemayoran area in general are Alluvial and Gray Hydromorf.

Based on meteorology and climate bureau data in 2015 the average temperature condition Kemayoran area that is equal to

28,15 °C, with average humidity equal to 73,8%. The average rainfall of Kemayoran area is 333,4 mm /month. Reservoirs in the Kemayoran area are artificial water bodies that are partly filled from main drain or main channels around the area that drains the water channel around Kemayoran area. The reservoir is located in the eastern part of the area which aims to control the flood controlled assisted with the help of pump houses and water gates that regulate the exit of water in Kemayoran area. The drainage channels on the tread are divided into open drainage channels and closed drainage channels. in this area is open drainage channel and closed drainage channel. The condition of drainage channel is quite good with no puddles on the road. There are several sizes of drainage channels in the area that is 3 to 7 meters wide.

The dominant vegetation on the green corridor is the sengon tree (*Albizia chinensis*). Vegetation on the site is grouped by species. The large number of existing plants and with a high enough density, making this tread as green open space is expected to ameliorate climate in the area and also provides other functions, such as the value of education and aesthetics on the site. The existence of these animals certainly provides an ecological value to the tread because the existence of these animals gives a natural impression and creates a natural food chain on the site. The presence of birds can also help in the process of plant pollination. Other animals such as snakes, lizards, and mice must be aware of its existence because it can affect the safety and comfort of users.

In the general condition of the facilities

contained in the area is less well maintained. Here are some of the facilities that are located in the area of the Trans Jakarta shuttles, street lights, garden lights on the median and green corridors, billboards, bins, security posts, guardrails and jogging tracks on the green corridor. Existing utilities include electrical substations, electrical panels, sluices, power grids, communications networks, water networks, inland ground gas networks, and drainage channels. The condition of the facility is poorly maintained so that many facilities are not working.

On each side of the North - South Road Green corridor has different visual conditions, ranging from golf courses, settlements, shops, apartments and hotels to swampy swamp forest. In general, the visual aspect of the northern part of the northern-southern part of the road is poor, this can be seen from the irregular vegetation at some point and also the dense vegetation density. The visual condition of the four traffic island is less well maintained, the existing plants have many dead, lots of weeds, and also a lot of vandalism in the planter box in this area. At the side of the road there is a ditch that has a bad visual condition, with the amount of garbage in the ditch and the black water. The visual condition of green path vegetation, median roads, and fences are bad.

This area is very strategic and easy to visit because the location is located in Central Jakarta, close to commuter line station, and often passed by public transportation such as Trans Jakarta, taxi, angkot, bajaj, and motorcycle taxi. Distance of this area from

Jakarta Kota station is 7.3 km and can be reached by about 10 minutes. The condition of road located in Kemayoran area, especially Benyamin Suaeb Street, is still good with asphalt material and can be passed by motor vehicle either two wheel or four wheel vehicle. The circulation located in Benyamin Suaeb Street consists of motor vehicle circulation, bicycle circulation, and pedestrian circulation.

4.2 Social Aspect

According to data from the Central Bureau of Statistics Kemayoran has a population of 242,610 people with a population density of 33,463 inhabitants / km². In general, the population of Kemayoran Complex consists of middle to lower class society and upper middle class. Overall Kemayoran area is managed by PPKK (Kemayoran Complex Management Center). Kemayoran area consists of several blocks, which at the moment several blocks are used for the construction of hotels, apartments, and shopping centers. Some of the blocks that have been built or under construction are self-managed by their respective stakeholders. Activities that can be seen during the survey in this area include jogging, cycling, and selling in the morning. During the day activities that take place are relaxing, just traversing, and used by traders to sell and homeless to rest.

The majority of site users were office workers. There were also street vendors selling around the site. The site was adjacent to two stations so that the site had the potential to become a new place in the center of the city. In addition, there were also routine activities held every week; it

was car free day. In regard to that matter, the site was very potential to facilitate the activity. Based on the results of interviews with some users of the site in which the majority of them were the office workers, it was expected that the planning of the park on Sudirman Street was not only a decorative park but also can facilitate the users of the surrounding site.

5. Analysis and synthesis

Physical and Biophysical Aspects

Location and Boundary Site

Location of the north-south green corridor Benyamin Suaeb Road has length of 3.4 km, width 30 m on the left and right sides and area of 8 Ha, which is a very large site for a green corridor. The north-south green corridor road located in a very strategic location as in the center of KBBK and connects the center of community activities, also connects KBBK with its surrounding areas. With these conditions, the site has many potential to serve as the main attraction for KBBK and supporting community activities and its function for improving the microclimate for the site and surrounding areas. The conditions of site which is border on appartement and hotels makes the site support the exiting activities around that.

Topography and Land

The green corridor of Benyamen Suaeb Road has the same slope of land and thopography, that is flat. The different level of the site caused by different height between road and green corridor, road median, and drainage line. The different of the height was made for fiffereentiate

between paths and also their usage. Drainage line which is in the green corridor (the big drainage line) has depth of about 1-15 m. The explanation of topography and land can be seen in the following Figure 2.



Fig. 2 Explanation of topography and land image

Climate

Based on BMKG data in 2015, the average temperature condition in Kemayoran area is 28.15 °C, with relative humidity of 73.8%. Based on the equation is known THI value of area of 26.7 which makes Kemayoran area is uncomfortable condition. On Benjamin Suaeb Road microclimate modification is necessary to obtain atmosphere for users.

Hydrology

The use of water around Benjamin Suaeb Road is mostly obtained through ground water. The channels on Benjamin Suaeb Road consist of open drainage channels and closed channels. Most of the channels on the green corridor side are open channels with widths varying from 3-7 meters. The widest drainage channel is in the north. With a width of 7 meters in the western part of the road from the south. The condition of the drainage channel is not maintained. Waste accumulation occurs in the drainage channel especially at the point of transition of the intersection. Type of waste that many found inorganic waste that require special handling for cleaning.

Vegetations

Vegetation on the tread appears to be dominated by trees with tree species namely sengon (*Albizia chinensis*). Planting vegetation on a site tends to be grouped by species, this is indicated by the number of similar trees planted in a similar and adjacent area. The vegetation conditions on the green corridor are not entirely in good condition. Many of the vegetation is not feasible to be planted in the area with the condition of vegetation that has been damaged and even died of disease. The large number of old trees with a very large diameter of trees that is about 70 cm -90 cm with a very close spacing of about 2.5 m - 3.5 m makes the area under the tree becomes moist and less sunlight. This requires intensive attention to this vegetation, especially for plants that harm the user by relocating.

6. Concept

Basic Concept

The basic concept of designing this green line is the urban connector. Urban connector is a green open space concept that can connect all aspects of urban life while maintaining a major focus on sustainable urban space. The urban connector is an integrated space concept with a multifunctional circulation pathway, implemented on the use of circulation paths for several functions such as pedestrian, bicycle, and jogging track in a single circulation corridor.

Design Concept

Based on the concept, the applied design pattern is organic where the spatial pattern follows the groove of the existing tree, thus minimizing the intervention of the site. This design concept also describes *motion and movement* that characterize a vibrant urban society.

Development Concept

Based on the basic concept of urban connector will apply some space that can accommodate user activities / users. Space that will be formed based on this concept that is like social space, conservation space, and circulation path. Social space in which there is interaction space, space gathering and educational space. Conservation space within which there are various plants existing collection of trees that have been divided into several groups and can be an area of support for urban activities both within and around utilized. Utilization of this collection is called urban arboretum, with this space is expected user/user can get education about plants located along the green corridor.

1. Circulation Concept

The circulation Concept to be used is referring to the basic concept of the tread is multifunctional circulation. This multifunctional circulation is integrated in the utilization of the circulation path for some functions. In addition, in this concept will also include a special path of reflection that is expected to accommodate the needs of the community / user.

The formation of circulation to be made that refers to the concept of design in the form of organic patterns or motion / movement that describes the dynamic Jakarta community. It

can be seen in Figure 3.

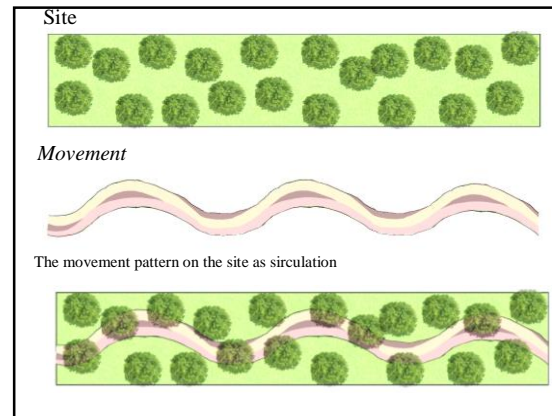


Fig.3 Circulation Concept

2. Space Concept

Based on the basic concept of urban connector will apply some space that can accommodate user activities / users. Space that will be formed based on this concept that is like social space, conservation space, and circulation path. Social space in which there is interaction space, space gathering and educational space. Conservation space within which there are various plants existing collection of trees that have been divided into several groups and can be an area of support for urban activities both within and around utilized. Utilization of this collection is called urban arboretum, with this space is expected user / user can get education about the plants located along the green corridor.

3. Vegetation Concept

The concept of vegetation to be used on the site refers to the existence of existing plants to be conserved. The diversity of vegetation species located on the site, especially the trees, causes no need for efforts to add shade vegetation, this is because the condition of the tread is quite well shaded. The addition

of vegetation will be maximized in the social areas that will be formed. Type of vegetation to be added to the area is aesthetic vegetation where to add a beautiful impression on the site. The addition of vegetation will also be done to replace the iron fence into a live fence. The addition of vegetation is done to reduce the rigid impression on the site and to make the barrier from the tread to the circulation of motor vehicles (Main Street). Vegetation to be used on the barrier is the type of thorny bush and ground cover where they will be combined so as to create an esthetic composition.

The next vegetation concept is in a certain segment a mini arboretum will be created. This mini arboretum contains a collection of tree plants that already exist on the site. Mini arboretum concept has a purpose that is to provide educational benefits to the community / user. Mini arboretum will be equipped with interpretation boards, making it easier for the community / users to know the types of plants collection.

4. Activity Concept

The concept of activities to be developed on the site is very diverse. Based on the results of the inventory and analysis of the activities of the users of this area, some of the activities that must be accommodated are walking, jogging, cycling, sitting, watching birds, interpretation of vegetation collection, sports, and others. These activities will be accommodated by the arrangement of facilities in some areas of this green channel. These activities are expected to accommodate the social activities of the community and are expected to reduce the level of individualism and social gaps that occur in the site.

5. Ecological Concept

Ecological concepts are raised to have a better long-term impact on the environment. Viewed based on the analysis of site conditions is very potential for the application of ecological concepts. Ecological concept to be applied that is by minimizing the intervention on the site. Form of such concepts as bird watching, bioswale, 3R (Reduce, Reuse, Recycle). This bioswale concept is applied to add better water absorption areas. The bioswale illustration can be seen in Figure 81. The 3R concept is also applied in utilization.

7. Site Plan

The site plan has a length of ± 3.4 km, width ± 30 m on the left and right sides and an area of ± 8 ha with a relatively flat surface area. The Green corridor landscape constituent elements consist of circulation paths and spatial elements supporting spatial circulation activity activities. The circular path of organic pattern divides the tread from north to south on each side integrated with the existing circulation path in several parts. The existing circulation path that has been built and managed by the partners is maintained in the new siting design and integrated in the site plan with the pattern adjustment at the points of the circulation path. The activity spaces connected by the circulation path are arranged on several sections in each segment with repeatable placement patterns at a certain distance interval. This is done to provide a uniform social space on each segment segaligus can be functioned as a rest area for users of the circulation path for both, walking, jogging

and cycling activities. Site plan can be seen in Figure 4.



Fig. 4 Site Plan

8. Conclusions and suggestions

Conclusion

The Benyain Suaeb street as corridor landscape is connected by circulation pattern and social space that create an active corridor with more ecological aspects and a natural atmosphere for urban peoples.

Suggestions

Urban connector is a good concept to create an active social space in the Jakarta urban area. So, it could be a good model that can be implimated in another part of Jakarta city.

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ARRECIFE. THE CAPITAL OF THE BIOSPHERE RESERVE.

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Abstract

Biosphere Reserves, the program launched by UNESCO in the seventies with the aim of fostering an organic relationship between human beings and Nature, have generally been very successful in promoting organic relationships in natural and rural areas, but rather less when it comes to urban environments.

This fact is very clearly demonstrated in Arrecife, the capital of the island of Lanzarote, one of the pioneering Biosphere Reserves in the world.

This paper describes the first attempts taken by the Biosphere Reserve of Lanzarote to improve this situation by implementing its biophilic agenda into the urban regeneration of Arrecife. Biophilic Urban Planning; Biosphere Reserves; Arid Cities.

1. Introduction

1.1. Lanzarote

The Island of Lanzarote is part of the Canary Islands, a subtropical archipelago of eight islands situated off the east coast of Africa. The island presents a dry landscape which was the result of multiple volcanic eruptions between 1730 and 1736, which were preceded by a small episode in 1824. These eruptions covered most of the fertile areas of the island with ash, making the island even more arid (fig.1).

This arid climate has brief spells of rain during the year with increased overnight humidity. Water scarcity has been one of the main issues in the history of the development of the island with water recollection, accumulation and saving encouraging the emergence of site-specific ways of water engineering in rural and urban environments.

In fact, some of the most attractive landscape configurations of the island came from a water efficient way of planting wine, called La Geria. It is an indigenous way of cultivating wine adapted for this arid and hostile ground consisting of funnel-shaped hollows filled with porous volcanic soil that

retains the water from night-time humidity which then feeds the plants. The system is topped by a low semi-circular wall that protects from the constant, drying wind (fig.3).

La Geria is a very good example of the postulates promoted by the Biosphere Reserve in its promotion of creative ways of living and working in harmony with nature. The landscape of La Geria has become part of the landscape identity of the island and its hydrologic intelligence.

This water culture and the ingenuity it requires, dates back to the beginning of the 60's when the first water desalination plant was built. The massive access to fresh water was a turning point in the history of the island as access to water will no longer be a problem.

This change made the development of mass tourism over the following decades possible, becoming the main economic activity of the island, with almost 3 million visitors a year. This development brought an exponential increase in the population and a much in demand tourism-focused work force that had to be accommodated in the capital. Since then, Arrecife has not been comprehensively planned, playing the role of a back yard; being a sort of dystopia with respect to the excellent landscape of the rest of the island (fig. 2).

1.2 Reserve of the Biosphere

The Biosphere Reserves are part of a UNESCO program entitled Man and Biosphere. Established in 1971, the main aim of this program is to explore innovative

solutions where people will live and work in harmony with nature.

A biophilic ambition announced almost 50 years before reconnecting nature and living processes became the agenda of the century. Since its foundation, more than 600 territories in the world have been declared a Biosphere Reserve.

The island of Lanzarote was declared a Biosphere Reserve in 1993 and has since counted on massive social support. It was not only one of the pioneering Biosphere Reserves, but the first to integrate the whole territory; the natural, the rural and the urban environment. The whole island was declared a reserve and therefore subjected to the biophilic ambitions of the program.

Since its founding, the Biosphere Reserve has developed an intensified action that protects and values the natural condition of the island. It includes issues such as the protection of biodiversity, sustainable development policies, campaigns against plastics and, more recently, the development of renewable sources of energy and light modes of mobility.

Next year the island will celebrate its twenty-fifth anniversary as a Biosphere Reserve. Despite its uncontested success in preserving the natural environment of the island and promoting new methods of human-nature integration, one can argue that incorporating the whole island into a reserve, including its urban environments, has not been addressed at all.

Faced with this ontological contradiction that may distinguish between the “biosphere” and the “urbanphere”, the team that run the Biosphere Reserve has decided to focus on the urban part of the island and, specifically, onto its capital, Arrecife.

2. The Objective

The challenge is now to transform the city of Arrecife into a true reserve capital, putting Lanzarote again as a leading member of the UNESCO program by coining and developing the term “Capital of the Biosphere Reserve.”

In order to achieve this, the Biosphere Reserve plans to test a new kind of city planning and design that will work by putting nature and living system dynamics as driving forces of its urban renovation; a truly biophilic approach. A new perception of (urban) reality, understood as a complex system in a dynamic equilibrium, coming from the constant interchange of energy, matter and information with its natural and social environment.

3. The Project

Arrecife has been the capital of the island since 1852. It is located in the centre of the eastern side of the island, at the foothill of a system of soft mountains that runs down the middle of the Island, from north to south. The city has a very unique waterfront made of reefs that define the city’s identity and give it its name (Arrecife means ‘reef’) (fig.2)

The city has developed like most coastal cities by first following the coastline, then, from the 70’s along two bypass roads in the form of two semi-circles. These have brought about the colonization of the hinterland, structuring the districts and the social classes according to their distance from the waterfront.

Arrecife contrasts sharply with the tourism paradise that the island has become. With poor urban planning, the city has become an exception to the ecological legacy prescribed by Cesar Manrique. It can be said that Arrecife remains isolated from the biophilic sophistication that has raised the prestige of Lanzarote as a natural reserve.

This situation was reported in a national newspaper which ranked Arrecife as one of the most deteriorated cities in Spain. The absence of a proper planning guide and the poor planning of most of the modest housing areas of the city have compounded this situation. To confront these antecedents, the Biosphere Reserve’s leaders have decided to intervene with an alternative approach to the dominant planning visions of the city by implementing biophilic principles to its urban planning and design. It is time to introduce the values and principles of the Biosphere Reserve into an urban space.

3.1 Principles and Methodology

At first, steps were taken to define a set of principles and a work methodology. The principles include a vision of the city as a living organism: managing urban flow will dictate how the city looks; what people feel

will prevail over expert intuition; bottom-up street-level surveys will replace top-down office-based approaches; and local patterns will be restored in place of ‘imported’ solutions. The first part of the methodology, the diagnosis, was done by an extensive walk of the entire city; including eight-hour sessions that were at times carried out alone and at other times accompanied by local residents and experts.

3.2 *Los Caminos del Agua*

The methodology of walking and talking raised the issue of the constant floods that the city periodically experiences. These are especially intense on the northern edges of the city, where poorer districts are located, as these are at the foot of the mountains off which water runs on its way to the coast.

This situation was not a problem for the ‘pre-desalinisation’ generation because they were educated to take advantage of this situation. As a result, the city has an impressive heritage of tanks and ponds that are strategically situated for collecting this water. Although this infrastructure is visible today, it is unused and the ravines are buried under an urban lay out that does not respect the topography of rain water.

The intelligence of the landscape of La Geria serves as a reference. We have to be ambitious for the city and with the intelligence applied to the urban areas, intelligence which is part of the genetics of the island. We only have to value it again (fig.4).

The walking tours showed that even though most of the ravines have been built over, there are still some fragments in parks and empty plots; places which have remained unseen to the clumsiness of poor urbanization. They offered a clear diagnosis: we have to re-integrate the three elements of the city: its territory; its natural environment; and its hydrology. This is even more urgent given the increased intensity of rainfall brought about by climate change situation. The project focused, then, on the reconstruction of these former hydrologic pathways.

The first phase of this reconstruction draws on the existing fragments and historical cartography. The network of tanks and ponds helped to map out the system which depended on them, with old maps and digital topography also playing a valuable role. Discussions with elderly residents who remembered when the water used to run within these channels shored up our findings (fig.7).

The result of reconstructing these fragments together with the introduction of new parts, in those places where the ravine had disappeared, was four waterways. These transverse the city; starting in the hinterland and ending logically at the beaches, constructed as sediment accumulated over time. The resulting lay out is a ‘Frankinstien’ sum of still existing water pathways and new eco-engineered parts. At the top, a set of retention parks connects the system with the rest of the territory and provide a communal open space in the most run-down districts (fig.6).

The idea is that these four ravines will work as a water infrastructure, both on a city and a district scale. They will channel the run-off and the storm water, incorporating small plazas and parks that connect the waterway with the residential districts. These plazas serve as an intermediate infrastructure for water harvesting and storm water storage preventing blockage in cases of heavy rain. They can also serve as natural grey water purification plants, where old tanks and ponds are ear-marked for restoration before being integrated into the system and put into service (fig.8).

The resulting waterway expand and contract to adapt to the limitation of working in an existing urban environment. The wider hydrological and infrastructural function has integrated pedestrian pathways and a cycle trail, along with vegetation and trees that provide shade and gathering spaces to form an urban landscape that performs infrastructural, ecological and social functions.

These four waterways called Los Caminos del Agua each extend for around 12 kilometres, forming a brand new lay out of the city that provides a new way of navigating the city apart from motor traffic flows. This new structure connects all districts and ensures they are all have convenient access to the coast. Reduced to only forty-five-minute walk, the beaches now become part of the new park, and not only a domain of the 'first line' residents. Nature imposes an alternative order to that imposed by the real-state.

4. The Model

Los Caminos del Agua is a critical part of the first vision of the city submitted by the Biosphere Reserve. This new system of water and walking is intentionally combined with the two existing motorways. The intersection of the two systems accommodates mobility interchange nodes, with car parks and bus routes allowing easy and convenient connections with the four Paseos. The system finalizes with a program of transforming each neighbourhood into an eco-district with accompanying small scale actions at street level(fig.5).

In December 2016 this city vision was presented to the local government where most of the political, social and professional stakeholders were represented. Unanimously, the board gave the overall project the green light. Since then the Reserve office has been working on the feasibility plan of the first of Los Caminos del Agua. The design development of the first phase is expected to be submitted during the first semester of 2019.

5. Conclusions

Although this is a project still in progress, some lessons can be taken from this initiative on different scales and dimensions.

5.1 *The outside from the discipline view.*

Sometimes it is easier to promote biophilic approaches to a city from institutions not directly involved in the official urban planning of that city. The case of the Biosphere Reserve of Lanzarote is not

only useful to other reserves that want to project their biophilic agenda onto urban environments, but also to any institution which wants to incorporate nature to a greater degree into their community life.

5.2 Landscape as Infrastructure.

Restoring storm water system is an opportunity not only to intensify the ecological and hydrologic performance of the city, but to integrate in a new urban landscape social, environmental, infrastructural and urban spaces.

5.3 Water approach at Arid Cities.

Paradoxically, it makes sense to have a hydrologic approach in areas where water is scarce. This places are going to have more frequent and more intense spells of rain as a result of climate change. Moreover, arid cities, like any other city, process the water consumed every day that could be filtered and used at the city scale without having to deliver it to the sea.

5.4 Interdisciplinarity.

A biophilic approach demands the participation of many experts that will contribute to production of synthetic proposals than integrate ecological, infrastructural, landscape and social demands into the project.

Acknowledgments

I would like to thank the Biosphere Reserve team and, in particular, to Ana and Quino for their commitment to the sustainable development of Lanzarote and their support and collaboration during the production of this work.

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Appendix. Figures and Captions

Figure 1. Canary Islands and Lanzarote

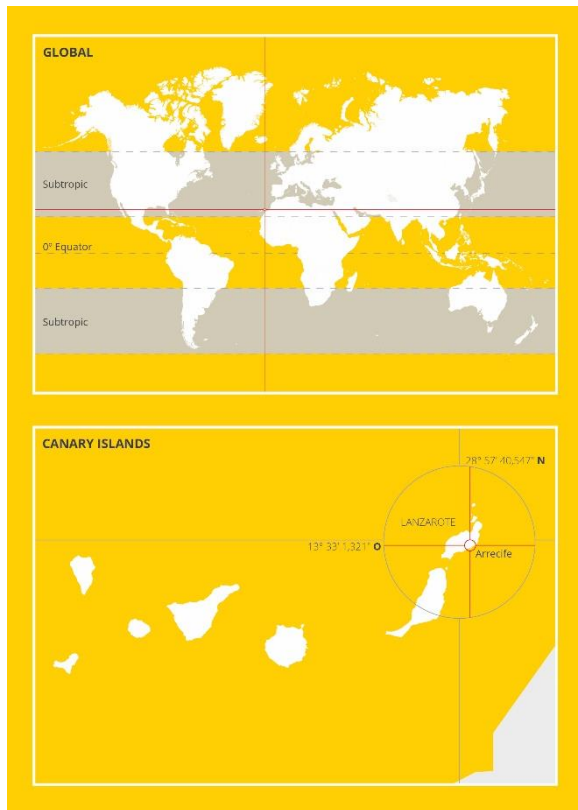


Figure 2. Aerial view of Arrecife



Figure 3. Wine landscape of La Geria



Figure 4. Landscape vs Urban

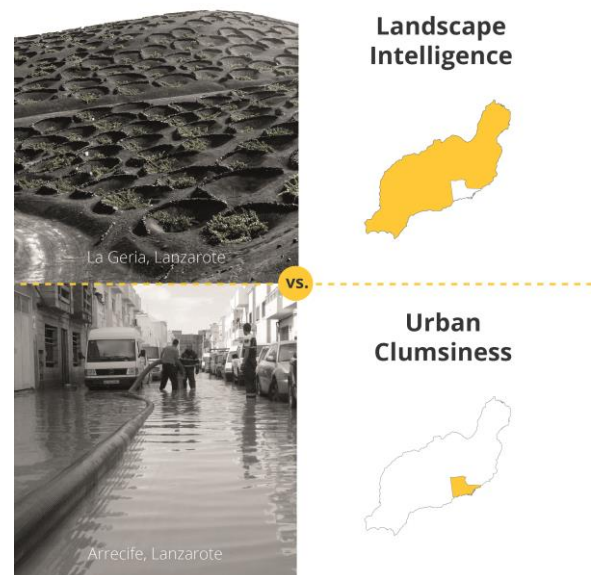


Figure 5. Arrecife Master Plan



Figure 6. Waterways layout reconstruction

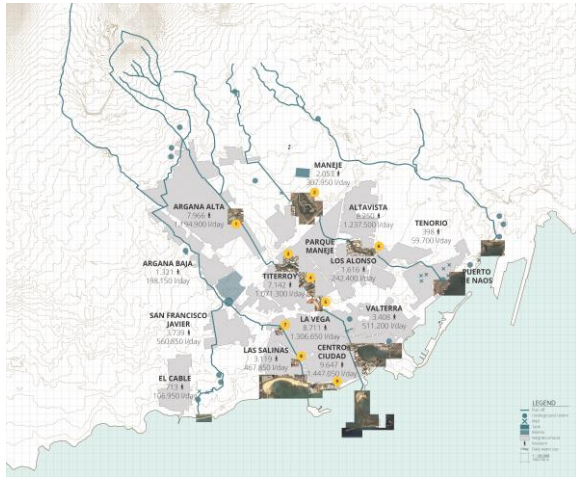


Figure 7. Waterways existing fragments

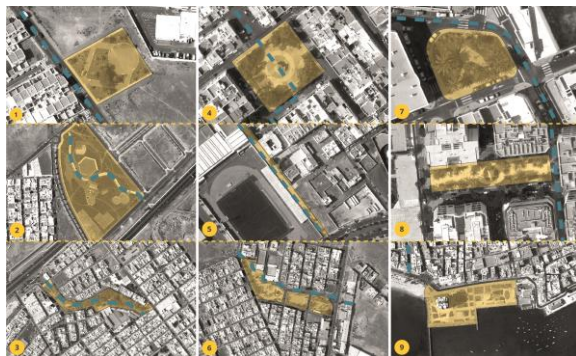


Figure 8. Camino del Agua: proto-section.



We are all Imigrants

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Abstract

The migration crisis is a worldwide phenomenon, at where social conflicts, natural disasters and the rise of the sea levels are some of the reasons of this process. In Brazil, there are 8,863 recognized refugees. From 2010 to 2015, this number suffered a 2,868% increase. ¹ The **We Are All Imigrants (WAAI) Project** is based on an initiative developed by the non-governmental agency Orientavida. Based in Potim, São Paulo, Brazil, in an area of 8.000 square meters the undertaking intends to: create an assistance model to the refugees; develop a model which can be used in different regions; strengthen partnerships with other NGOs and other supporters of the cause. The Project, conceived by the David Ito Arquitetura office forecasts the construction of 32 houses and a community center. It scopes to shelter families (4 people average), guaranteeing legal assistance and aiding the immigrants in cultural insertion processes. With an estimated permanence of 6 months per family, within a period of 10 years, the project aims to attend 15,000 people. The Landscape Architecture Project, developed by the landscape architect Marcelo Vassalo, proposes Nature as the top priority of the design of both free and constructed spaces, addressing a better environmental quality and the creation of “affective bonds between people and the place or physical environment”.²

Keywords: landscape architecture; design with nature; green solution; green infrastructure; biophilic city.



Fig. 01. Aerial View. By: Esphera Visual, 2015.

1. Introduction

The migration crisis is a worldwide phenomenon, at where social conflicts, natural disasters and the rise of the sea levels are some of the reasons of this process. In Brazil, there are 8,863 recognized refugees. From 2010 to 2015, this number suffered a 2,868% increase.¹

The **We Are All Immigrants (WAAI) Project** is based on an initiative developed by the non-governmental agency Orientavida. Based in Potim, São Paulo, Brazil, in an area of 8.000 square meters the undertaking intends to:

- create an assistance model to the refugees;
- develop a model which can be used in different regions;
- strengthen partnerships with other NGOs and other supporters of the cause.

The Project conceived by the David Ito Arquitetura Office forecasts the construction of 32 houses and a community center. It scopes to shelter families (04 people average), guaranteeing legal assistance and aiding the immigrants in cultural insertion processes. With an estimated permanence of 06 months per family, within a period of 10 years, the project aims to attend 15,000 people.

The Landscape Architecture Project developed by the **landscape architect Marcelo Vassalo**, proposes Nature as the top priority of the design of both free and constructed spaces, addressing a better environmental quality and the creation of “affective bonds between people and the place or physical environment”² Ao The urban dimensions proposed in WAAI

In the following, some of the key concepts of the project are shown below.

2. Biophilic city: solutions based on nature

- Nature as a priority on the design of the project;
- Multi-functional usage of the vegetation: insolation protection, food production, bird fauna attraction and local Biodiversity increment;
- Vegetable garden and orchard areas, providing contact with the ground (connection, belonging);
- “The existing processes and cycles of the Nature”³ present in the design of the external areas; differentiated Implementation, providing coexistence and contact with the Nature.

3. Smart nation | technology: green infrastructure system

- ICF Constructive System (Insulated Concrete Forms) guaranteeing better quality to the internal environment;
- simulation performed with Design Builder Program, evaluating the quality of the built environment;
- project adopted as Pilot Project by GBC (Green Building Council Brasil) program certification Referential Condominium, and Leed NC (New Construction) for the community center;
 - network involving supporting NGOs;
- Green Infrastructure System, using high-performance landscaping-related technologies, such as biovalves, rain gardens, green ceilings, etc.

4. Future resilience: living with nature

- a Project to serve the ecosystems;
- rain water exploitation and reuse of grey water;
- prepared environment to tackle social phenomena;
- urban forest and restoration of the hydrological cycle;
- recycling and composting structures for the organic residues;
- environment sharing and exchange of experiences;
- natural draining systems, contributing to an increase in the quality of the infiltrated water;
- efficient planning, providing better environmental quality with the same cost and occupied area of conventional projects;
- creation of dynamic systems and use of efficient solutions, promoting a reduction in 30% of the consumption of electricity, 40% of the waste of potable water and 100% of the waste water for non-drinkable purposes.

5. Final considerations

- The WAAI residential project is in the development phase of projects and is scheduled to start in 2019
- The project aims, demonstrates that it is possible to build residential habitats where nature-based solutions are part of the concept and program in landscape design and

promote the benefits of being integrated with nature.

- The Project demonstrates that it can be applied in federal and state housing programs, since it has the same urban characteristics as those provided for in the legislation.
- New fronts of migration are currently occurring, for example with Venezuela, where the concept of WAAI residences could be used by adapted tents or "containers", demonstrating that through a differentiated deployment, we built environments where integration between the natural and constructed elements occur with more harmony and meaning.
- The Project uses a process of Planning and Integrated Project, where all the disciplines act interdisciplinarily in the making of decisions and in the definition of the projects. Systems are chosen according to their cycles, trying to transform waste into products and guarantee vital resources, such as water, abundant in the enterprise.
- Taking into account the architecture of the vegetation we can predict the benefits that the landscape has to offer us. The multifunctional use of vegetation deserves to be highlighted by the amount of benefits it offers.
- Simulation performed with Design Builder Program, evaluating the

quality of the built environment. A creation of dynamic systems and use of efficient solutions, promoting a reduction in 30% of the consumption of electricity, 40% of the waste of potable water and 100% of the waste water for non-drinkable purposes.

- Graphics below, with evaluation of the built physical environment, demonstrate that technology helps to measure results and direct investments;
- “Wherever we choose to live, Nature will always be our Home.”⁴
- “You do not change things by struggling against today's reality. To change something you need to build a new model that will make the current model obsolete.”⁵

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Acknowledgments

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Research on Landform Sports Architecture Design Based on The Sinking Mode

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Abstract

Under the trend of national physical fitness in China, what the large-scale sport architecture represent is no longer just the region image. With the theories of regionalism, humanism, green ecological building spreading and developing, architects begin to rethink, as the important public buildings, if the large-scale sport architecture should take on the greater social mission. Meanwhile, the urbanization process causes the city density increasing day by day, making the problem of environment and the shortage of construction land become the main contradiction nowadays. Under the situation above, green ecological is becoming the main stream consciousness. Architecture, landscape and environment will become increasingly integrated and creating landscape through architectures will become an inevitable trend. In this context, in view of the characteristics of large span, large volume and large interface of sports architecture, this paper analyzes the feasibility of the sinking mode in the design of sports architecture, summarizes two kinds of sinking patterns, and puts forward the landform sports architecture design based on the sinking mode, through which the sports architecture can minimize the oppression to the environment and become the creators of urban landscape. According to the particularity of sports architecture, this paper analyzes the disadvantages of sinking mode, and puts forward the applicable reference. For the disadvantages, combined with the actual cases, this paper summarizes the coping strategies in natural lighting and ventilation, traffic streamline and disaster prevention, aiming at to lead the sport architecture design on the road of ecological and contribute to the creation of the sustainable development of eco-economical city from the perspective of sports architecture design.

Keywords: Sport Architecture, Landform Design, Sinking Mode, Sustainable Development

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1. Introduction

With the large volume, sports architecture always occupy a large area, which inevitably affect the urban environment. Since 21st Century, the urbanization process in China has led to shortage of construction land and environmental problems. With the popularization of the "national fitness" in China, the construction of sports venues has entered the peak period, causing the contradiction between the environment and the shortage of construction land. Under this background, the sinking mode is becoming one of the sports architecture patterns and showing the trend of landform so as to maximize the optimization to urban space. But the sinking mode can also lead to many disadvantages, such as energy saving, streamline organization and so on. Therefore, how to rationalize the multiple criterions of sports architecture has become an unavoidable problem in the development of the sinking mode.

This paper analyzes the applicability of sinking mode in sports architecture, summarizes the advantages and disadvantages of this pattern, and points out coping strategies with actual cases, aiming at pointing out the essentials of the sinking mode and guiding landscape become the new direction of sports architecture, thus promoting the harmonious between

architecture and urban environment, the efficient use of urban land and the innovation of sports architecture.

2. Early sports architecture base on the sinking mode

The origin of sports architecture is based on the sinking mode.

In the first ancient Olympic Games in 776 B.C., in order to save time and effort, people use the natural terrain and put the main field in the flat canyon through the hills and set up the bleachers along the hillside[1]. The way of embedded design makes the site hidden and shows the harmonious between people, nature and architecture (Fig.1).

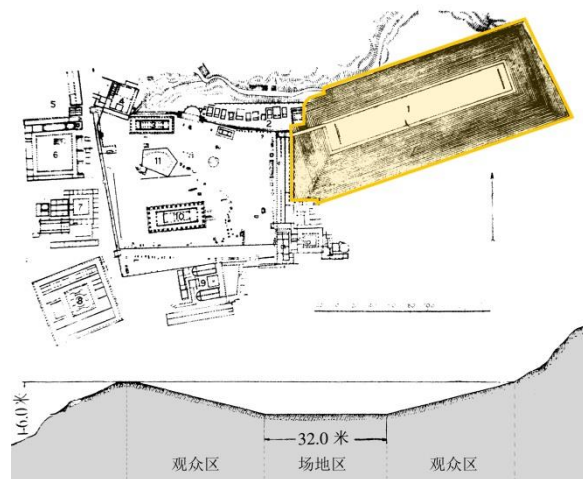


Fig. 1. A caption is positioned left-justified below the figure or scheme.



Fig.2 Marble stadium at Athens 1896 Olympic Games



Fig.3 1936 Berlin Olympic Stadium (before expansion)



Fig.4 1968 Mexico City Olympic Games University Stadium

The 1896 Athens Olympic marble

stadium (its predecessor is the ancient Greek arena), which was built in 330 BC, was rebuilt in 1895. It was also built according to the terrain. The 47 rows of bleachers were arranged along the hillside, as if they were broken out from the earth (Fig.2) . The 1936 Berlin Olympic stadium was built in 1913. As the ancient Greek arena, the whole site seemed to grow out of the land and merged into the surrounding landscape (Fig.3) . Similar to the above , the University Stadium in 1968 Mexico City Olympic Games , which was built in 1953, also inserted the seat to the earth, hardly used any concrete, gracefully integrated into the environment (Fig.4) .

Actually, there are similar works of Chinese early sports venues. The Nanjing Central Sports Conference, which was designed by Guan Songsheng and Yang Tingbao in 1931, contained a number of outdoor venues. In order to save time and money, the whole plan was on the hillside. Some of the bleachers were built based on the slope, and the national sports field and basketball court were layouts based on the original terrain. The whole site was embedded in the earth, and the construction only spent 6 months (Fig.5-6)

3. The feasibility of the sinking model in the current sports architecture

3.1. The problems of sports architecture in China

Firstly, in the past sports building construction, for the major events, it is customary to use high standard construction to create landmark and pursue visual effects.

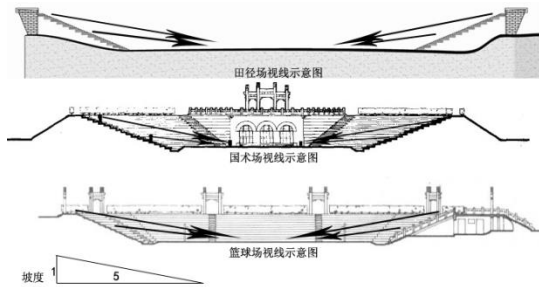


Fig.5 Section of main stadium of Nanjing Central Sports Venue

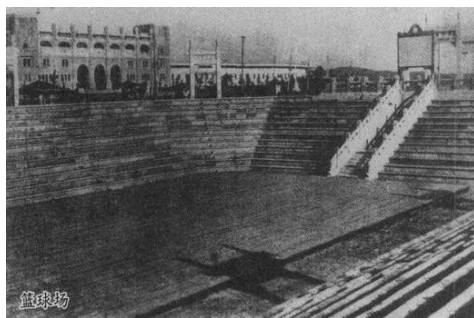


Fig.6 Nanjing central sports venue basketball court

With the smooth curve and form, the Tokyo new national arena designed by Zaha Hadid Architects shows the sense of future, while it has been questioned as a result of the negative impact on the environment so that eventually replaced by Kengo Kuma and Associates. Besides the high cost, the environmental concept reflected is worth thinking (Fig.7) .

Secondly, the urbanization process leads to the increasing tension in urban land. The 2016 China National Land Resources Bulletin shows that the area of urban construction land has fallen year by year since 2013 (Fig.8) The sixth bulletin of China sports field census data shows that the average sports area is only 1.46 m² in 2014, which is much lower than developed countries. Besides, China's State Council

"on accelerating the development of sports industry to promote sports consumption" proposed that in 2025, the area of per capita sports field in China should reach 2 m². Therefore, the reduction of urban construction land has prevented the increase of sports area and become another major contradiction.



Fig.7 Tokyo national arena

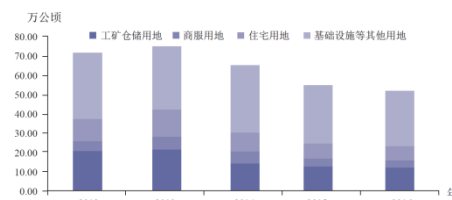


Fig.8 Supply situation of construction land in China

3.2. Feasibility analysis of the sinking mode

The above two contradictions are mainly reflected in the conflict between the growing sports venues demand and the shortage of land and urban environment, which can be alleviated through the sinking mode. Firstly, the sinking mode can reduce the volume of sports architecture and abate the pressure on the urban environment. The Wukesong gymnasium in Beijing is located in old Beijing. The court is sank to 10 m underground, and the ultimate height fell to

27.4 m[2], reducing the impact on the environment. The application of wood composite material in the facade also expresses the rare affinity in sports architectures (Fig.9)

Secondly, for the contradiction between the land and the area, the underground space can be used for stacked layout and increase the area[3]. The sports center of Beijing Forestry University is limited to the shortage of campus land. In the planning, we suggest excavated down the existing stadium in the campus and layout the gymnasium, natatorium and training hall in the underground and then arrange the stadium above them. Finally, the stadiums are sank to 10 meters underground and the new stadium is 5 meters on the ground, and the the new sports center is realized without extra occupation of campus land (Fig.10) .



Fig.9 Beijing Wukesong Basketball Hall



Fig.10 Section of of Beijing Forestry University sports center

3.3. Classification of sinking mode

Thus the sinking mode is not mited to the site in contemporary, but also often uses the underground space to meet other functions, which can be divided into the court sinking and space sinking (Tab.1) .

3.3.1 Court sinking

Court sinking refers to the playing area and its related main rooms. This model is often used, mainly for single venues, can effectively reduce the volume create a harmonious external space environment, which is more suitable for outdoor stadiums or large indoor gymnasium.



3.3.2 Space sinking

The space sinking refers to the singking of the venues or ancillary facilities and then layout of the sports venues above. The common underground spaces include sports function, parking function or ancillary function. This mode is applicable to the construction of venues that are contradictory to the land supply and the area.

4. The landscape design strategy of the sinking mode sports buildings

The large-scale of sports architectures makes it appear in the high-density cities in face of many contradictions. However, from the perspective of landscape architecture, the unique volume and space of sports architecture conforms to the architectural requirements of the landscape architecture. Therefore, it is more conducive to create a harmonious environment by combining the

Tab.1: Classification and application of sinking mode

Classification and application of sinking mode					
Type	Mode	Advantage	Shortcoming	Earthwork	Application
Court sinking		Optimize the environment; Simplify streamline of audience	Amplify the quantities of construction and cost	Decide on the sinking range	Natural terrain; Historic Region; High density region; Scenic spot. etc
Space sinking		Improve land use; diversify multi-function	Challenge for fire fighting and structure; No volume reduction	Massive	Reconstruction or expansion of old building; Shortage of land; Multi-function

landscape and the sinking mode of sports architecture. In the landscape design, there are three common strategies for sports architecture: Form metaphor, vegetation loading and ecological materials.

4.1. Form metaphor

In the process of seeking a harmonious coexistence with the natural environment, the morphological constitute is one of the most common points for architects. Starting from the morphological constitute, reducing the volume of buildings, optimizing the architectural form and trying to weaken the artificial traces, so that the architecture is no longer to appearance as a conqueror.

For example, Berlin Olympic Racing Museum and natatoria, Germany, are located in a park, to avoid destroying the original environment, the idea is to simulate the entire roof as a lake surrounded by surrounding trees. The design sinks 17m underground so that people can only see a

metal roof as if a lake on the ground, which contributes to the landscape in the city (Fig.11). In the design of the sports center of Beijing Forestry University, the sinking landscape courtyard is built on the east. One side of the wall is carved artificially. The bottom of the wall is introduced into the pool and vegetation, and the metaphor of Chinese traditional landscape are finally expressed (Fig.12)



Fig.11 Berlin Olympic Racing Museum and natatoria, Germany



Fig.12 Courtyard of Beijing Forestry University sports center

4.2. Vegetation loading

Vegetation loading is using the characteristic of large interface of sports architecture to reproduce vegetation, which gives green back to urban and also effectively improves the city surrounding micro-climate.

The central gymnasium of Osaka is located in the city park. The concept of "harmony with nature" is put forward in the design, and the sinking mode is adopted. The diameter of the main arena roof is about 110 meters and above the roof architects built a green artificial hills, planting a variety of plants and flowers, and setting the ring walking path onto the roof to create a miniature park for the city. As a result, the nature environment is preserved above the building, creating a new landscape for the city. According to the measurement, the planting roof not only contributes to the improvement of climate, but also contributes to indoor thermal stability. The sinking mode makes the building take full advantage of the underground constant temperature and thermal insulation characteristics (Fig.13). The Dalian Shide stadium, designed by the

NBBJ architects, sinks the court 6m underground to reduce the volume, while the outer wall of the building loads green plants just like a vertical garden in the city (Fig.14). The height of the Beijing Forestry University stadium is 5 meters on the ground, and the grooves are designed to plant the vine vegetation at the bottom of the field protection fence, where we want to show the green vegetation on the fence (Fig.15)



Fig.13 Central gymnasium of Osaka



Fig.13 Central gymnasium of Osaka



Fig.15 Beijing Forestry University stadium

4.3. Ecological materials

Under the social trend of sustainable development, the selection of environmental low carbon materials has attracted the attention of architects. In the project of Meishan Sports Center, in order to fully integrate the building into the environment, we sink the court 6 meters underground in order to relieve the oppression. In the facades and the peripheral structures, the wood composite material is used to echo the local bamboo culture. The roof form is derived from the traditional Chinese folk, absorbing the design idea of the harmony between heaven and man in the ancient Chinese architecture, and finally realizing the harmonious dialogue between architecture and environment (Fig.16)



Fig.16 Meishan Sports Center

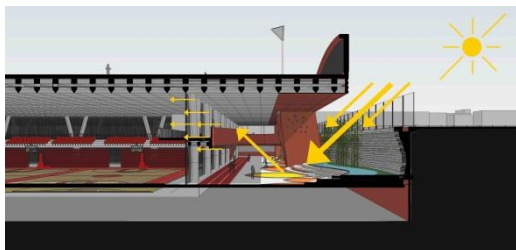


Fig.17 Beijing Forestry University sports center

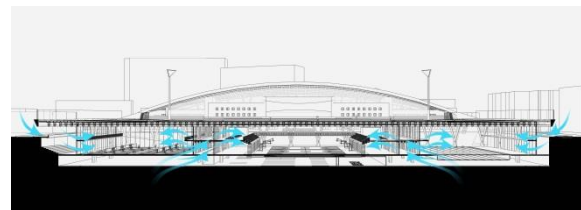


Fig.18 Beijing Forestry University sports center

5. The applicable and coping strategy of sinking mode

5.1. Application situation

It is worth noting that there are many challenges in the investment, ventilation, lighting, evacuation, and disaster prevention in the sinking mode sports architecture. It should be considered whether to adopt the sinking mode, and several factors should be taken into consideration such as the urban planning, the surrounding environment, building scale, the geological strip and the investment and so on (Tab.2)

5.2. Coping strategy

Aiming at the potential challenges of sinking mode sports architecture, we should meet three principles of ecological conservation, streamline unimpeded and disaster prevention. The following will combine with the plan of Beijing Forestry University sports center to explore.

5.2.1 Natural lighting and ventilation

In the design of the sports center of Beijing Forestry University, because the upper of the gymnasium is a stadium, so the

Tab.2: Reference for applicability of sinking mode

Reference for applicability of sinking mode									
Type	Competition level	Scale	Investment	Utilization rate	Process	streamline	Sinking mode	Effect	Application degree
Urban	Major events (Olympic, National games, etc)	Large	High	Low	High	Complex	Court sinking	Optimize environment; Simplify streamline	★★★★★
	Professional league (CSL, CBA, ATP, etc)	Medium	Medium	Medium	High	Complex	Court sinking mainly	Optimize environment; Simplify streamline	★★★★☆
	Other shows (commonwealth or commercial)	Nonuniqueness	Medium	Nonuniqueness	Medium	Medium	Both	Optimize environment; Simplify streamline	★★★★☆
	Community activities (fitness, training, small event)	Small	Low	High	Low	Simple	Both	Optimize community; Difficulty streamline	★★★★☆
Campus	Major events (Olympic, National games, etc)	Medium	Medium	Low	Medium	Complex	Court sinking	Optimize campus; Simplify streamline	★★★★☆
	Education (PE class, national fitness)	Small	Low	High	Low	Simple	Space sinking mainly	Save land; Increase area	★★★★☆

roof can not be lighted and ventilated. The solution is to expand the courtyard on the east and indirectly realize the natural lighting. Through the opening of the window, the air is circulated in the three Gymnasiums (Fig.17-18).

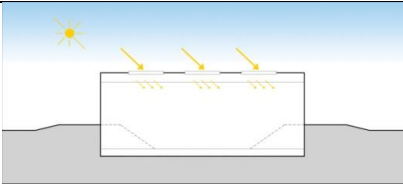

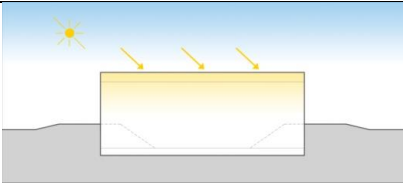

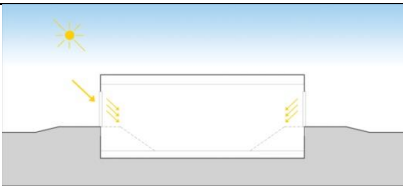

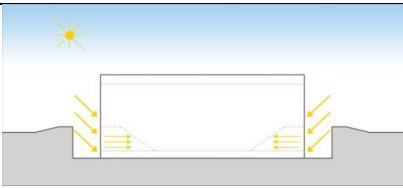

Besides, for other sinking mode sports architectures, natural lighting and ventilation can be done through the top interface and the side interface generally (Tab.3).

5.2.2 Streamline organization

The underground gymnasium, training hall and natatorium of Beijing Forestry

University have taken an independent and parallel layout, compared with the integral-style, reducing the evacuation distance in the horizontal direction. In the vertical direction, each level of elevation is connected through the platform to realize the evacuation. Through technical measures, it can ensure that there is no fire and smoke in the outdoor platform and underground courtyard at the time of the fire, where it would be a safe region people can be evacuated and wait for rescue. In the fire fighting, the underground fire line is

Tab.3: Comparative analysis table of natural lighting mode

Type	Mode	case
Top interface	 <p>Fig.(Tab.3-1) Skylights</p>	 <p>Fig.(Tab.3-1-1) Interior of Yangzhou Gymnasium</p>
	 <p>Fig.(Tab.3-2) Translucent material lighting</p>	 <p>Fig.(Tab.3-2-1)Interior of Guangzhou Gymnasium</p>
Side interface	 <p>Fig.(Tab.3-3) High side window</p>	 <p>Fig.(Tab.3-3-1) Vicenza gymnasium, Italy</p>
	 <p>Fig.(Tab.3-3) Sunken square or courtyard lighting</p>	 <p>Fig.(Tab.3-4-1) Underground swimming hall in Francisco de Vitoria University,Spain</p>

arranged through the sinking courtyard around the building, so that both the ground and the underground have fire fighting ability (Fig.19-20) .

For other sinking sports architectures, the evacuation mode is basically similar to the traditional way. The difference lies in the cancellation of the outdoor platform. For the audience streamline, it can be organized by the upstrike and middle type, and for the

other streamlines, it can be passed through the sinking square (Tab.4)

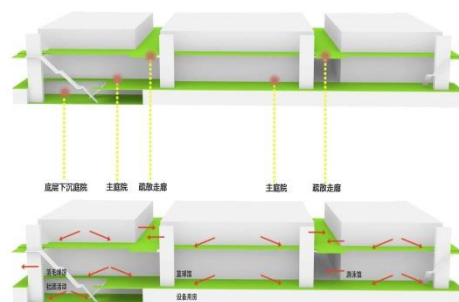


Fig.19 Evacuation platform

Tab.4: Analysis on evacuation mode of sinking sports architecture


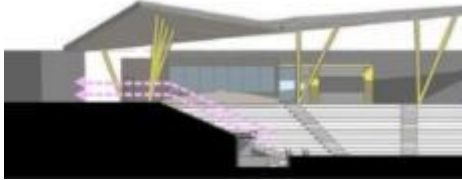


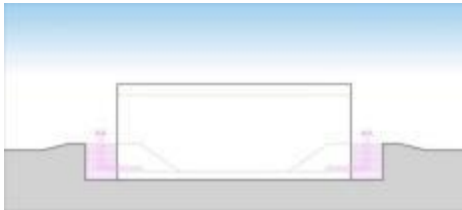

Streamline	Mode	Case
Audience	 <p>Fig.(Tab.4-1) Upstrike</p>	 <p>Fig.(Tab.4-1-1) Section of Baseball Stadium at Oregon University</p>
	 <p>Fig. (Tab.4-2) Middle type</p>	 <p>Fig.(Tab.4-2-1) Section of Brasilia Stadium</p>
Others	 <p>Fig.(Tab.4-3) Sinking square</p>	 <p>Fig.(Tab.4-3-1) Section of Beijing Wukesong Basketball Hall</p>



Fig.20 Streamline analysis

6. Conclusion

In the past, large sports architectures in China have always pursued spectacular and magnificent visual effects based on the high investment, in order to highlight the prosperity of political and economy achievements, thus actively repel the sinking mode[4]. At present, the contradiction between urban development and sports architectures is becoming increasingly prominent. Sinking mode is conducive to

solve the contradiction between sports architectures and environment and land supply. At the same time, using the morphological features of the large interface of sports architectures to make a landscape design on the basis of rational structure, thus relieving the sense of oppression and ritual of the sports buildings, will undoubtedly be a new trend of sports architecture in the sustainable development nowadays. Therefore, the "sinking mode" is an attitude that reflecting the attention to the urban environment from all sectors of society. "Landform" is an idea that reflecting the progress of ideology and the sublimation of social aesthetics.

However, the sinking mode of sports architecture does face many technical challenges. This paper advocates that architects should choose the sinking mode reasonably according to the characteristics of the environment and the project itself, and at the same time should also meet the design criteria of ecological conservation and streamline unimpeded. At present, the research on the design strategy of the sinking mode sports architecture is relatively

deficient. This paper hopes to attract more attention to the sinking mode sports architecture, so as to provide new references from the perspective of sustainable development.

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Forested Roof for Biophilic Cities

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Abstract

Urbanisation has become the norm for human settlement on this planet. Increasingly, world population are moving to live in urban area either for convenient, jobs opportunities or other reason even though it is not an ideal environment for human. It is the time we need to re-think how we build our cities that could still nurture environment.

The conflicting factors while developing a city is the build-up area versus greenery. To deal with this, emerging trend of the new buildings is to integrate greenery on the roof. While it is a noble idea, there are questions of how to make these greenery sustainable for the long future.

Ideas of growing a forest on the roof were explored on 2 projects in completely different scale in the hope to find a solution for sustainable green roof in urban area. One is a business park of 35,000 site area and another one is a private house in city area.

Mapletree Business City II, Singapore

The site that this project stood on was once occupied with warehouse covering the entire site with concrete surface. However, this new development give us opportunity to reclaim back the greenery. A 'Forest Ecosystem' is created on top of car park podium and on sky roofs of the stacking tower with average soil depth at 1.5 meter to ensure forest future growth. 70% of the site area is covering with greenery.

Varying tree's size from sapling to mature trees are randomly placed to form a true forest composition. Variety of flowering and fruit baring trees and shrubs species help enhancing the created forest as habitat for butterflies, dragon flies, bird and other wild animal to maintain biodiversity at large.

Series of mounds are created to deal with storm water management with bio-swale at the foot of each mound to effectively regulate drainage pattern while allow the run-off to slowly filter

through the sandy layers. Eventually, the pre-filtered rain water is collected at the lowest point and leads into the rain water harvesting tank, treated and recycles for irrigation. The tank size is calculated to hold 7 days of irrigation water. Incorporated with rain sensor system, which will save irrigation water during rainy days, the amount of irrigation water saved in the tank will be sufficient for the relatively wet island of Singapore.

Forested House, Bangkok, Thailand

For a private house, a more simple strategy to create forest is employed. Varieties of young trees of around 1 year old are selected to ensure that it can adjust to the 1 meter depth planter depth condition. All dry leaves, are not treated as garbage but instead return back to the soil ground to become natural fertiliser as in the real forest. Within 10 months after planting, the trees grow to double the height providing natural shading reducing heat into the house greatly.

We hope this 2 projects will demonstrate how to integrate a sustainable greenery into city of the future – a Biophilic Cities.

1. Introduction

Urbanisation has been a major global trend since 1950s and UN's statistic predicts that 66% of world population will be urban by 2050. City as a product of capitalism has to perform to mainly sustain the economy which results in a typical compact hi-density living coupled with well-connected transportation system. This model might works well economically, though, it creates much stress to 'Nature' as it is not in the equation from the start. Some cities introduces Public Park to provide greenery to offset the harshness of the built-up area. However, proportionally, buildings both in commercial and residential area still occupy much of the space in the cities.

There are many problems arises from lacking nature in the cities including urban heat island, flooding, poor air quality, less

social interaction, and unhealthy lifestyle. To introduce greenery back to the cities while still maintaining density of build-up area, many cities starts to look into the integration of greenery on roofscape of these buildings.

Advance construction technique which solves waterproofing and loading issue, certainly allow us to integrate greenery on the roof. Though, long term maintenance of these green roof require a lot of resources to ensure moisture and fertilizer content is optimal for plants' growth as the condition is still different from true ground planting where moisture and fertilizer can be exchange naturally. Many green roof that were built without considering maintenance factor has ended up with removal of plants altogether.

In search of a sustainable way to execute a green roof, we have explore how to create a condition as close to nature as possible so that the plants can survive without having to provide too much resources.

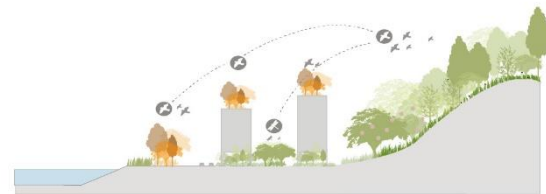
2. Can we grow forest on the roof?

Idea of growing forest on the roof were explored on 2 projects in a completely different scale. One is a business park of 35,000 sqm. site area and another one is a compact private house in city area.

2.1. Mapletree Business City II

This project is situated in Singapore amidst the nearby Nature Reserve and Parks; Labrador Park, Hort Park and Kent Ridge Park. The main concept is to create a forest to extend ecological corridor from these nearby parks into the site. The main challenge is the fact that most of planting area is on a vast car park's podium roof designed as a new ground floor to connect seamlessly to adjacent buildings and main public transportation.

Various consideration were taken into account in order to achieve a sustainable forest on the roof



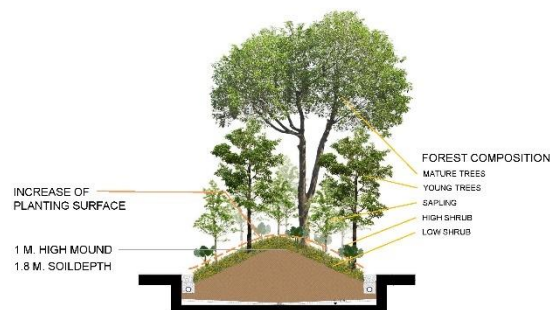
TO EXTEND ECOLOGICAL CORRIDOR FROM THE SURROUNDING NATURE RESERVE

Master Plan

2.1.1. Soil Depth & Space Creation

Due to the limitation on ceiling height of the car park below, average soil depth initially achieved is only 800 mm. which is not sufficient to grow big trees. To deal with this, series of mounds is created throughout the roof. The highest point of each mounds is set at 1 metre high, thus, 1.8 metre soil depth is achieved at the highest point. The mounds in natural form, varies in size, becomes a 3 dimensional elements in the landscape shaping various spaces mimicking deep forest experience.

Forest Mound Diagram





Network of pedestrian walkways in different width cuts through the mounds creating a natural movement of people wandering/commuting through the greenery. Some of the mound is integrated with private sitting area on the top of the mound surrounded with lush vegetation.

2.1.2. Water Management

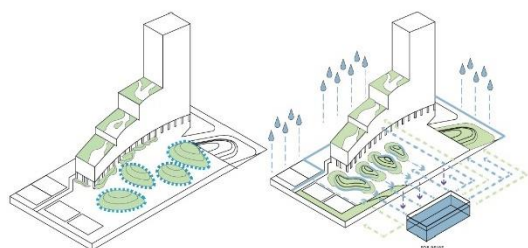
Over a large expand of roof area, flat surface of greenery usually induce water clogging problems. Therefore, the mounds are not only designed to solve the soil depth issue, but they also utilised as main device

to regulate the surface water run-off pattern efficiently.

Bio-swale is integrated at the foot of each mound to slow down the downpour and at the same time filtering dirt and toxin that come along with the rain water through sandy layer. Unlike concrete gutter system, bio-swale retain some moisture in the ground after the rain making depend less on the irrigation watering.

Eventually, the pre-filtered rain water is collected at the lowest point and leads into the rain water harvesting tank, treated and recycles for irrigation. The tank size is calculated to hold 7 days of irrigation water.

Incorporated with rain sensor system, which will save irrigation water during rainy days, the amount of irrigation water saved in the tank will be sufficient for the relatively wet island of Singapore.



*Storm Water Management Diagram:
 Bioswale collect water run-off to the rain water harvesting tank for reuse*

2.1.3. Mixed Indigenous Planting Species

In order to create a forest habitat, over 65 indigenous species of trees, shrubs, ground cover, and water plants mostly found at nearby Nature Reserved were specified.

Another good property of the mound is that it provide greater surface to plant more number of trees as and shrubs as compare to flat ground of the same outline. Varying tree's size from sapling of 0.5-1 metre high to young trees at 2-3 metres high to mature trees at 6-8 metres high are randomly placed to form a true forest composition. Feature trees of more than 8 metres high is only used at area where instant shaded is needed.

Majority of the trees planted are the younger trees which have better growth rate as compared to an older specimen. Average spacing of each trees is around 2-4 meters to

achieve dense foliage which allow less sunlight to reach the ground

Variety of evergreen, flowering and fruit baring trees and shrubs species help enhancing the forest as habitat for butterflies, dragon flies, bird and other wild animal to maintain healthy biodiversity at large.



Biodiversity Diagram

Tropical Forest Tree Species:

Fagraea fragrans, Michelia champaca, Bucida moleneti, Dalbergia cochichinensis, Calophyllum inophyllum, Chrysophyllum cainito, Elaeocarpus hainanensis, Pouteria obovata, Lagerstroemia floribunda, Eugenia polyantha, Dillenia philippinensis, Melaleuca cajuputi, Garcinia subelliptica, Dillenia indica, Pometia pinnata, Brownea grandiceps, Millingtonia hortensis, Shorea leprosula, Xanthostemon chrysanthus, Khaya senegalensis, Sterculia parvifolia, Barringtonia acutangula, Tecoma rosea, Ficus lyrata, Barringtonia asiatica, Crescentia cujete

Tropical Forest Shrub Species:

Jatropha integerrima, Crinum amabile, Alocasia macrorrhiza, Asplenium nidus,

Philodendron burgundy “green”,
Neomaria longifolia, *Heterocentron elegans*,
Justicia gendarussa, *Belacanda chinensis*,
Ophiopogon jaburan, *Calathea loesseneri*,
Philodendron scandens, *Hymenocallis littoralis*,
Sphagneticola trilobata,

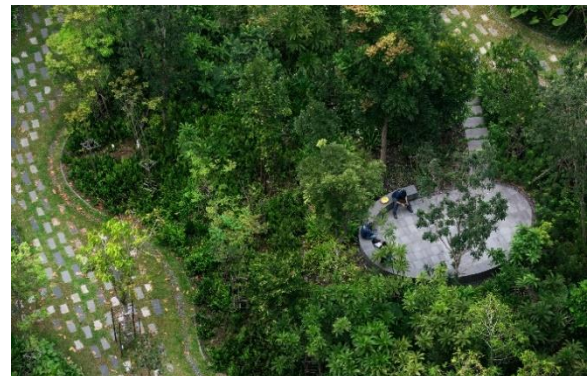
Water Plant:

Thalia geniculata, *Nymphaea*, *Pontederia cordata*,
Typha angustifolia

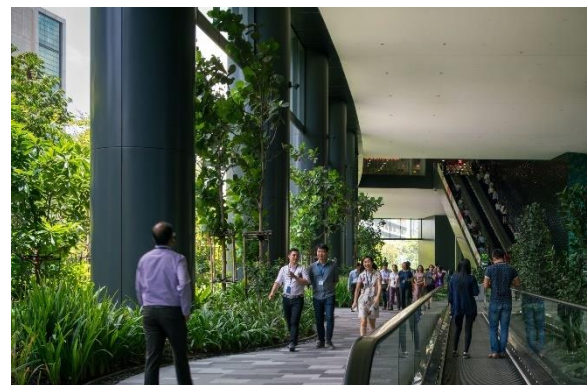
2.1.4 Activities

Even though it is designed as dense forested roof, full ranges of activities including small/large gathering area, seats, natural ponds, green amphitheatre and various sport courts are also inserted to encourage a healthy lifestyle for all users.

The forested roof is destined to be a vibrant communal nodal point for both human city life as well as urban wild life



Private sitting area on top of the mound surround with lush forest species



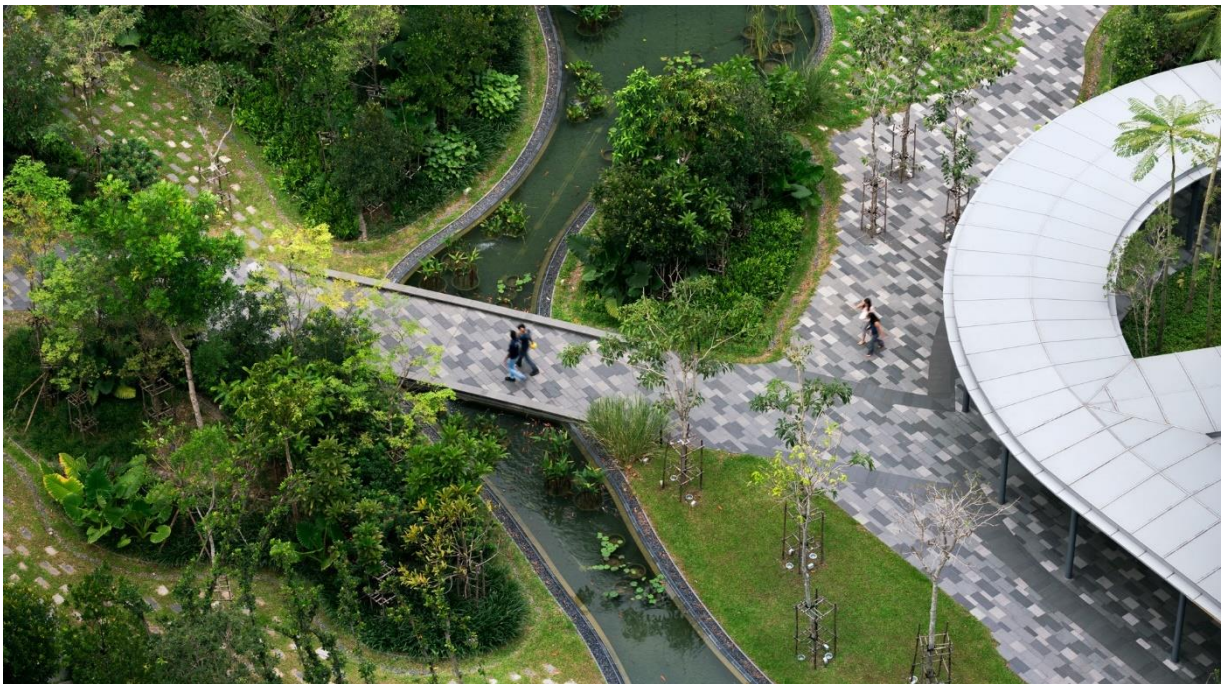
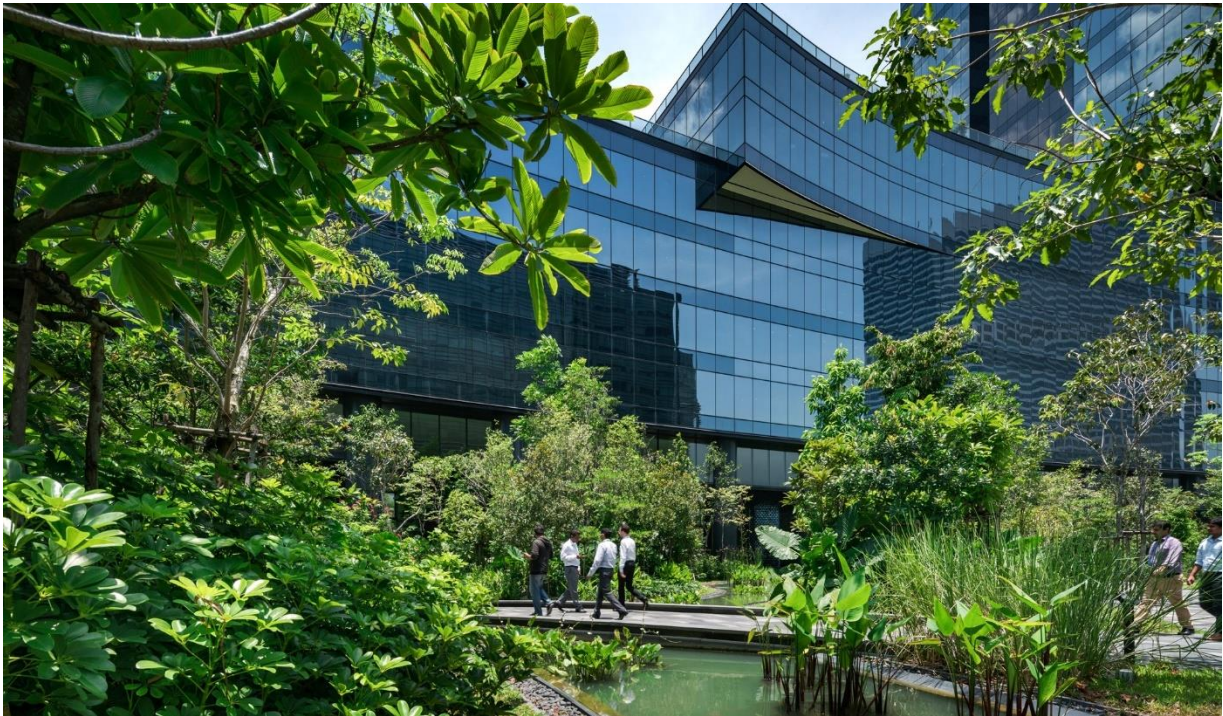
Main corridor where part of the forest extended underneath the building footprint



Green Amphitheatre



Sport Court and Fitness Station



Main passage with the experience of crossing the stream and forest

2.2. Forested House

Another project is a private house situated in a low density residential district adjacent to rail line mass transit station in Bangkok city. Typical home in this area built during 1970s' usually contains sizable front garden with the home at the back. This allow big trees to grow at the street level providing shade and greenery for the neighbourhood. As a result of good vicinity to rail line mass transit, price of land has risen up considerably, so its understandable that new homes built to replace the older one in the last few years often maximise the plot area as much as what the regulation allow. Though, this trend is worrisome because it leaves no space to plant any trees any trees anymore.

This project is also following this trend. New bigger home was to be built to replace the existing smaller one to cater for extended family. Though, its also the vision to still integrate greenery as much as possible into the house utilising various roof surfaces.

Few strategies were considered from the beginning of design stage to ensure that planting location and method is ideal for tree growth and require less maintenance for house owner.

2.2.1. Make Room for Trees

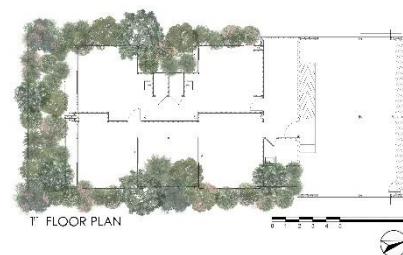
To deal with the rectangular plot of 12x24 metres, the layout of the house is segmented to 3 sections to allow 2 courtyards in between. This is not only encourage good wind flow to reach every room in the house

but also allow space to plant trees at the courtyards.

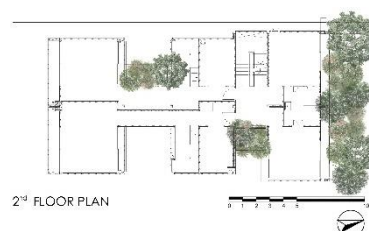
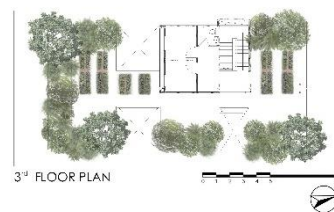
On second floor, planter is integrated in front of the house to provide privacy for the bedroom facing the local street. Another planter is also added at the courtyard to allow connection to the bedroom.

On third floor, where the roof is, the planter of 1 meter high, double up as railing, occupied around half of the total area leaving flat surface for other functional use such as, dining table, urban farm, and cloth drying area.

Altogether trees will be grown on every floor from ground up to the roof.



1st Floor Plan
2nd Floor Plan



Roof Plan

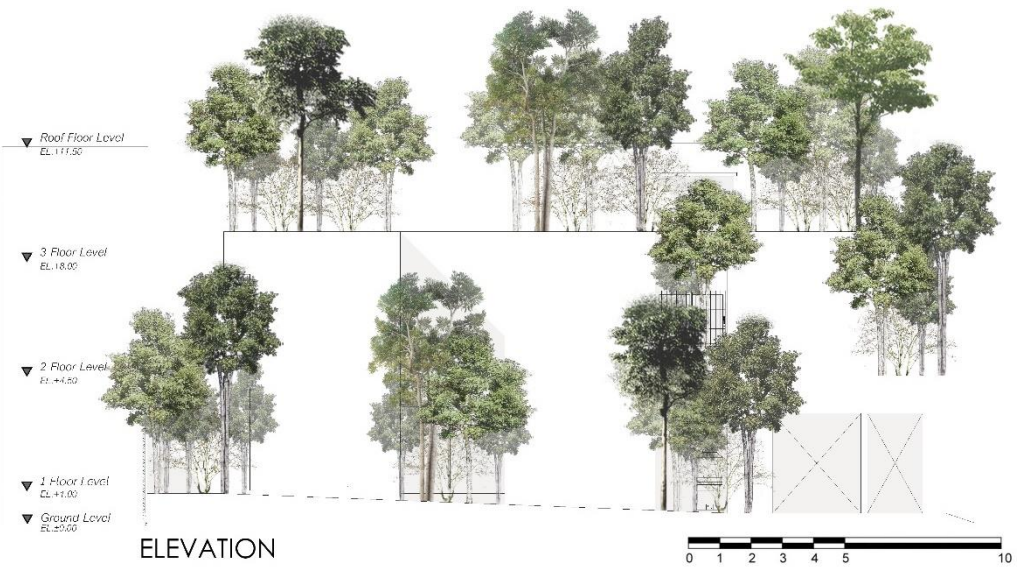


Location for tree planting both on ground and on planters

Elevation showing Tree's location from ground up to



the roof



2.2.2. Forest in the box

The average planter height is around 1 to 1.5-meter-deep with limited size of around 2 * 4 metre. Only young trees of 1-2 year old with 1 inch trunk diameter were selected to be planted because the young root system still have a higher chance to adapt to the limited soil condition. The whole planter box is filled with high nutrition topsoil help to provide enough food for the roots. To increase number of trees to be planted on the small planter size, only columnar shaped trees were specified.



Tree size when first planted

Indigenous tree species typically found in mixed deciduous forest were used as they demand less watering to save the resource. More than 20 species of Evergreen, Flowering, Fruit Bearing, and Edible trees creates a much more biodiversity for urban area.



3 months after completion

It is a design process to allow nature to success through the years rather than to create an instant thick forest look which might not last long. Within 10 months after completion, trees are grown up to twice the height of the original size when first planted.





10 months after completion

2.2.3. Urban Farm

Roof surface is an ideal place to have an urban farm as there plenty of sun that herbs and vegetable needs. Thus, another important function of the forested roof is to produce fresh, organic food for the family.

Thai fruit tree such as Star Apple, Rose Apple, and Star Gooseberry were randomly mixed into other forest trees to lessen the chance of getting attack from the insect. Variety of Thai traditional herbs is planted in series of planter boxed of 400mm depth



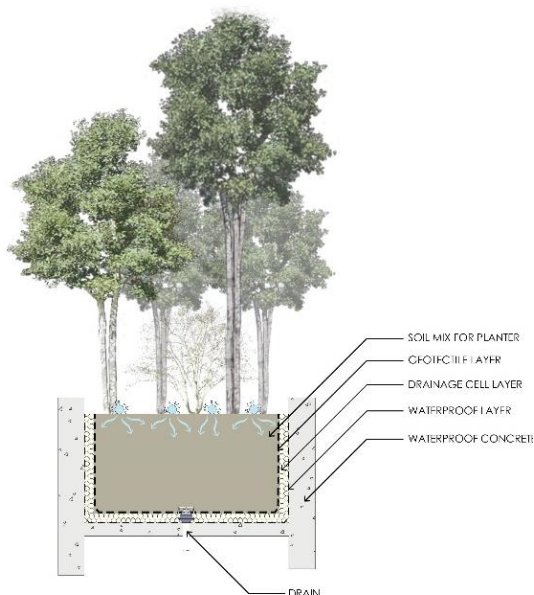
Thai Herbs Planted in 400 mm Deep Localised Planter

2.2.3. Sustainable Forest

As this is a private house, simple maintenance were planned from the beginning to ensure that the forest grow well in the long run with out too much resource. Following are few important points.

Water Irrigation

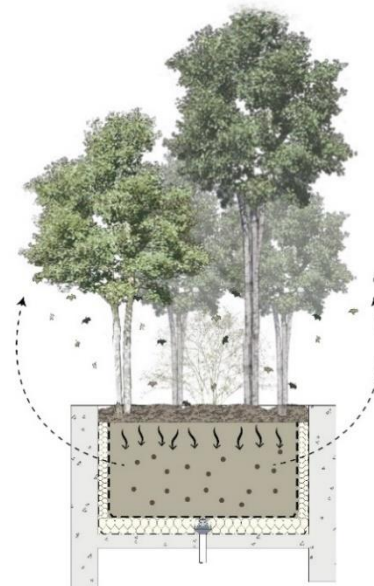
Slow release drip irrigation at the root is chosen to save water. Perforated micro poes tube run through the top soil layer releasing minimum water through out the day maintaining sufficient humidity at the root of each tree. In this way, lost of excess water is less than sprinkler system.



Irrigation Diagram

Encourage Natural Composting Process

Underneath the trees, shrubs and ground cover were not planted to leave bare soil for fallen leaf to cover. All dry leaves are collected not to throw away, but to fill the forest floor. Over the times, natural degradation process from microorganism turn the leaves into natural nutrient-rich fertilizer producing food back for the trees. Each tree species consume and produce different kind of nutrient. Variety of trees help to balance the nutrient distribution.



Natural Composting Process Diagram and Photo

Selective Pruning

Because of limited space, over the time when each tree grow at different speed, branches may crash effecting growing rate of the slower trees. Quarterly, selective pruning of the branch may be required to give way to the slower tree to grow.

2.2.3. *Species List*

Fragrace Flowering Tree:

Fagraea fragrans, Michelia champaca, Calophyllum inophyllum, Millingtonia hortensis, Shorea roxburghii G.Don, Citharexylum spinosum, Melodorum fruticosum



Citharexylum spinosum

Fruit Baring Tree:

Star Fruit, Star Gooseberry, Jack Fruit, Rose Apple



Rose Apple

Distinctive Flowering Tree:

Mayodendron igneum, Jacaranda obtusifolia, Spathodea campanulata, Lagerstroemia floribunda, Lagerstroemia speciosa, Lagerstroemia floribunda, Cassia grandis, Cassia 'Siam White', Shorea robusta, Gardenia sootepensis Hutch



Jacaranda obtusifolia

Evergreen Tree:

Azadirachta indica, Dalbergia cochichinensis, Elaeocarpus hainanensis, Lagerstroemia speciosa, Dolichandrone serrulata (DC.) Seem, Swietenia macrophylla,

Thai Herbs and Vegetable:

Basil, Sweet Basil, Hairy Basil, Stevia Grass, Pepper Mint, Spear Mint, Lemon Grass, Lime, Chilli Padi, Butterfly Pea, Passion Fruit, Cucumber, Climbing Wattle, Yellow-Berried Nightshade, Mulberry



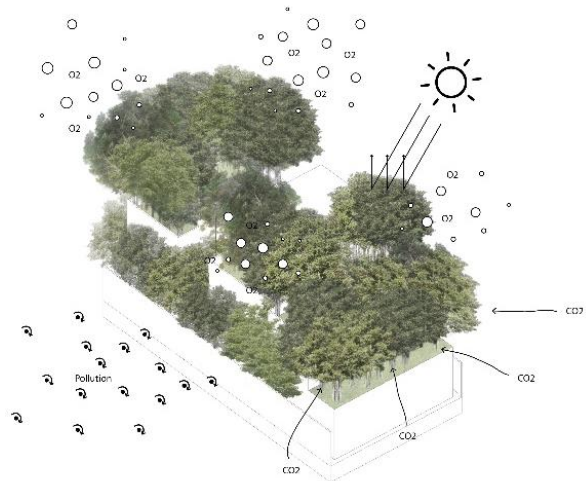


months after completion

3. Conclusion

Both Mapletree Business City II and Forested House show the potential of how to integrate greenery sustainably into dense urban fabric of many cities without having to sacrifice build-up area usage.

Many more possibility could open up if ‘Forested Roof’ is applied throughout the city. It might become a new ground for recreation, commuting, food production, education, etc., that also help to mitigate the impact of many challenges cities are facing today such as, urban heat island, absorb rain water to prevent flash flood, produce oxygen, generate social interaction, and promote healthy lifestyle. Biophilic Cities could become true.



Acknowledgement

Credit for Mapletree Business City II

Developer : Mapletree Business City Pte Ltd.

Architect : DCA architects Pte Ltd.

Main Contractor : Shimizu Corporation

Softscape Contractor : Tropical Environment Pte Ltd.

Lighting Designer : The Lightbox Pte Ltd.

Photograph Credit : Mr. Wison Thngthunya

Perception Study of Industry Pioneers on Dense and Green Building Typologies

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Abstract

With the increasing number of dense and green building typologies in Singapore comes a paradigm shift in the perception of greenery as part of the built environment. This shift on the side of authorities has produced firm legislation-driven guidelines to achieve Singapore's vision of being "a city in a garden". Despite this motivation and the fact that having greenery in buildings has many benefits has generally been acknowledged, such typologies are still not often pursued by building industry professionals. This study was carried out to determine the current perception of industry pioneers and relevant recommended schemes promoted by the Singapore Government. For the investigation, seven industry pioneers (four architects and three landscape architects) who have designed and realised award-winning dense and green buildings, were chosen. In order to understand the impact and challenges that lead to individual perceptions, they were probed through a detailed analysis of interview transcripts. Information was collected using structured open-ended interviews, and the results were qualitatively analysed on NVivo. The qualitative study revealed that while there is a significant appreciation of the legislation leading to such typologies, there is also a consensus on improving such legislation to avoid pertinent issues. These legislations and relevant issues are identified and discussed in the paper. The study shows that the pioneers generally agreed on the advantages and benefits of dense and green building typologies. However, there was a disagreement among architects and landscape architects on the designed aspects that lead to usage and maintenance of greenery in buildings. Also, the study shows that there is ambiguity among the pioneers on the interpretation of existing legislation and its corresponding impact, which may or may not lead to flexibility in designing such typologies. The paper seeks to stage a two-way conversation among the industry professionals, to highlight and improve the gaps in perception while discussing existing policies, programs and incentives, aiming to enhance understanding of dense and green buildings in Singapore.

Keywords : building legislation, landscape urbanism, maintenance, greenery

1. Introduction

With the increasing number of dense and green building typologies in Singapore comes a paradigm shift in the built environment. It produces strong legislation-driven guidelines to remain committed to “City in a Garden” concept even into its heights. Nearly half the size of metropolitan London, Singapore has transformed modern metropolis with diversified economy in a short span of 50 years. In the wake of rapid urbanization, Singapore’s unique circumstances and land scarcity demand the need to find innovative ways to optimize “Garden City Ambience” with the limited land area. In the year 2001, Prime Minister Goh stated that ‘going vertical’ in the form of roof deck gardens, sky terraces, landscaped balconies and planter boxes could be one amongst few other strategies. He also highlighted the need to generate awareness of the benefits of high-rise greenery so that building owners and designers would incorporate such greenery in their building designs. [1]

The benefits of skyrise greenery have since then been well documented. Among them are environmental benefits such as storm water retention, improvement of air quality, economic benefits such as energy resource savings, and socio-economic benefits that include recreational opportunities in dense urban environment [2]. Much of the greening efforts in Singapore are put into action through governance and schemes that promote greenery in dense urban environments.

1.1. Skyrise Greenery Incentive Scheme (SGIS) by National Parks Board (N Parks)

The Skyrise Greenery Incentive Scheme was introduced in the year 2009 to increase greenery provision in Singapore by funding up to 50% of installation costs of rooftop greenery and vertical greenery. Singapore to date has a total of 182 projects and 80.5 hectares of rooftop greenery. Skyrise greenery in Singapore is set to increase with the Sustainable Singapore Blueprint (SSB) target envisioning 200 hectares of rooftop greenery by 2030. [3,4]

1.2. Landscaping for Urban Space and High-rises (LUSH) by Urban Redevelopment Authority (URA)

Introduced also in the year 2009 complementing the Skyrise Greenery Incentive Scheme is LUSH where new developments and redevelopments can be eligible for incentives in the form of additional Gross Floor Area (GFA) for incorporating rooftop greenery. Over the years, the LUSH Programme [5] has evolved to include co-located greenery and roof top solar panels, rooftop urban farming to name a few.



Fig. 1. LUSH Programme details by Urban Redevelopment Authority explaining different areas of building with greenery provision

1.3. GreenMark Scheme by Building & Construction Authority (BCA)

The BCA Green Mark Scheme was launched in January 2005 as an initiative to drive Singapore's construction industry towards more environment-friendly buildings. In the year 2010, with the release of V4.0 Green Mark Scheme started to recognise and award points for Green Plot Ratio (GnPR) which is calculated by considering the 3D volume covered by plants using the prescribed Leaf Area Index (LAI). [6]

1.4. Landscape Excellence Assessment Framework (LEAF) by National Parks Board (NParks)

Introduced also in the year 2013, the Landscape Excellence Assessment Framework, or LEAF for short, is a certification scheme to recognize development projects with outstanding greenery. This is the first scheme in Singapore that is solely dedicated to the provision and management of greenery. With LEAF, NParks aims to encourage more greenery in Singapore's urban landscape. [7]

Despite the motivation in the form of legislation and the fact that greenery in buildings have many benefits, the dense and green building typologies are still not often pursued by building professionals. [8] Hence, it may be appropriate to ascertain whether the assumed benefits of skyrise greenery are perceived to be true among the professionals in the building industry. If they were indeed deemed to be true, it

would raise the question of why greening of urbanscapes are not as widely adopted as they should be and what obstacles there are to their development. A qualitative perception study of built environment professionals such as architects and landscape architects would aid in removing the inherent barriers in adoption of greenery in dense urban environments.

The objective of this study therefore to conduct qualitative interviews with industry pioneers to understand perception of the following:

1. Dense and green building typologies [9]
2. Role of Legislative frameworks such as SGIS, LUSH, LEAF and others and their contribution to the design process
3. Challenges of integration of greenery into different building functions
4. Suggesting measures to overcome challenges and existing legislation, if any

2. The Study

2.1. Respondents

The objective of conducting face to face interviews for this study is to determine the inherent benefits and barriers of deploying dense and green building typologies that industry pioneers perceive to be true. Another aim of the interview is to analyse any disparity in views between the different disciplines. The participants in the part of the study reported here consisted of seven respondents who are industry pioneers in Singapore. The interviews were conducted among two target disciplines, namely Decision Makers/Design Lead from the

architectural firms registered under the Singapore Institute of Architects (SIA), landscape architectural firms recognized by Singapore Institute of Landscape Architects (SILA). [10,11] These two target disciplines also enable to study perception that influences design thinking and thus adoption of dense and green building typologies.

The respondents have completed several noteworthy and award-winning projects

across Singapore with varying functions such as The Interlace, Skyville@Dawson, Punggol Waterway Terraces I, Oasia Downtown, Khoo Teck Puat Hospital and Solaris. These projects are each distinct in nature and embrace incorporating greenery into dense urban environments in their own unique ways. The interviews were taken during a period of March 2017 till July 2017.

Table 1: Detailed list of industry pioneer respondents

Respondent Name	Organization	Discipline	Projects	Interview Period
Tan Shao Yen (SY)	CPG Consultants	Architecture	Khoo Teck Puat Hospital Solaris	March 2017
Richard Hassell (RH)	WOHA Architects	Architecture	Skyville@Dawson Parkroyal@Pickering Oasia Downtown	March 2017
Manuel Der Hagopian (MH)	Group8asia	Architecture	Punggol Waterway Terraces I Punggol Waterway Terraces II	March 2017
Sonny Chionh (SC)	RSP Architects Planners & Engineers	Architecture	The Interlace Jewel@Changi D'leedon	July 2017
Simon Morrison (SM)	ICN Design International	Landscape Architecture	Punggol Waterway Terraces I The Interlace Skyville@Dawson	May 2017
Henry Steed (HS)	ICN Design International	Landscape Architecture	Punggol Waterway Terraces I The Interlace Skyville@Dawson	June 2017
Franklin Po (FP)	Tierra Design	Landscape Architecture	Marina Barrage Parkroyal@Pickering	June 2017

2.2. Survey

Questionnaire

A comprehensive questionnaire was developed with consultations not only from architects, academics and urban designers but also from researcher/s specializing in cognition, perception and behaviour in urban environments. The interdisciplinary consultation allowed to frame the questions in a manner which was neutral, unbiased and open-ended in nature. The interviewee responses were therefore not constrained to certain categories as provided by the interviewer but consist of whatever answer they wish to give. By using such a strategy, it is expected that the open-ended questions will provide replies that better reflect a person's own perception. All the respondents are asked the same questions in the order in which design thinking is progressed namely, concept, design development and post occupancy, only 4 most relevant of the 26 questions asked to have been included in this study. This structured strategy was a way of increasing the comparability of responses and ensure responses to all questions for every interviewee. Furthermore, this approach provides a 'natural' basis of organization for analysis of data from design to construction and handover to post-occupancy.

Question 1: How do you define dense and green building typologies?

Question 2: Could you please explain the role of LEAF (Nparks), Green Mark (BCA) and Replacement Greenery (URA) programs and how does it contribute to the design process and architectural configuration?

Question 3: What are the challenges (direct and indirect) for the integration of greenery into buildings?

Question 4: What more could be done to improve incentive schemes from the Government, please highlight with an example of the completed project?

2.3. Analysis

The interview data were transcribed, typed into word files. For the selected questions, only selected quotes were analysed using NVivo. NVivo usage was kept limited to helped with categorization and classification of the interview data. NVivo allows qualitative data to be easily managed, cross-referenced, organized and analysed. Purpose built for qualitative and mixed-methods research NVivo enabled visualization of results to brainstorm and map ideas and explore connections between project items. [12]

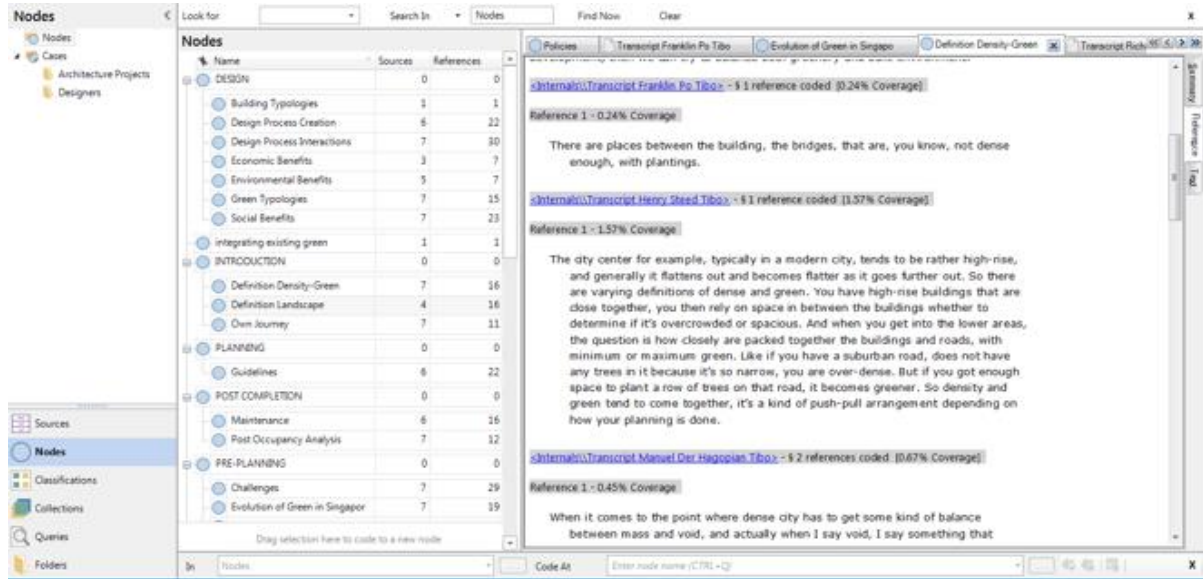


Fig. 2. Visual of NVivo tool used for categorization and classification of the interview transcripts.

3.0 Defining Dense and Green Building Typologies

Architects

RH: *"Particularly tied to the amount of architecture in your field of view, and that's where we think planting can be very helpful to make density bearable."*

MH: *"When it comes to dense typology, you need to think about the void, and then what is in the void? The green."*

SY: *"Traditional understanding is that, greenery is lost, because the building replaces the green. But, if we can lift that site, or find a way to replace it within that building development, then we can try to balance both greenery and built environment."*

SC: *"With buildings, if you green it, whether is it on the ground plane or up on the elevated plane, or even on the elevation, it would be green."*

Landscape Architects

FP: *"Architecture is not just about buildings. It's always about the relationship to the external. Always in connection with the greenery."*

HS: *"If you have a suburban road, does not have any trees in it because it's so narrow, you are over-dense. But if you got enough space to plant a row of trees on that road, it becomes greener. So, density and green tend to come together, it's a kind of push-pull arrangement depending on how your planning is done."*

SM: *"I am interested in landscape spaces having a function. I am more interested in that leading into design, rather than a proportion of space that is 'green'."*

It is clear from the transcripts that both architects and landscape architects agreed that greenery is a powerful tool to reduce the perceived development density. While the weightage in architects' perception are inclined towards a balance of form and visual relief, the landscape architects perceive greenery in relation to the surroundings. Although one landscape architect highlighted quantum of greenery should not be seen in isolation with its function.

4.0 Governance and Schemes Promoting Greenery

Architects

RH: *"It helps in getting the whole industry talking about greenery. It means there is a sort of eco-system of specialist landscape companies who can supply green solutions. These programs are creating statistically significant increases in green all over the city."*

MH: *"At the beginning we try to free from all these regulations. And also, we always try to get a bit of freedom on these rules and regulations and see how we can expand. Sometimes I feel it is a bit too framed, too rigid."*

SY: *"I think these policies are very useful. Without the policy, sometimes obstacles are from the client. The client may*

not subscribe to the same philosophy and look at the return on investment only, therefore policies help to balance that consideration for the decision making of the architect.”

SC: *“Frankly, it’s a hassle because it provides that challenge for designers, to really critically think about how to encompass or accommodate all these requirements. And that is good intention.”*

Landscape Architects

FP: *“The government should not have to define how to deal with handicapped people, and elderly people, etc., practises have an obligation to think holistically about design. Same applies to greening”*

HS: *“Limitations with LEAF and Green Mark are that LEAF certification may be harder to achieve where product of architecture is building focussed and Green Mark’s green plot ratio is heavily dependent on plant species and growth assumptions of green cover. LUSH must be used for the purpose of replacement of usable space in a green environment anywhere on your building. I’m a great fan of landscape replacement, I sell it everywhere, including overseas.”*

SM: *“I think there is a kind of fundamental difference, that we see as design. We don’t approach projects, or clients or situations from a policy point of view. You approach it from a design expression or functional point of view.”*

Architects and landscape architects have varied views in relation to governance and schemes promoting greenery. The architects’ have mixed opinion about role of

governance, some find it rigid, challenging and framed, whilst others see it a way to integrate industry, create new ecosystems and also support architects to push the agenda of greenery to the clients. Two of the landscape architects agreed that greenery is part of holistic approach to design and need not be policy driven. Although one landscape architect highlighted challenges in achieving specific schemes.

5.0 Challenges in Integrating Greenery with the Buildings

Architects

RH: *“Technical spatial challenges such as soil depth, complicated drainage runs and blockages, irrigation, accessibility for maintenance, wind and anchoring large trees.”*

MH: *“Cost of high rise structures with respect to additional structural weight for trees and maintenance issues sometimes limits the exploration.”*

SY: *“Without the policies behind it, developers would be concerned about the capital investment and maintenance aspect. Singapore has actually been quite successful in building our system that allow this amount of urban greenery to thrive, to happen.”*

SC: *“Not just complying with 100% replacement greenery but also costs of implementing this compound the challenge.”*

Landscape Architects

FP: *“I think, one of the major challenges is to have developers understand that we*

should come into the project much sooner than later. Usually we get the project after it's already been approved for planning."

HS: *"There is a lot of complexity across all the disciplines, with everybody dealing with everything: from structural loading to drain discharges."*

SM: *"We can have all the ideas and principles we want, but fundamentally we are working for someone who has a commercial agenda, the client. And government authorities also have an agenda, there is no fixity to design that makes our job much more difficult in terms of coordinating these external aspects, while focusing on installation and maintenance."*

There is a general consensus between architects and landscape architects about the capital investment cost and maintenance issues that need to be resolved. One architect highlighted that because of policies and early adoption Singapore has developed an ecosystem that allows for greenery to thrive. On the other hand, a landscape architect highlighted the need for early involvement in design that can help mitigate some of the challenges that may arise.

6.0 Potential Improvements

Architects

RH: *"One of the significant improvement was when URA made sky garden free of GFA, I think they are a little rigid with the 45-degree rule. If the vertical greenery U-value, shading coefficient calculation would be accepted, then it would potentially be adopted at much higher rate than it is now. Would be interesting if NParks would have an integrated greenery masterplan with*

actual requirements that your vertical greenery must connect to the canopy of the street trees for instance, to provide routes for squirrels to reach more part of the gardens. Categorisation of garden and more studies to have a complex understanding of the various roles and nature performance rather than just seeing as a decorative manicured garden, I would really like to see the research on how can we retain all the benefits of this but do it in a way that people can really make sensible decisions about the level of cost in maintaining the gardens, and manpower."

MH: *"Definitely GFA relation, how can we give some more bonus with GFA, when it comes to greenery. Then I think the regulations should be in a way more flexible to push more the specificity of each project. Because of rigidity with 45-degree rule, developers do not negotiate with architects."*

SY: *"Feedbacks from my clients, is that the current incentives balance the investment they put in. It's equivalent to GFA given, so if we want to intensify further, it's always about economic incentives. Perhaps to provide incentives for maintenance and operational subsidies. A multi-agency collaboration to promote greenery in buildings as opposed to existing individual schemes."*

SC: *"I would say, maybe, not so much in terms of implementation but in terms of built environment industry education. Also, the upcoming improvements to be implemented in a staged manner for the industry to adapt along the way."*

Landscape Architects

FP: *“In a quantum leap, not very much. Because everything takes a step by step process. And can we get to a point where we can fully integrate, buildings layers and everything? It will take a lot of effort, and probably new mind-set, new thinking, are we there yet? We are getting, as a city, in 50 years, doing what it has done. It’s phenomenal. And the grand experiment can continue in Singapore, I think, it’s the only city in the world where something like this can be done.”*

HS: *“My view is that it should not be dollars and cents. The incentives which give more GFA for doing certain things are good. The government wants to have an environmental gain, but it hasn’t found a mechanism to do it, that allows flexibility on the GFA issue.”*

SM: *“An individual designer come and do-little component parts rather than having more of a significant say on some other broad issue. One needs to understand landscape should be thought about as a series of connected spaces, and purpose that they have. So, where landscape is accessible, and let’s widen the term, accessible to mean functional as purpose, it got amenities. And all sorts of characteristics, if we could make those arguments and then stitch those into those planning frameworks instead of just replace like-for-like 100% of the site with green.”*

The need to integrate greenery on buildings with the larger networks of city and research on areas such as biodiversity, urban heat island mitigation, ecosystem services to help designers and policy makers frame future policies with a holistic view. Architects specifically thought the GFA exemption with 45-degree rule must be flexible to relate with specificity of each

project and should not be applied to all projects as a standard rule.

7.0 Discussion

Although the transcripts are elaborate, only selected quotes have been used for this paper. The discussion takes into account complete answers for these four questions. The amount of skyrise greenery in Singapore has grown from 61ha in 2013 to 72ha in 2015, which far exceeded the target of 50ha the Government had hoped to hit by 2030. The new target is now 200 ha of building greenery by the year 2030. [2] A qualitative and research-based approach on functionality, ecological performance and post occupancy maintenance should be considered as opposed to only quantifying greenery and landscape areas. Each government agency has its own targets when it comes to greenery and its adaptation in built environment with different greening programs. There is an emerging need for an inter-agency collaboration to harmonise the commonalities and qualitatively review different legislations and schemes against the set goals. Most architects and landscape architects were of the view that the existing regulations and schemes need to be flexible for a case by case adaptation. The author identifies the need for conducting an industry wide survey and developing key categories for flexibility in existing legislations and scheme to provide the designers with more innovative freedom.

It is imperative that the industry pioneers strongly perceive that for clients to pursue dense and green building typologies economic incentives play a significant role. Existing economic incentives balance the investment but need to be intensified. For instance, an incentive for maintenance of

existing skysrise greenery and awards/recognitions to the same will help the greening agenda. With high rise built environment, maintenance came out as the biggest challenge and needs to be reviewed holistically. With visionary goals for “vertical kampung” the industry also needs to work in an inter disciplinary collaboration towards greening Singapore.

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Comparing the surface temperatures of greenery and artificial materials—A field study of green infrastructures in Singapore

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Abstract

From ‘garden city’ to ‘vertical kampung’, the urban evolution of Singapore to its current dense and green morphology has long been influenced by some form of biophilia. It is commonly claimed that urban greenery can cool localities but few studies have analysed the surface temperature differences between greenery and artificial materials across multiple building developments. We conducted an observational field investigation to quantify the thermal performances of exposed and shaded surfaces, including greenery and artificial materials, in five case studies of green infrastructure in Singapore. We then assessed the results against expectations about urban cooling strategies from existing literature. The difference in mean surface temperature between greenery and various artificial materials, namely masonry materials, plastic and rubber, ranged from 4.82°C–23.5°C. The effect of shading on mean surface temperature was a reduction of up to 6.37°C. For every 1°C rise in air temperature within the recorded range, the difference in surface temperature between greenery and artificial materials increased by 0.88°C–5.17°C while the surface temperature reduction from shading increased by 0.50°C. Owing to differences in context and methodologies among studies, it is difficult to directly and fairly compare the effect sizes we detected with those from existing literature. Nonetheless, our results validate that the substitution of conventional artificial surfaces with greenery and the introduction of shade are plausible strategies for localized cooling in dense tropical cities.

Keywords: surface temperature, material type, shading, green infrastructure, ecosystem services

1. Introduction

1.1. The City in a Garden — Biophilic urbanism in Singapore

Biophilia—the desire to have and experience nature—is well rooted in Singapore’s urban evolution. Since the early days of independence, the nation’s first Prime Minister, Lee Kuan Yew, had the vision to grow Singapore into a ‘garden city’ and through the ‘Clean and Green’ campaign, managed greenery sprouted in the spaces between buildings all over the city [1,2]. In 2012 and onwards, the vision for green Singapore has shifted to the concept of a ‘city in a garden’ which emphasizes making environmental sustainability part of the city’s DNA [3]. At the same time, innovations in greening technologies and policies such as the Sky Rise Greening Initiative have facilitated the sprouting of greenery on building facades and rooftops [2]. From an aerial view of the entire of Singapore in Google Maps, it is evident that the city has grown to be dense and green.

In Singapore and the wider tropics, the implementation of urban greenery is not only motivated by biophilia but also by people’s valuation of their functional benefits. These benefits range from environmental and ecological ones such as mitigation of the urban heat island (UHI) effect [4], supporting urban biodiversity [5,6] and noise reduction [7], to socio-economic ones such as provision of visual relief [8], being a destination for leisure and recreation [8] as well as increasing the value of properties [9].

1.2. Dense and Green! But too hot? — Biophilic urbanism for a cooler Singapore

With urban development and global warming continuing largely unabated, there have been concerns about the health consequences of the increasing intensity of UHI in cities across the world. This is

because the phenomenon directly exacerbates the risk of heat-related stress, injury and mortality for city dwellers, particularly during extremely hot spells and heatwaves which are expected to increase in severity and frequency in the future [10–12]. For tropical cities with high relative humidity like Singapore, UHI is more pressing as the threshold temperature above which conditions become lethal is considerably lower than cities with drier climate, e.g. at 20% relative humidity, temperatures typically become deadly only when above 40°C whereas at 80% relative humidity, temperatures above 30°C can already kill [13]. High relative humidity makes it more difficult for the human body to dissipate heat through sweat evaporation.

Often overlooked but also of concern is the impact of high temperatures on the health of the other living residents in the city—the urban flora and fauna. For instance, high temperatures have caused multiple mortality events of urban bats [14]. As recently as January 2018, more than 200 flying foxes in the city of Campbelltown, Sydney, succumbed to heat stroke as temperatures reached 47°C [15]. In November 2014, up to 5000 flying foxes in Casino, northern New South Wales, were killed by a heatwave sporting temperatures of 44°C [16].

To mitigate the UHI effect, one of the many strategies proposed is to increase the extent of urban greenery [17,18]. The cooling effect of urban greenery has been quantified by many studies spread over a wide geographical context. An investigation of the cooling effect of shade trees in a park in Taiwan revealed that air temperatures underneath tree canopies can be up to 2.5°C lower than the air temperatures in adjacent unshaded spaces [19]. A study of an extensive green roof in Hong Kong stated that greenery lowered the daily maximum floor surface temperature by 5.2°C, and the

air temperature 10cm above the ground by 0.7°C [20]. A green wall in Beijing was monitored and reported to be, on average, 4.5°C cooler than its bare counterpart [21] while an experiment at Reading, United Kingdom, illustrated that between vegetated walls and exposed brick walls, the difference in adjacent air temperatures and surface temperatures reached 3.0°C and 9.9°C respectively [22].

Numerous relevant studies have been done in Singapore. At a rooftop garden, Wong et al [23] found that the maximum floor surface temperature measured under a shrub was about 30°C cooler than that of an adjacent floor without plants. The same study also reported a maximum difference of 4.2°C in air temperatures, measured at a height of 300mm above the ground, between areas with and without plants. In terms of vertical greenery, Tan et al [24] showed that a concrete wall could be 6.9°C cooler when clad in a layer of greenery. There are also studies investigating what factors account for greenery's cooling effect. Using data from three plots of rooftop greenery, Tan et al [25] produced a prediction model linking plant evapotranspiration rate and shrub albedo with the mean radiant temperature above the greenery. At a reference mean radiant temperature of 50°C , the model predicts that greenery with an evapotranspiration rate of 0.030mm per minute and a shrub albedo of 0.30 will lower the mean radiant temperature by 16.5%.

There is general consensus that urban greenery can cool localities by 1) intercepting solar radiation and preventing the warming of surfaces and air in its shade, 2) acting as a heat sink by having surfaces that are cooler than artificial materials or the air temperature, and 3) evapotranspiration which converts sensible heat to latent heat and consequently, reduce the energy

available to increase ambient temperatures [26].

When exposed to the same amount of solar radiation, the surface temperatures of plants are likely to rise to a lesser degree than conventional artificial materials such as concrete and asphalt because 1) plants have the ability to self-shade, with the lower layers of leaves and stems receiving less solar radiation, 2) the biotic morphologies of plants often result in there being pockets of insulative still air between and within layers of leaves and stems, and 3) some of the heat energy absorbed by the plants is diverted to fuel biological processes, particularly photosynthesis and evapotranspiration. As such, we hypothesized that greenery tend to have low heat admittance and accumulate less heat over time. With greenery being less responsive to the temperature of its surroundings as compared to artificial materials, we expect that the surface temperature difference between the two will widen at higher ambient temperatures.

Our main research question was "What are the thermal performances of exposed and shaded surfaces of greenery and artificial materials in green infrastructures in Singapore, and do they align to expectations from existing literature?" To answer this question, we quantified the surface temperature differences between greenery and several artificial materials across shaded and unshaded conditions. In contrast to previous studies, which typically collected data from a single landscape feature repeatedly over time or in an experimental setting, we recorded field observations of five post-occupied buildings which embrace greenery in their design and have greenery on and around them. This serves to most directly assess and compare, on a building development scale, the actual thermal performances of the different surfaces in those existing infrastructures.

2. Methods

2.1. Data collection and image classification

The five case studies investigated are Punggol Waterway Terraces I, SkyVille @ Dawson, Khoo Teck Puat Hospital, SOLARIS and Oasia Hotel Downtown. Snapshots of surface temperatures were measured and recorded in the form of thermal images using a FLIR E8 infrared camera (FLIR Systems, Wilsonville, Oregon, United States). The camera has a reported accuracy of $\pm 2^{\circ}\text{C}$ and a thermal sensitivity of $<0.06^{\circ}\text{C}$, and was calibrated to an emissivity of 0.93 to compromise for the emissivity of concrete (0.92), rubber (0.95), plastic (0.93), wood (0.90) and that of plants (0.94-0.98) [22,27–29]. At each building, we surveyed the surface temperatures of the range of materials and plants present on-site by taking 30 thermal images of various spaces with greenery, including ground gardens, landscaped deck, elevated gardens and vertical greenery. The thermal images were taken on two non-rainy days per case study, between 14:00 to 18:00. Ambient weather conditions, namely air temperature, humidity, wind speed and solar radiation, were recorded during the survey periods using an Ambient Weather Ws-1001-WiFi OBSERVER weather station (Ambient Weather, Chandler, Arizona, United States) set up at a height of 1500mm above the ground. The surveys were carried out between 21st August 2017 and 20th March 2018.

We set the infrared camera to capture a digital image of the same resolution and field of view whenever a thermal image was taken. The surfaces in the digital images were categorized by surface type, consisting of eight categories—water body, shrubs and trees, turf, metal, masonry materials, wood, plastic and rubber, as well as a binomial shading condition (shaded or unshaded). This is accomplished through a semi-

automated, two-step image classification process which involved manual demarcation and color range selection in Adobe Photoshop, followed by K-means clustering using the raster package [30] in the R software environment. Subsequently, the thermal images were overlaid onto the corresponding categorized digital images and the mean temperatures for the shaded and unshaded surface types in every pair of images were determined (Fig. 1).

2.2. Statistical analysis

All statistical analyses were performed in R version 3.4.1 [31]. Using the lme4 and lmerTest packages [32,33], we generated a global linear mixed-effect model based on the mean temperatures of shaded and unshaded surfaces in all the analysed images. In this model, the response variable was mean surface temperature. The fixed explanatory variables were surface type, shading condition, air temperature, relative humidity, wind speed, solar radiation, as well as the first-order interactions between surface type, shading and air temperature. Collinearity between the explanatory variables, excluding interactions, was assessed using the vif.lmer function and the variance inflation factors calculated were all less than 2.15. Two nested random intercept variables were also included to account for the spatial and temporal variability between the thermal images. These random effects were the identity of the thermal image, nested within the identity of the case study, and the time at which the thermal image was taken, nested within date. Subsequently, we used the “dredge” function from the MuMIn package [34] to propose multiple candidate models and ranked them according to the Akaike information criterion. The best model had a weight of 0.79, thus we deemed model averaging unnecessary. The model matched our hypothesis that surface type, shading and air temperature had synergistic effects on surface temperature.

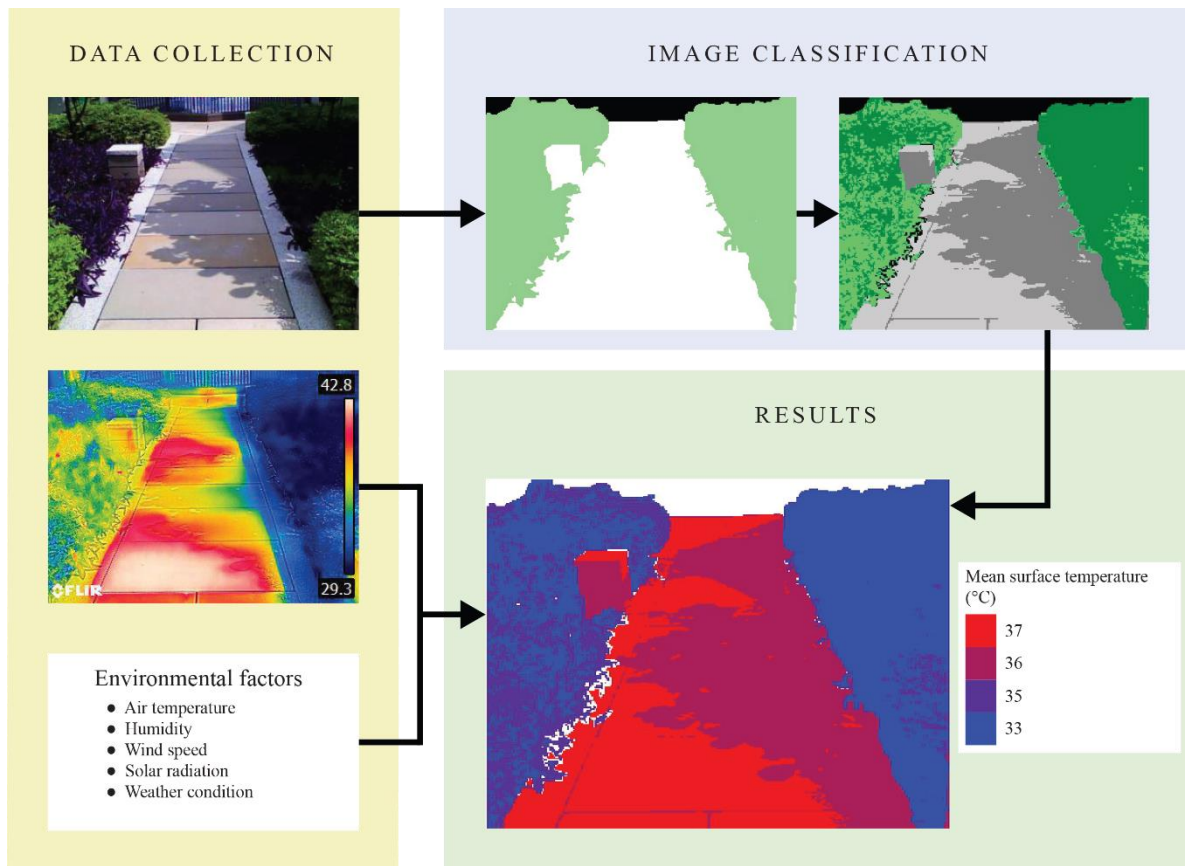


Fig. 1. Process flow for the surface temperature study

3. Results

3.1. Surface type

In our model, the reference category for surface type was shrubs and trees. Under unshaded conditions, and at the average recorded air temperature of 31.0°C, there was no significant difference between the mean surface temperature of shrubs and trees, and that of water body, turf, metal or wood. However, shrubs and trees were expected to be 4.82°C cooler than masonry materials, 8.35°C cooler than plastic and 12.9°C cooler than rubber (Table 1). These differences became more prominent at higher air temperatures. When air temperature reached 33.4°C, the maximum recorded, shrubs and trees were predicted to be 7.05°C cooler than masonry materials, 12.4°C cooler than plastic and 23.5°C cooler than rubber.

3.2. Shading

Shading was more significant for artificial materials than greenery, with the cooling effect on the particular surface types increasing in the order of masonry materials, wood, plastic and rubber (Table 1 and Fig. 2). At the mean air temperature of 31.0°C, shading was estimated to lower the mean surface temperature of masonry materials by 3.09°C, the mean surface temperature of wood by 4.25°C, that of plastic by 4.52°C, and that of rubber by 5.16°C. This stands in contrast with the surface temperature decrease experienced by shrubs and trees which is 0.98°C. With the air at a maximum of 33.4°C, the surface temperature reduction caused by shade on these artificial materials increased by a magnitude of 1.22°C each, to 4.31°C (masonry materials), 5.47°C (wood), 5.74°C (plastic) and 6.37°C (rubber).

Table 1. Coefficients of the best model explaining the effects of surface type, shading, air temperature and their first-order interactions on mean surface temperature.

Variable	Estimate	SE	df	t-value	p-value
Masonry materials	-27.24	6.06	525	-4.50	< 0.001
Plastic	-51.17	12.98	591	-3.94	< 0.001
Rubber	-147.08	23.63	599	-6.23	< 0.001
Shading	14.65	5.41	536	-2.71	0.00697
Air temperature	0.97	0.27	14	3.62	0.00290
Shading × masonry materials	-2.06	0.56	514	-3.72	< 0.001
Shading × wood	-3.22	1.09	527	-2.94	0.00158
Shading × plastic	-3.56	0.81	519	-4.42	< 0.001
Shading × rubber	-4.76	1.18	517	-4.02	< 0.001
Air temperature × masonry materials	1.04	0.20	525	5.30	< 0.001
Air temperature × wood	0.88	0.44	545	2.02	0.04389
Air temperature × plastic	1.93	0.42	590	4.63	< 0.001
Air temperature × rubber	5.17	0.75	599	6.91	< 0.001
Shading × air temperature	-0.50	0.17	535	-2.89	0.00405

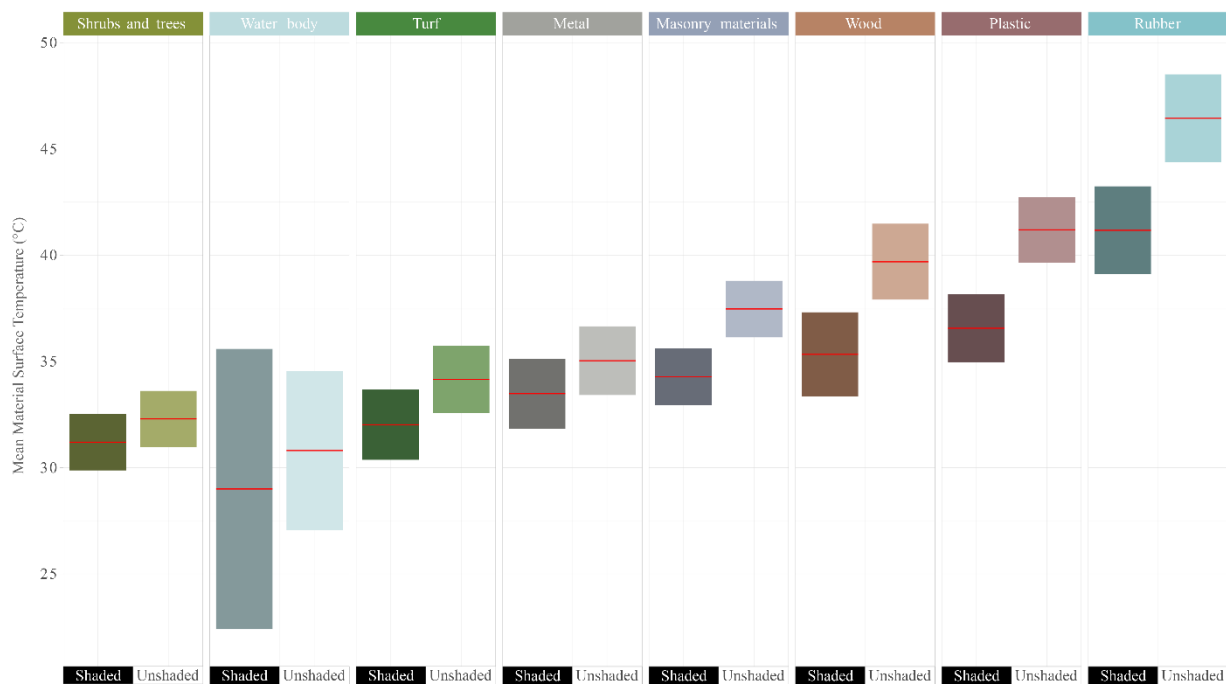


Fig. 2. Predicted mean surface temperature (\pm confidence interval) of the various surface types under shaded and unshaded conditions

3.3. Air temperature

For every 1°C increase in air temperature, the difference between the surface temperature of shrubs and trees and that of masonry materials, wood, plastic and rubber increased by 1.04°C, 0.88°C, 1.93°C and 5.17°C respectively (Table 1). Similarly, the surface temperature reduction owing to shading increased by 0.50°C per 1°C rise in air temperature.

4. Discussion

4.1. Thermal performances of greenery and artificial materials

The results of this study match the general understanding established by previous research that greenery is mostly cooler than conventional artificial materials, and support our hypothesis that plants have low heat admittance (Fig. 2). Under exposure to solar

radiation, the differences in surface temperature between greenery and artificial materials that were detected ranged from 4.82°C–23.5°C, depending on surface type and air temperature. Some parallels can be drawn with comparable studies. For instance, the estimated 4.82°C difference between shrubs and trees and masonry materials supports Di and Wang’s finding that the average temperature of leaves on a green wall was 4.5°C cooler than that of an exposed brick wall in Beijing at summer time [21].

It is, however, difficult to directly compare our results with those from existing literature because many previous studies were conducted in different environmental conditions. For example, a study in Phoenix, Arizona, detected a 10.6°C difference in mean surface temperature between concrete and turf which is larger than what we reported [37]. This is possibly because the data was collected from open plots in a hot desert climate [39], whereas our measurements were taken within green building developments situated in an equatorial humid climate [39]. This highlights the importance of recording and reporting the range of contextual variables such as air temperature and relative humidity which affect local surface temperatures.

In addition, studies often employed different methodologies which makes it difficult to fairly compare their results. Most investigations about the cooling effect of greenery on building envelopes compared the temperatures of artificial surfaces when exposed to solar radiation versus when underneath greenery [20,22,23,35]. This is as opposed to a comparison of the former against the canopy or leaf surface temperature as we had done. In contrast to the variety of artificial materials we studied, the majority of previous studies focused only on the temperature difference of greenery

with concrete and asphalt [20,35–38], the most common artificial surfaces in urban areas.

Irrespective of shading, the hotter artificial materials seen on-site were invariably masonry materials, plastic and rubber, with masonry materials having the lowest mean surface temperature among these materials, and rubber the highest. The thermal performances of these materials were largely attributed to their thermophysical properties, specifically 1) albedo, which affects the amount of incident solar radiation absorbed and reflected, 2) emissivity, thermal conductivity and diffusivity, which influence how fast heat is absorbed, transferred and released, as well as 3) volumetric heat capacity which concerns the amount of heat required for the material’s temperature to rise [39]. By enhancing these properties, a material can have cooler surfaces and likewise, materials with low values for these properties have a greater capacity to absorb and store heat [39]. Many of the rubber and plastic surfaces we surveyed were dark colored, e.g. black and brown, and rough textured, suggesting that they had low albedo. Also, the high surface temperatures of these materials can be explained by their low thermal conductivity and diffusivity [40]. Conversely, the cooler artificial materials were water body, metal and wood. This is likely accounted by the relatively higher heat capacities of water and wood, and the characteristically high albedo and thermal diffusivity of polished metal [40].

Regarding greenery, we found that shrubs and trees had similar mean surface temperatures as turf. Any biological variations inherent to the plant forms, which might have affected their surface temperatures, were likely concealed by the unintended consequence of urban design in determining their microclimates. As a case in point, the difference in evapotranspiration

rates between shrubs and grasses might not be a significant factor in the light that turf is often relegated to open areas receiving direct solar radiation, whereas shrubs are more likely to be incorporated into shaded scenarios. Furthermore, we did not measure the evapotranspiration of greenery during our surveys, such as conducted by Shashua-Bar et al [41], and hence we cannot conclude whether evapotranspiration differed significantly between the plant forms or how this phenomenon relates to the observed surface temperatures.

4.2. The effect of shade on the thermal performances of greenery and artificial materials

As expected, surfaces were cooler when shaded because shading is essentially a form of solar radiation protection that reduces the amount of heat energy reaching the shaded surfaces. Since air temperature can be a proxy for solar radiation, it follows that the cooling effect of shade becomes more significant at higher air temperatures. However, this cooling effect was not equal across surface types. At the mean air temperature of 31.0°C, the surface temperature reduction of shrubs and trees by shade was less than 33% that experienced by the hotter artificial materials, including masonry materials, wood, plastic and rubber. The lower variability of surface temperatures in greenery was also remarked by Wong et al [23] and Köhler et al [42]. This might be because of the plants' low heat admittance and their ability to actively regulate their temperatures as part of homeostasis which the artificial materials lack.

Interestingly, the greater the material's potential to get hotter, the bigger the difference in its surface temperature under shaded and unshaded conditions (Fig. 2). We deduced that since shading virtually blocks out solar radiation, its effect on lowering surface temperature should be directly

proportional to the materials' ability to accumulate heat from solar radiation. As such, shading is more effective on materials that can attain higher surface temperatures. One such material from the case studies would be rubber which was recorded to exceed 70°C when unshaded. Rubber was predominantly used as the flooring for play areas, some of which were located on roofs and highly exposed to the sun. It would be highly efficient to shade these play areas to improve the thermal comfort of the people using said space.

4.3. Recommendations

Replacing various conventional artificial materials in unshaded spaces with greenery, or placing greenery on shading structures creates an offset of solar radiation interception, whereby the shading structure receives the solar radiation instead of the surface below it. This can effectively reduce the UHI effect. Greenery implemented in the case studies lowered surface temperatures by a maximum of 23.5°C.

Based on potential surface temperature reductions, shading should be prioritized on artificial materials rather than on greenery, and particularly on those materials that can attain high surface temperatures such as rubber and plastic with low albedo and low thermal diffusivity. Shading of artificial materials was found to decrease surface temperatures by up to 6.37°C. This could be a viable strategy for localized cooling in tropical cities.

Since the magnitude of the surface temperature reduction by greenery and shading increased with air temperature, more impactful cooling can be achieved by implementing landscaping and shading structures on buildings or spaces anticipated to experience the hottest microclimates.

Further research should investigate the relationship between the duration of shade and how that interacts with different species or functional groups of plants. In a high-density urban environment, different shading conditions are common. To green the city most efficiently, it may not be necessary to pick specialist species that have high thermal performances in particular shading scenarios, e.g. fully shaded spaces.

5. Conclusion

This study presented the thermal performances of exposed and shaded greenery and artificial materials in five green infrastructures in Singapore. Our results support the general understanding established by previous research regarding the potential of greenery and shading for cooling urban localities. It is difficult to directly and fairly compare the effect sizes we detected with those from existing literature because of differences in context and methodologies. Nevertheless, the reported surface temperature differences between greenery and the various artificial materials, as well as the surface temperature reduction by shade validate the effectiveness of cooling strategies utilizing greenery and shading when applied to the context of the case studies in particular, and to dense tropical cities in general.

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Smellscape design wisdom of Jiangnan gardens in Ming-Qing Dynasty

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Abstract

In Chinese traditional culture, living plant's smell is an important aesthetic object. Smellscape is an organic part of Chinese traditional gardens. Jiangnan gardens in Ming-Qing Dynasty (1368A.D.-1912A.D.) paid much attention to smellscape design and formed a unique design wisdom from long-term gardening practice. Through studying historical literatures about gardening and garden living, such as *Yuan Ye*, *Zun Sheng Ba Jian*, *Zhang Wu Zhi* and *Xian Qing Ou Ji*, this paper firstly summarizes 102 species of aromatic plants used in Jiangnan gardens in Ming-Qing Dynasty, and points out 22 species of them are the typical ones. Secondly, it presents the design methods of smellscape by using aromatic plants: land planting, pot planting and vase planting, and reveals the key points of these design methods. Thirdly, it concludes the aesthetic characteristics of smellscape: seasonality, metaphoricity and philosophy, and analyzes how they benefit to well-being. Although smellscape design wisdom of Jiangnan gardens in Ming-Qing Dynasty cannot be simplified as an accurate plan to be directly grasped, it should be an enlightenment to modern high-quality living environment and healing garden practice.

Keywords: smellscape; aromatic plant; Chinese traditional garden, design method, aesthetic characteristics, well-being

1. Introduction

Living plant's smell is an important aesthetic object in Chinese traditional culture. Its sensibility and indescribability make it fascinating. Smellscape is an organic part of Chinese traditional gardens. Jiangnan gardens^① in Ming-Qing Dynasty (1368A.D.-1912A.D.) paid much attention to smellscape

design and formed a unique design wisdom from long-term gardening practice.

In the historical literatures about gardening and garden life, we can find that Jiangnan gardens used a large number of aromatic plants to design smellscape by different methods which were integrated with the ancients' aesthetics. It can be seen from some views and their names^②, such as "Bamboo Fragrance Pavilion" (Zhu Xiang Zhai),

^① "Jiangnan" means the lower Yangtze region which is in east central China. It includes many cities such as Suzhou, Shanghai, Changzhou, Hangzhou, Jiaxing, Huzhou, Nanjing, Zhenjiang, Yangzhou, Shaoxing and Ningbo. "Jiangnan gardens" means the gardens built in the above cities.

^② In Chinese traditional garden, a view usually is named by the most significant feature of the surrounding landscape.

“Lotus Fragrance Pavilion” (Ou Xiang Xie) and “Smelling Osmanthus Fragrance Pavilion” (Wen Mu Xi Xiang Xuan). This is one of the unique artistic characteristics of Chinese traditional gardens.

Against this background, this article focuses on three key questions.

- What aromatic plants are used in Jiangnan gardens?
- How to design smellscape by using the above aromatic plants?
- What are the aesthetic characteristics of this smellscape?

The following paper is organized in 5 parts. Section 2 – 4 solve each of above questions respectively. The last part concludes.

2. Aromatic plants in Jiangnan gardens

In order to summary the aromatic plants in Jiangnan gardens, a unique database was established. This database included 10 historical books and 500 garden notes. More specifically, these 10 books included *Yuan Ye*, *Zunsheng Bajian*, *Kaopan Yushi*, *Zhangwu Zhi*, *Xianqing Oujie*, *Guang Qunfang Pu*, *Huamu Xiaozhi*, *Runan Pushi*, *Xuepu Zashu* and *Hua Jing* [1-10], which are the important historical literatures about gardening and garden living. In addition, 500 garden notes are also the important historical literatures to investigate aromatic plants in Jiangnan gardens, they were collected by Chen Congzhou, Wang Jiaju, Gu Yiping, Chen Yifu, et al [11-14].

Based on this unique database, there are 102 species of aromatic plants mentioned in Jiangnan gardens, wherein 22 species are the

typical ones (Tab. 1.), as their fragrances were the most frequently described.

Tab. 1. Typical aromatic plants in Jiangnan gardens

Life form	Aromatic plants	Latin name	Family and Genus	Aromatic organs	Seasons	
Tree	Plum blossom	<i>Armeniaca mume</i>	<i>Rosaceae Prunus</i>	Flower	Spring	
	Magnolia	<i>Magnolia denudata</i>	<i>Magnoliaceae Magnolia</i>	Flower	Spring	
	Orange	<i>Citrus reticulata</i>	<i>Rutaceae Citrus</i>	Flower	Spring	
	Osmanthus	<i>Osmanthus fragrans</i>	<i>Oleaceae Osmanthus</i>	Flower	Autumn	
Shrub	Wintersweet	<i>Chimonanthus praecox</i>	<i>Calycanthaceae Chimonanthus</i>	Flower	Winter	
	Gardenia	<i>Gardenia jasminoides</i>	<i>Rubiaceae Gardenia</i>	Flower	Summer	
	Peony	<i>Paeonia suffruticosa</i>	<i>Paeoniaceae Paeonia</i>	Flower	Spring	
	Daphne	<i>Daphne odora</i>	<i>Thymelaeaceae Daphne</i>	Flower	Spring	
	Jasmine	<i>Jasminum sambac</i>	<i>Oleaceae Jasminum</i>	Flower	Summer	
Liana	Banks' rose	<i>Rosa banksiae</i>	<i>Rosaceae Rosa</i>	Flower	Spring	
	Multiflora rose	<i>Rosa multiflora</i>	<i>Rosaceae Rosa</i>	Flower	Spring	
	Rosa rubus	<i>Rosa rubus</i>	<i>Rosaceae Rosa</i>	Flower	Spring	
	Beach rose	<i>Rosa rugosa</i>	<i>Rosaceae Rosa</i>	Flower	Spring	
Herb	Orchid	<i>Cymbidium</i>	<i>Orchidaceae Cymbidium</i>	Flower	Spring	
	Daffodil	<i>Narcissus tazetta</i> var. <i>chinensis</i>	<i>Amaryllidaceae Narcissus</i>	Flower	Winter	
	Plantain lilies	<i>Hosta plantaginea</i>	<i>Asparagaceae Hosta</i>	Flower	Summer	
	Chrysanthemum	<i>Dendranthem a morifolium</i>	<i>Asteraceae Chrysanthemum</i>	Flower	Autumn	
	Lily	<i>Lilium brownii</i>	<i>Liliaceae Lilium</i>	Flower	Summer	
	Tawny day lily	<i>Hemerocallis fulva</i>	<i>Hemerocallis</i>	Flower	Summer	
	Lotus	<i>Nelumbo nucifera</i>	<i>Nelumbonaceae Nelumbo</i>	Flower, Leaves	Summer	
	Rice	<i>Oryza sativa</i>	<i>Poaceae Oryza</i>	Flower	Autumn	
	Other	Bamboo	<i>Bambusoideae Nees</i>	<i>Poaceae Schizostachyum</i>	Leaves, Trunk	Spring

3. Design methods of smellscape

Smellscape is constructed by planting aromatic plants in garden. Through studying the historical literatures and surveying the garden heritages, design methods of smellscape could be summarized as following: land planting, pot planting and vase planting.

3.1. Land planting

Land planting is the most common design methods of smellscape. The design methods

include two dimensions. First, the aromatic plants were usually planted in land by varied forms, such as isolated, symmetric, multiple and group. Second, these plants are combined with other garden elements like rockery, water, building, corridor, pergola and fence.

Different aromatic plant has its relative stable land planting form to create typical smellscape, which is usually depended on the plant's ecological habits, ornamental characteristics (posture, color, smell, sound, etc.), cultural connotations, utilitarian functions, as well as the surrounding conditions. The typical land plantings are as following.

Pulm blossom's fragrance is light, its branches are sparse and thin, and its character was considered as pure and lofty. Therefore, it usually was planted individually beside the study house or water, and this could create an imperceptible aroma environment.



Fig. 1. The pulm blossom view of Jichang Garden. Painting by Song Maojin (Ming Dynasty)

In addition, the white pulm blossoms which were considered better than the red ones, usually were planted in group covered a rockery and surrounded a pavilion or living room, this created the so-called "Aromatic Snow Sea" smellscape (Xiang Xue Hai, Fig.

1.), because the white color looks like snow and the view of large group looks like sea.

Magnolia is another aromatic plant which was loved by its white flowers and light fragrance. In Chinese traditional culture, magnolia has a laudatory name called "Jade Tree", because when flowers are in full bloom, all the tree is white like pure jade. Jade Tree has been given an elegant connotation, and it usually was planted in front of a hall (the highest class of residence building) in a solemn way: symmetric planting.

Unlike pulm blossom and magnolia's light fragrance, wintersweet's scent is strong, sweet, cold and very easy to be perceived but not vulgar, so it was deeply loved by the ancient literati. They called it "surprising aroma", and considered it was the indispensable smell in winter. So wintersweets always were planted with well-designed rocks in the courtyard of a quiet area (Fig. 2., Fig. 3.).



Fig. 2. Wintersweets in Ge Garden. Photographing by Xie Qing



Fig. 3. Wintersweet in Wangshi Garden. Photographing by author

Bamboo was one of the most important plants in Jiangnan garden. A large number of bamboos usually were planted along waterside, cover artificial mound, around pavilion or study house, and to create a clear realm. And bamboos' smell is the key element to lead to the clear realm.

Bamboo's smell which is sent forth by leaves and trunk is different from flowers' fragrance, it's very light and hardly to be perceived. But it fits for the ancient literati's olfactory aesthetic. In Chinese traditional culture, bamboo's smell is considered as "thin delicate fragrance". And there were so many buildings in Jiangnan gardens named by bamboo's smell, "Bamboo Fragrance Pavilion" (Zhu Xiang Zhai) in Lvjing Garden was a typical one.

Lotus is another aromatic plant which was very common in Jiangnan garden. As aquatic plant, lotuses were usually planted in pond around the pavilion which was located in the middle of pond or at the edge of pond. In order to smell lotus flowers and leaves, the pavilion's elevation was kept open to let the wind come in with lotuses' fragrance (Fig. 4.), just like Chen Haozi (1612A.D.-?) said:

Open room that suit for long summer residence should be close to water, and its windows should be taken away, Chinese parasols should be planted in the front of it and bamboos should be at the back of it, pond with lotuses should be kept around and closed to it, water pavilion should beside of it, so that it could be resistant to sunlight and let the aromatic wind pass through.^[10]



Fig. 4. Lotuses and water pavilions in Yipu Garden. Painting by Cheng Tinglu (Qing Dynasty)

Except the aforementioned aromatic plants, other typical species such as orange,

osmanthus, gardenia, peony, daphne, roses and rice were also usually planted in land in Jiangnan gardens in Ming-Qing Dynasty.

3.2. Pot planting

Pot planting is another design method of smellscape. As well known, bonsai is an excellent Chinese traditional art. Bonsai is a fashion in Jiangnan in Ming-Qing Dynasty. The Jiangnan literati especially liked cultivating plants in pots (sometimes with stone or many other decorations) to make them to be artworks and putting them indoors to enjoy them.

Most of bonsais were made by aromatic plants and their smells attracted the literati which can be discovered in historical literatures:

Wintersweet which height is more or less 35cm but posture is old and flowers have strong fragrance, suit for desk in study room to make attractive scene for enjoying.^[15]

The characteristics of daffodil and orchid are leisurely, they fit for porcelain bucket and beautiful stone, should be settled under windows of bedroom, so that their fragrances could be enjoyed in everyday life.^[10]

These phenomena are also showed in Ming-Qing paintings (Fig. 5., Fig. 6.).



Fig. 5. Orchid bonsai. Painting by nameless (Qing Dynasty)



Fig. 6. Daffodil bonsai. Painting by Sun Wen (Qing Dynasty)

In short, the typical aromatic plants under pot planting in Ming-Qing Dynasty's Jiangnan gardens were as follows: Plum blossom, wintersweet, peony, daphne, jasmine, orchid, daffodil, plantain lilies, chrysanthemum, lily, tawny day lily and lotus.

3.3. Vase planting

Flower arrangement is another excellent art in ancient China. The aromatic flowers which were cut to plant in vase is another effective way to create smell environment. From the most important flower arrangement related books in Ming-Qing Dynasty: Pinghua Pu and Ping Shi ^[16], we can see that so many typical aromatic flowers were the popular cut flowers, they are plum blossom, magnolia, osmanthus, wintersweet, gardenia, peony, daphne, jasmine, roses, orchid, daffodil, plantain lilies, chrysanthemum, lily, tawny day lily, lotus and bamboo.

Vase planting followed certain rules. For example, peony's flower is big, colorful and aromatic, it was well known as "national beauty and heavenly fragrance", so it fitted to big and gorgeous vase in high class of residence building like hall (Fig. 7.). Plum blossom's flower is tiny and its fragrance is hidden, so it fitted to small and elegant vase in bedroom or study room (Fig. 8).



Fig. 7. Peony vase in hall. Painting by Sun Wen (Qing Dynasty)



Fig. 8. Plum blossom vase in bedroom. Painting by Sun Wen (Qing Dynasty)

4. Aesthetic characteristics of smellscape

In Chinese traditional garden culture, smellscape is not only an olfactory environment, but also an aesthetic object. Therefore, it has some important aesthetic characteristics such as seasonality, metaphoricity and philosophy.

4.1. Seasonality

Aromatic plants are living organisms, they have different characteristics in the four seasons, and their florescence are not the same (Tab. 1.). The ideas of "the garden which is considered to be excellent should has flowers in four seasons and has fragrances all year round" is a common design pursuit in Jiangnan gardens.

For example, the Humble Administrator's Garden (Zhuo Zheng Garden) would be filled with fragrances of peony, magnolia, michelia, orange, roses, plum blossom and bamboo in spring; in summer, it would be full of scents of lotus and gardenia; in autumn, it would be pervaded with aroma of osmanthus; and in winter, it would be filled with wintersweets' fragrance (Fig. 9.).

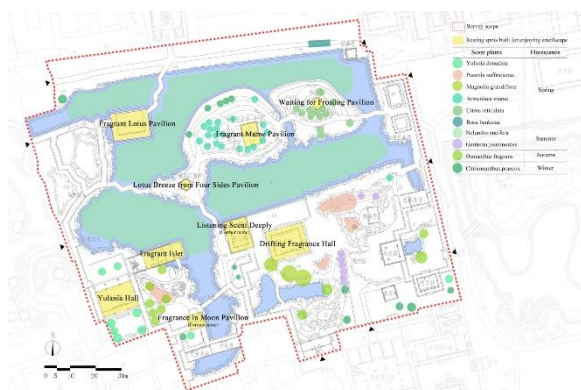


Fig. 9. Aromatic plants of four seasons in Humble Administrator's Garden. Drafting by author

The smellscape in four seasons contains the message of nature, just like the famous poet Lu You (1125A.D.-1210A.D.) said: "The flower's fragrance attacks could know the weather suddenly turn warm". The ancient Chinese literati got physical and mental pleasure and happiness in feeling the rhythm of natural by enjoying different smellscape in four seasons.

4.2. Metaphoricity

In Chinese traditional culture, the fragrances of plants are endowed with profound connotations, giving smellscape certain metaphor and symbolism.

For example, lotus aroma is a symbol of refusing to be contaminated by an evil influence. So, the garden owners usually created lotus smellscape and gave it a name, such as "Far Fragrance Hall", to express their personality thoughts of nobleness and the principle of living.



Fig. 10. The rice view of Lijiao Garden. Painting by Shen Shichong (Ming Dynasty)

The rice scent which is quite different from flower sweet is a symbol of reclusive live. Withdrawing from society, cultivating rice and vegetables to live self-sufficiently is an idea life to the ancient Chinese literati. It was originated from Tao Yuanming (352A.D.-427A.D.) and became an idealistic concept in garden design. The above picture (Fig. 10.) shows rice smellscape in Lejiao Garden, it expressed the owner's idea that was free from vulgarity and his pursuit of seclusion life.

4.3. Philosophy

Philosophy is another aesthetic characteristic of smellscape in Jiangnan garden, it was usually emerged in the name of view.

"Smelling Osmanthus Fragrance Pavilion" (Fig. 11., Fig. 12.) is a famous view in the Linger Garden (Liu Garden). The name of this view is an allusion to the zen book of *Wu Deng Hui Yuan*. It enlightens people getting out of the existing knowledges and appreciating the universe noumenon from every nature things like osmanthus fragrance floating in the air.



Fig. 11. The stele of Smelling Osmanthus Fragrance Pavilion. Photographing by author



Fig. 12. Osmanthus in front of the pavilion. Photographing by author

“Listening Fragrance” (Ting Xiang) is another name of view which was common used in Jiangnan garden. As is known to all, five senses have their own specialization, fragrance can only be perceived by smelling, but not by listening. However, why the ancients constantly emphasized “Listening fragrance” and even embedded this idea into the garden design? The ancient literati said:

From the perspective of spirit, nose and ear are the same.^[17]

Listening is not through the ear, but the spirit.^[18]

These prove that the experience of “listening fragrance” is not a perception of physical sense, on the contrary, it means closing all the physical senses and getting rid of rational logic, using spirit to feel the five senses interdepend and interconnect. This is an otherworldly experience and highest aesthetic realm. In this realm, the soul attained clear, bright and absolutely free, and the mental life was settled down.

5. Conclusions

In summary, smellscape is an important and organic part of Jiangnan gardens in Ming-Qing Dynasty. There are 102 species of aromatic plants used in Jiangnan gardens, and 22 species of them are the typical ones. These

aromatic plants are planted in different way such as land planting, pot planting and vase planting to design smellscape. It depends on the plant’s ecological habits, ornamental characteristics (posture, color, smell, sound, etc.), cultural connotations, utilitarian functions, as well as the surrounding conditions (rockery, water, building, corridor, pergola, fence, etc.).

In Jiangnan garden, mellscape is not just olfactory environment, it’s an aesthetic object. Seasonality, metaphoricity and philosophy are the important aesthetic characteristics of smellscape, and they benefit to well-being.

Although smellscape design wisdom of Jiangnan gardens in Ming-Qing Dynasty cannot be simplified as an accurate plan to be directly grasped, it should be an enlightenment to modern high-quality living environment and healing garden practice.

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Study on the Mode of Regeneration of Urban Abandoned Quarry —a Case of Fenghuang Lake Park in Nansha,Guangzhou

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Abstract

With the rapid development of urban construction, the ecological problems of abandoned quarry have become urgent problems in the construction of biophilic city. Nowadays, the mode of regeneration of mine abandoned land has changed from the initial single ecological rehabilitation to the integration of ecological rehabilitation and landscape function, and the pits have become part of the urban green infrastructure. Taking the design of Fenghuang Lake Park in Nansha, Guangzhou as an example, on the basis of ecological rehabilitation, this paper studies how to better play its functions of flood control and drainage, recreation and popular science education. And ponder several issues after the completion of the park, with a view to providing new ideas for the design of regeneration of urban abandoned quarry in the future.

Keywords: ecological rehabilitation; mode of regeneration; abandoned quarry; Fenghuang Lake Park

1. Introduction

With the development of the world economy, urbanization, industrialization, and resource development have led to the ecological destruction of the drainage basin and the deterioration of the urban living environment. The situation of the urban ecological environment has become increasingly severe. As the economic structure of developed countries shifts ahead of the developing countries, the problem of urban industrial abandonment caused by the arrival of the post-industrial era appears earlier. As early as the end of the 19th century, there have been renovations of industrial abandoned sites. Successful redevelopment can turn abandoned land into retail commercial land, residential land, office land, non-polluting industrial parks, parks, plazas, exhibition halls, etc., embodying the reusable recycling of land fully^[1].

From the early transformation, we can see that the designer retained the picturesque part of the scene and tried to use traditional aesthetics and design ideas to transform the fragmented landscape. Art began to intervene in the transformation of industrial wasteland, mostly abandoned quarries^[2]. With the introduction of ecological thought, major changes have taken place in the methods for the reuse of urban abandoned land. The respect for the site's ecological development process, the recycling of the material and energy, the advocating of the self-sustainability of the site and the advocacy of sustainable treatment technologies, reflect the strong ecological concepts. These concepts have been fully

reflected in the landscape design after the industry^[3].

Similarly, in order to reduce the input, quarry adopts vertical mining methods which leaves vertical quarrying surface behind. Abandoned quarry as a type of industrial waste, still looks like a piece of messy “patch” even after the quarry is closed, seriously destroying the surrounding natural landscape^[4]. Abandoned quarry can be used as land for various purposes after reasonable ecological restoration. The sunken ore pit is a scar on the earth, but its special topography is also the origin of wonderful design ideas. With years of development, there have been many cases of the design of utilization of abandoned quarry pits at home and abroad (see Table 1).

In a word, the regeneration mode of urban abandoned stone-pit has experienced continuous development in aesthetic design, ecological environment restoration, etc. Now it is not only necessary to realize ecological restoration, but also to change from a single ecological restoration to ecological restoration and fusion of landscape functions. Based on the ecological restoration and integrating various landscape functions, the abandoned quarry plays a more ecological, social and economic role.

Name	Place	Waste type	Site conditions	Renovation method
"Cricova" underground cellar	Chisinau, Republic of Moldova	Apatite quarry	The temperature and humidity of underground tunnels are constant throughout the year. It is the ideal natural brewing and storage environment.	Use abandoned tunnels to build wine cellars.
Butchart Gardens	Vancouver, Canada	Limestone quarry	Hierarchical subsidence terrain	Botanical gardens were built to highlight landscaping and reflect the garden culture of the East and the West.
Chenshan mine garden	Shanghai	Xuanshi quarry	The two pits in the east and west the bottom of which formed a pool, created a fine microclimate for plant growth.	Combine the postindustrial elements of the site, the Chenshan culture and the characteristics of the botanical garden, and build a recreational park.
Tianma mountain deep pit hotel	Shanghai	Andesite quarry	Deep quarry pit and large area	Exploring the value of unique landforms and building sunken 5-star hotels

Table 1: Comparison of repair cases of abandoned quarry pits at home and abroad
(Source: author homemade)

2. Project Practice

2.1. Project Overview

Guangzhou Nansha Fenghuang Lake is located in the central area of the Jiaomen River in Guangzhou, which was originally a six-large-stone pit left over from the south foot of the Nansha Dashanna Mountain. The stone-pit has a wide area and its depth is as high as more than 50 meters. The wall of the pit is steep, which has a great impact on the surrounding environment, and there are great safety risks. The construction goal of this park is to connect the six large quarry pits as a whole. Then connect water from rivers and lakes to divert water from the Jiaomen waterway, drill the valleys to connect the water in the mountain ponds, and excavate the lake to form artificial lakes.

Construct the embankment and supporting waterfront, else. The park would become a comprehensive pit park with multiple functions, such as improving the landscape of the area, rainwater storage as the main function, and improving the ecological environment, displaying the humanities and history, and providing recreational tourism sites .etc.

This article focuses on the construction of the completed Nansha Fenghuang 2[#] Lake. The total area of the lake is 143862m². This area is the middle construction area of the central of the Jiaomen River recently. The lake is combined with the exhibition hall key project for development and construction, which meets the priority construction conditions. It will help improve

the overall environment and image of the region (see Fig.1).



(Fig.1. Aerial view of Phase 1 of Fenghuang Lake construction project in Nansha)

2.2. Flood control and drainage

Nansha New District is located in the subtropical monsoon climate zone, with mild and humid climate, warm and rainy. The Fenghuang Lake Project has formed 6 lakes by integrating the original 9 quarry pits, and is connected with the downstream of the Jiaomen village River and Guiheng River, which forms the "Fenghuang Lake" of the Jiaomen River with a water surface area of 54.3hm² and a total length of 6.59km along the lakeshore. In the surrounding area of the lake, interception ditch will be set up to increase the area of rain collection in the lake, increase the natural runoff, create a clear spring water landscape in the dry season, and intercept mountain floods during the flood season. The landscape water level in the lake is maintained at about 5m by culvert sluice scheduling. Strengthen the vertical landscape convergence, improve the connectivity and accessibility of the lake

range, and explore its recreational value^[5] (see Fig.2).



(Fig.2. Replenishment water transfer schematic)

The main function of the 2[#] artificial lake is drainage, and the design standard adopts the regional drainage standards—the rainstorm in 24 hours in 50 years is not a disaster. Through the calculation of the characteristic parameters of the entire lake district of Fenghuang lake, the 2[#] lake is connected to the Jiaomen Village River through the connecting section. The landscape water level is same as the one of the Jiaomen Village River and Jiaomen Rivers, which is 4.7-5.3m. The maximum water level for the drainage is 5.74m, the maximum storage capacity is 1.79 million m³, and storage capacity is 85000 m³. The height of the lowest point of the surrounding land and road is about 6.3m. The lake bottom elevation of the Southern half part of the 2[#] Lake Construction Project is basically determined according to the status of the pit, with a maximum depth of about 50m and a minimum elevation of -27.5m. When torrential rain occurs, if the flood level H is

bigger than landscape low level which is 4.7m, and the flood level H is smaller than the outer river level H, the floodgate cannot self-discharge. Then the pump station needs to be turned on. This time, the direction of the water flow is the direction of the center of Jiaomen River to the direction of each pump station. And the direction of the water flow is multidirectional.

2.3. Viewing and recreation

As the lake area was originally a quarry pit, the water depth was deeper. For security reasons, the 2[#] lake area was unable to set up a cruise ship for people to play. What's more, the wall of the pit is relatively steep, and the ornamental green design along the edge of the pit has become the design focus(see Fig.3).



01. South Gate Plaza
02. Rest Gallery
03. Exhibition Hall
04. Hydropath
05. Sub Entrance Square
06. Phoenix Plaza
07. Phoenix Bridge
08. Viewing platform
09. Cultural Square
10. Landscape sculpture
11. Phoenix Plank Road
12. Five Hall Square
13. Main entrance
14. Parking
15. Bicycle position
16. Tea room
17. West Plaza
18. Hydrophilic platform
19. Public toilet
20. Fortress site

(Fig.3. Master Plan of Phase I of Fenghuang Lake Construction Project)

From the recreation point of view, this design combined with the current terrain, lays out as a circular overall structure in the plane, which combined slow traffic and node recreation. The overall layout of the plane is dug and filled to form a "gourd" shape, which takes the "blessing" and "wishful" meaning of traditional Chinese culture. On the side of Liuyuan Road, the water trestle shall be constructed under the premise of ensuring safety, to avoid excessive lengthening of the section of the road with the sidewalk, and to solve the problem of lack of slow traffic problem on the lakeside of Liuyuan Road. In order to enhance the accessibility of the park, a high-level viewing platform with close contact with the sidewalks, will play a role in

enriching the spatial level of the lake and providing a diverse view of the lake, together with the hydrophilic platform and the water plank road. At the same time, a landscape corridor bridge is added to the mid-lake island. The landscape corridor bridge is designed with the concept of "Phoenix Spreading Wings and Walking in the Woods". It spans the middle of the park and connects park courier station, mid-lake island and east entrance plaza into a whole, which is an important landscape node of the 2[#] Lake Park. In order to maximize the protection of the island's ecological environment, the landscape corridor bridge adopts an overhead form, with the terrain varying and ups and downs and forming a viewing platform. It is like a phoenix wing that rises above the lake island and is set amidst the forests of the lake island, which enrich the spatial level of the park greatly(see Fig.4).

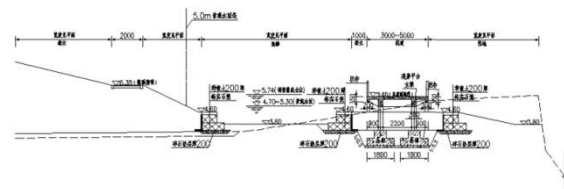


(Fig.4. Rendering of the landscape corridor)

The Fenghuang Lake Park bicycle path and trails are set along the lake and connected with the city's green road. Its entrances and other important nodes near the river bank are magnified into landscape plazas to facilitate the gathering of tourists. Along the main road, as far as possible, the original ecological pattern was maintained, and the polyline trails were partially embellished, which is interspersed with

greening and is rich in change. Cleverly set up a viewing platform to form a platform for picking up feet, choose a relatively smooth position on the shoreline, and walk through the steps down to the hydrophilic platform to give visitors the opportunity to get close to the water while ensuring safety.

From the viewing point, around the landscape walks set up along the lake, shrubs and flowers form a multi-layered landscape that covers the shores of the lake. Waterscapes, vegetation, and leisure trails echo each other. The greening of the lake adopts the form of planting troughs along the coast. Because the slope of the lake bank is very large, and almost no soil is available for plant growth, concrete planting troughs are set up along the banks, and the greening plants are potted in the planting troughs, as the greening of the lake(see Fig.5).



(Fig.5. Trestle standard section)

The artificial floating island technology can be adopted at the lake center far away from the lake shore. The functions of the artificial floating island include the prevention of embankment erosion and protection of the coastline, providing habitat for wildlife, landscaping, water purification and filtration, and biological disinfection six aspects^[6]. The use of artificial floating island technology, on the one hand, will increase the green coverage of the park and enhance the overall landscape effect of the

park. On the other hand, improve the overall water quality environment of Fenghuang Lake by the use of floating islands, to purify water bodies and achieve the effect of water purification and water beautification. By using the wet-framed ecological floating island, aquatic plants with strong resistance and a certain purifying effect on water quality are selected as the first-choice species, such as *Acorus calamus*, *Thalia dealbata*, *Iris*, *Canna generalis*, *Arundo donax var versicolor*, *HornLian*, *Zizania aquatica*, etc. At the same time, in order to imitate the vegetation greening effect of natural tidal flats, plants of different heights are selected to form three levels of high, middle and low level plant effects.

2.4. Science education

The stone-pit is unique urban landscape left behind by human activities. Its ecological and educational significance is also an important part of the cultural connotation of the area. The original fish ponds on the side of Fenghuang Avenue will be resources and facilitate ecological protection, improve water quality, and enhance the ecological character of 2[#] Lake. The layout of wetlands and trestle bridges take example by the flat pattern of mulberry fish pond in the south of the Five Ridges, forming a series of shoaled waters of varying sizes and shapes, with grouped plants of *taxodium distichum* and various types of aquatic plants. And water plank roads that shuttle between them to provide close contact with the water environment. opportunity. Plant the background forest along the top of the lake road, face the wetland with a gentle slope lawn to form the high spot of the site, and adorn the

ornamental trees locally, along with the sloping stone benches. The view is wide, and the panoramic view of the wetland is visible. Markers and science cards are set up to show the history of quarry pits, lake water purification, and conservation of native plants and animals.

From the perspective of historical culture, the ruins of the Jiaomen battery on the northeast side of 2[#] Lake are mainly protected in design. Keep the original terrain and text stele, and set the retaining wall according to the change of the actual terrain. In the ruins of the side, increase the entrance and set up the steps. Through the text and structure design, show the history and culture of Jiaomen battery. The fort sites can enhance the cultural connotation of the 2[#] lake. Because of the higher position, there is also a good view point. (see Fig.6).



(Fig.6. Rendering of protection and design on the old site of the Jiaomen battery)

3. Think

This article have expounded the restoration and utilization of Fenghuang Lake Park in Nansha, Guangzhou from three aspects: flood control and drainage, viewing and recreation, and science education. After the park was built, it was discovered that

there are still several issues to be considered by the park's post-evaluation :

3.1. How to better consider the use of mine pits in upper level planning

Because the distance between the red line of the urban planning road and the Fenghuang Lake pit is too close in the upper planning of the area surrounding the Fenghuang Lake, there are many congenitally deficient issues for the planning and construction of the Fenghuang Lake. For example, There is not enough space for park recreation, especially on the east side of the park. Due to being close to the main road Fenghuang Avenue, park road can only overhang the cliffs of the pits, which greatly increases the difficulty and cost of the project; There is a lack of green transition between the surrounding high-rise residential buildings and the park, and the viewing experience in the park is more depressing; The municipal bridge on the west side of the park passes directly over the lake surface of the park. The mass of the municipal bridge divides the lake into two parts, which is incongruous with the park landscape. The upper-level plan does not adequately take into account the use of the pit park, which has a great impact on the subsequent planning and construction of the park.

3.2. How to coordinate security and landscape issues

The particularity of the stone-pit terrain makes its safety issues need to be carefully considered in design. For example, after the project was completed and used, it was found that there was a security problem in

the park's gently sloped grass near the lake and the greening of the road adjacent to the main road. So a green wire mesh fence was temporarily added. Although the addition of these two places guarantees certain safety, the landscape effect is poor. Therefore, how to satisfy the needs of landscape visual effects and safety at the same time is a problem, which needs to be emphatically considered in landscape design.

3.3. How to better reflect the pit site characteristics

The stone-pit has a steep rock wall and generally has a large depth. In the current scheme, the connectivity of the water system has completely hidden the stone-pit, and the part of the mountain body exposed on the lake surface has been cleared. The special site characteristics of the stone-pit have not been reflected. How to use and display the unique topography and landform of stone-pit more rationally is a key research issue for the future planning and design of pit parks.

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Tactical Rural Planning in China ‘Beautiful Country’ Rural Renewal Planning Project

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Abstract

This paper contends that country public engagement and participatory of villagers in rural renewal planning project in China. It based on a rural regeneration project called ‘Beautiful Country’, This policy focus on the regeneration of poor condition and environment of rural China. The author argues that all of people who work for ‘Beautiful Country’ should familiarize themselves with strategies and tactics focus on effective, low-cost and long term changes in countries, especially for those rural public spaces out of management. Those public spaces were the keys for rural regeneration and it was an efficient way to create a popular and active open space, for people who have a desire to change and reconfigure their country. This paper chooses the regeneration plan for Bangzhuang country in Guangdong Province, China, with the strategies used by Tactical Urbanism, but in the rural China, it could be called as Tactical rural planning. Those actions (happened in Bangzhuang regeneration plan) include: community gardening, stimulate space rebuild, water canal cleaning and system rebuild, natural play, abandoned building reuse and more. These plans insight on the poor rural environment which designers and planners are ignored and it makes an effort to achieve more flexible spaces for people who live in the rural. It also tries to find solutions to the problem that ‘Beautiful Country’ faces: The regeneration of country and the people participation. Many of the efforts have been done before Bangzhuang, but lacking of participation of stakeholders leads ‘Beautiful Country’ works limited. The town planning and design need professional skills but the deep understanding of the rural China could be reflected by public participation, especially in the community gardening building, reuse of abandon spaces by locals and the processes for the rebuilding. The tactical rural planning gives Bangzhuang country the potential to move with the participation of stakeholders. This illustrated through the analysis of standards of ‘Beautiful country’ goals and it could be an effective way to doing the rural renewal planning.

Keywords: Tactical Rural Planning, Rural Renewal, Beautiful Country, Natural Play, Chinese village.

1. Introduction

A rural renewal planning project called ‘Beautiful Country’ was set up in rural China from 2013. The policy and strategies for this project will focus on 5 areas: agricultural development, life quality, rural civilization, cleanliness of countries and management democracy. Many researchers for problem of rural China are agreed with the policy. Many researches in macroscopic have been done before the thousands of designers and architects go to the countries for doing the rural planning and regeneration.

It is a difficult and huge rural regeneration project never happened in the history of China. In the Traditional Chinese Villages Catalog (TCVC,2012-2014), it shows that the number of traditional Chinese village is 4153, but the whole number of them is 662,238 (2016). It means that only 0.627% of villages are included in the catalog. Villages in the catalog have the priority for the design plan, special funding and more policy support. Architects and planners also will take those seriously, spend much time in this kind of village and do the design after a series of field research. With this policy and special funding support, the regeneration of villages in the catalog going quite well and the it succeeded (Fig.1) .Designers keep the traditional buildings, roads and other infrastructures, design with natural elements which are really important to these traditional villages. The policy supports the development of the traditional villages. Most of them found the right track on their development method, such as traditional

travel, characteristic agricultural products, characteristic crafts , natural education, etc.

As it mentioned before, only 0.627% of the villages in China are in the TCVC, it means 658085 villages which out of TCVC will not get enough technical and financial support. This illustrates the outcome of



Fig. 1. A traditional Chinese village:Dahekou village, Cangling Town, Youyang, Chongqin, China. (village of TCVC)

regeneration of these villages will be unsatisfactory as that in TCVC.

2. The disadvantages of rural renewal method in some villages of China

With the limited time and funding, the architects and planners who work for ‘Beautiful Country’ have to do the design in a simple but efficient way, although it might not be a good choice. They dismantle almost all the old buildings, except those in the listed buildings. Dismantle an old building and build a new one will cost much less time or funding than repair it. They usually have several templates which from urban building, but called ‘beautiful village housing’. Most of them look the almost the same, even in the same size (Fig.2). All the buildings located regularly as what we could see in

many modern cities of China (Fig.3). For those villages which are generous for their land, architects and planners will find a new land which near the original one, then they



Fig. 2. A New Chinese village, most the buildings designed by from same template.

build a new village and suggest villagers to move in. This could be seen as the lowest cost plan without any cost to dismantle. It seems that the villagers abandon the original village and move to a new village which

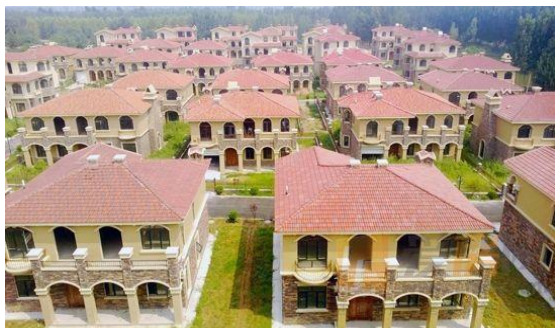


Fig. 3. Villas in Zhengzhou, Henan province, China.

looks like the city. This kind of regeneration effect not good as those villages of TCVC.

As what happened in many villagers of China, designers set oversize squares which are not matching the need and population for villagers. Those squares are rarely used because it is not friendly, popular or active enough. It really costs a lot of funding but

with a low return. No matter in the view of environment update or public space regeneration (Fig.4).



Fig. 4. Square in a village of Huian county, Fujian province, China.

Some of designers and decision makers lacking the consideration of budget and they prefer to put the money into some memorial archways or monuments in the entrance of village (Fig.5). Those high-priced monuments are not the primary task for village regeneration, they could not update the living condition, either.

To decrease the time of construction, local materials are rarely used in the villages regeneration project. Concrete, cement, tile, brick and quartzite are the suitable choices for designers. Another reason is that designers and decision makers believe these materials will contribute to making a clean



Fig. 5 Memorial archways of Datian and Jingnan, Fujian province, China.

and tiny village environment. However, this thinking will change the landscape style of village. It will change the texture and the fabric before which lead to a destruction to local characteristic. What is more, the frequently use of cement flag pavement is also waste and environmental-unfriendly. Earth, local plants and water, these nature elements is also a part of village, it is no need to avoid them (Fig. 6, Fig.7).

Above all, for some villages which are out of TCVC, the ‘Beautiful Country’ rural renewal planning project partly could be seen as ‘Constructive destruction’. The rural housing made by same template, oversize squares, useless but expensive memorial archways and overuse of cement, their disadvantages are obvious. All of those



Fig. 6. Cement covered the earth and grass under a ficus microcarpa, Dongshan, Fujian province, China.



Fig. 7. Cement barriers of the river , Huian, Fujian province, China.

method of rural renewal should be reviewed and correct before it leads to a greater destruction to Chinese villages (Yu, 2006) .

3. The potential methods

For those villages out of TCVC, the funding of village renewal is limited. Road system, drainage system and garbage disposal, which are usually the main problems villages face at the moment. Improving those infrastructures should be the first task. It will cost a huge part of the funding but it is essential and worthy. Those improvements will contribute to the village landscape, cleanliness and life quality of villagers at the same time. Then the second task of rural renewal could be focus on the public spaces. Those public spaces were the keys for rural regeneration and it was an efficient way to create a popular and active open space, especially for villagers who have a desire to change and reconfigure their village. In a Chinese village, villagers usually have a blood relationship with others and they will have temple fair, village traditional event quite often. It means the public space could be a link between villagers, this is particularly important: to keep the public space open and active. So the decision makers and designers need to consider the event and the things could be happened among villagers which close association with existing public spaces and the updating projects might be done. The strategies used by Tactical Urbanism might be a potential solution to activate the public space, it could be called as Tactical Rural Planning. The tactical rural planning is to

use effective, low-cost interventions for local rural areas benefit (Elrahman, 2017). It could be a simple or short-term revisions to use public space during the time out of the traditional events, to change the existing public spaces structure (Fayoumi,2017). With the rich landscape of rural areas, water, mountain, forests, grassland and agriculture land could be the elements of tactical rural planning, villagers familiar with these and revisions could be done and run by themselves. As it mentioned before, tactical rural planning could be done after the infrastructure, it could be seen as a method to close the connection of villagers. This benefits the rural civilization and rural management, it also meets the rest demand of ‘Beautiful Country’.

4. Bangzhuang Country and Tactical Rural Planning

4.1 Bangzhuang Country

Bangzhuang country is a small country in the Longjiang town, Jieyang city, Guangdong Province, China. It located in the south of Guangzhou, 5km to the South sea. Bangzhuang consists with 3 villages, there are Bangzhuang village, Xiangzi village and Lintai village. The total population of Bangzhuang Country is 4015, 2161 of them live in Bangzhuang village, 1104 live in Xiangzi village and 1013 live in Lintai village.

It has rich landscape resources, only 5km Southward is the South Sea, a river called Longjiang River passes through the Bangzhuang Country, three villages surrounded by agriculture land, parts of them covered by forests and there are some lakes in the villages. It also has historical

human resources, with several temples of Buddhism, temples for village god, ancestral halls and some ancient trees identified as the protection god of villages.

The problems of Bangzhuang are still obvious. Except those problems faced by other villages, the bad quality and too narrow road (Wu, 2014), incomplete drainage system and poor village environment, Bangzhuang suffered with other two main problems. The one is that it has a week land drainage. villages did have drain pipes, which were only for those drainage from indoor to outdoor. In village, sewers still need updated, this will be covered by infrastructure improvement. However, the land drainage between villagers was poor, ponding area is huge during the rainy days, especially in a wet climate of Guangdong province. Ponding may be harmful to some crops in Bangzhuang. It also makes the decrease of agriculture land. What is more, the open drainage canal covered with water hyacinth, a kind of aquatic weed, this dramatically slow down the speed of water flow (Fig. 8). Villagers are dissatisfied with this and it also become breeding grounds for the mosquitoes. The other problem Bangzhuang faced is the low quality of public space. There are some public spaces in villages, but it is not attractive enough (Fig. 9). However,



Fig. 8. Dranaige canal coverd with water hyacinth, a kind of aquatic weed



Fig. 9. Children play in a public space with a bad environment in Lintai village

it could not be successful without the participation of stakeholders. decision makers and designers could consider the opinions form villagers before making the decision. It also plays a key role in the rural regeneration.

4.2 Tactical Rural Planning

Those tactical rural planning actions could include: community gardening, stimulate spaces rebuild, water canal cleaning and system rebuild, natural play, abandoned building reuse and more. It could start from the gap space filling by local, like community garden or crop plot. The existing public spaces could hold traditional event as the local drama show, village god's birthday celebration and so on. Then the water canal cleaning could be activities for children and villagers, they could clean the water hyacinth by physical and biological way. This could be an activity for school, also could be seen as a natural class. For those abandon old building near the lake of village, the village management could have recreational activities or cultural movement. Some of old building also could be reuse for activity rooms for children, elders or women.

4.2.1 Community garden

Villagers in Bangzhuang wish to improving their living conditions, especially in the new village area. A lot of new buildings have been set there. It could not change the building style and the building patterns in the new building area. Nevertheless, it still could change the gardens, the gap between buildings and the line spaces along the roads. In the new building area, land have been separate into many blocks and every block has it owner. At this moment, there are some blocks still the empty. Maybe villagers could use that empty block and the gap between building to make a community garden. Just some chairs and table, surrounded by plants which villager like. Trees could be planted in the planter so that they could be remove easily. After this, a good place for relax and community communication will be done (Fig 10). This community garden might be short-term, with the development of village, the community garden could be replaced by a new house or garage. However, villagers will have the long-term benefits for their relationship with neighbors. There are a lot of water pump in Bangzhuang, this could be used for watering the community garden.



Fig. 10. Community garden between buildings

Everyone could help their neighbor and villagers water the plants anytime. The road in Bangzhuang is quite straight but narrow, the local material could be used for construct a pergola. This will totally change the façade of buildings and contribute to a better street landscape. Every family could have their opinion to choose the plants they like, flowers, vine, bamboo even vegetables

catching the fish by hands are well liked by everyone. Ponds could be classified by different depth of water for safe. Decks might be good but it is not necessary. A good option is to keep the ponds and the natural elements as original after safety check. Water, mud, water plant and the topography could be beneficial for children who play (Fig 12). Those are parts for nature and they



Fig. 11. Line community garden of Bangzhuang (sketch)



Fig. 12. Children are playing and catching fish in the pond.

are suitable for this line community garden (Fig. 11). The community garden boost the landscape of building area of Bangzhuang. Moreover, the social goals are achieved and the environmental benefits the whole village. This is will contribute to the regeneration of the village and meet the demand of village management.

4.2.2 Public spaces rebuild

Ponds, squares of the temple, spaces under the trees and agriculture land close to the village, those existing public spaces are potential for the village. For tactical rural planning, those spaces are close to buildings, the surroundings might be used for the background to support the events psychologically. People could change the spaces by short-term structures. Fishing and

could not be insulated in the development of children. The only thing designers could do might be keep them safe and try to create more possibility. Villagers will use those renewal spaces with limited interference. The trees in the village also could be used. A tree in the entrance of Lintai village is quite popular to children, it is only 10m to the next building. Designers could change level of the ground for a flexible way to play. Facilities for children play could activate these places after school. Some soft material as plastic papers, pipe and mirror paper could be freely used by villagers to create a colorful and attractive places (Fig 13). Those small changes might contribute to the public space renewal in village, more elders will refer to go to this place with their

grandchildren. The boundaries between building areas and public spaces will be flexible, this will make people come outdoor. During the time of traditional event, the play facilities could be replaced by show field by slightly changes. All of these methods used in the public spaces might be an efficient



Fig. 13. Public spaces in Lintai village (sketch)

way for rebuilding the spatial pattern of the village(Bayat,2016).

4.2.3 water canal cleaning

Land drainage is the main drainage way of Bangzhuang village. Most of the water canals were covered with water hyacinth. One way to solve this problem is to renew



Fig. 14. Children are cleaning water hyacinth by mini excavator, could be a activity.

Lantana is planted by the water.(sketch)

the water canals with concrete as other villages did. However, it might not be a good choice, it is not ecological, cost much and it will have negative impact to local ecology. The water hyacinth could be remove by villagers cleaning. This might be seen as a play activity for children. Some recreation facilities could be used for this, such as mini excavator, mini crane or hay mower (Fig.14). Children will enjoy the time of playing and the water hyacinth will be removed in the same time. The cleaning time could be set according to the growth cycle of water hyacinth and other water plants. Anther way is to increase the grade to make sure the speed of drainage flow rate, this will slow down the grow speed of water hyacinth. What is more, the walking paths between agriculture land and villages could be redesign. This will lead to a better walking system for villagers who do the farm work. Designers could set some terrestrial plant which negative to the growth of water hyacinth, such as lantana, along the walking paths. The fallen leaves of lantana into the water have inhibitory effect to the growth and development of water hyacinth (Yi, 2006). It could be seen as a biological, low cost and ecological way to deal with the existing water canal problem.

4.2.4 abandoned building reuse

The amount of old buildings in Bangzhuang is more than 50. Those old buildings are not used or less used, some of them are abandoned. Some old buildings are located in front of the Fengshui pond, it is potential to be a popular public space for villagers. People who play in this space will build the sense of their own community. Those old buildings are always with a strong traditional features, even could be seen as

the land mark for Bangzhuang. It could be renovated and switch to a public building such as library, junior or senior activity center and center of traditional event. Designers and decision makers could evaluate the quality of those old buildings first, then they decide which could be the most valuable for villagers to renew. It is no need for they to renovate all the buildings, they could make the process of the renovation freely. The stakeholders could participate in the whole process, even could DIY the building to what they wish to be (Fig. 15). Villagers have the talent with handicraft, traditional music could show these to others. The wall of the building, could be the background for the activities, or people could do some sketching, painting, doodling or writing in the suitable place. This could be a potential way for reusing the abandoned building (Sargin, 2012) and it



Fig. 15. Building reuse for creative activity(sketch)

could activate the community in the building area of Bangzhuang.

5. Conclusion

The difficulty of ‘Beautiful Country’ rural renewal planning project is more serious than we thought. Those villages out of TCVC faced the problems above and they could be lead to constructive destructions if we ignore the problems made by decision makers and designers. From the discussion above, Tactical Rural Planning may be a potential method for doing the rural renewal planning after the construction of infrastructure. Those participation of stakeholders, activities and the freedom decision makers and designers offer could contribute to the improvement of public spaces in Bangzhuang village. What is more, this will make the villagers have a strong sense for build a better village for themselves. Tactical rural planning may not solve all the problems, but it really responds to the problems we faced in ‘Beautiful Country’ project and it made us realize the challenges we have in follow. The method we try in Bangzhuang could be an example to show how it improve the environment and how public participation could be in the way of rural renewal project. With the public participation through the whole process, it could be an effective and potential way to do the rural renewal planning.

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Thinking and practice of the landscape LID technology in City Park Green Space - Case from Xuzhou, China

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Abstract

Based on the idea of system, over all planning the Rain systems、 the Natural systems and the LID systems in city, work together, to form water system belong to the city park green space in the specific climate and geographical environment, that work on permeate water、 retain water、 water Purification、 water Drainage、 Use water, for landscape ecological environment design is very important. The LID system is an effective complement to urban Rain system rather than an alternative to the water environment problem of urban park green space. On the one hand, the city park green space is naturally more permeable soil, natural vegetation water storage power, producing runoff speed slow, when heavy rain and floods, the park green space is the key unit to the city to regulate the rain water. On the other hand, due to the ground surface of road and paving in modern park is obstruct with the impervious surface, urban ground water recharge is insufficient, the rainwater resources by rainwater pipe network quickly go, city park green space caused by drought, water shortage which will affect the park microclimate environment and greening plant growth. Through two case of city park green space landscape design practice, from China Xuzhou, discusses the landscape LID technology application and effect, in the city park green space, and the thinking process, summed up six LID strategy about city park green space landscape. Main research contents include: research of Xuzhou city hydrology and rainfall conditions, the field into a natural savings, natural purification, natural irrigation and rain refinement using intensive green space, using both the construction garbage and surrounding demolition road waste materials as cavity packing, at the same time for real-time monitoring of field ground water environment and the use and management of collecting rainwater.

Keywords: City park, Green space, Landscape design, LID technology;

1. Introduction

The precipitation distribution in nature has its special law: there is a certain correlation between natural geography and precipitation, and this correlation has a significant difference in the gradient of precipitation in geography.

The spatial distribution of precipitation in China is unbalanced, and it gradually decreases from the southeast coast to the northwest. In the eastern part of China, the southwest and south China are affected by the southeast monsoons from the Pacific Ocean and the southwest monsoon from the Indian Ocean. The northwestern hinterland, which is

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blocked by mountains and far from the sea, is vulnerable to summer monsoon rains.

Area more than 1600 mm annual rainfall, is mostly in the southeast coastal area, precipitation in most places of Taiwan, an average annual rainfall of 6489 mm; 800mm and other rainfall lines pass through Qin MOUNTAIN -- Huai River to the southeast edge of the Tibet plateau; 400mm and other rainfall lines are mostly through the Daxing 'an ridge, Hohhot, Lanzhou, Lhasa to the eastern edge of the Himalayas; More than 200 millimeters are concentrated in the northwestern hinterland. The driest and driest place is Tokelson, west of the Turpan basin, with an average annual precipitation of just 5.9mm. (Fig.1)

Precipitation gradually from the south to the north of Jiangsu province, south of Wuxi, Changzhou, such as more than 1200 mm, annual average rainfall in northern areas such as Xuzhou, Lianyungang, annual average precipitation is 600-800 - mm, only the more significant difference between the north and the south. (Fig.2)

2. RESEARCH PROBLEM

In the process of urbanization, changes in the underlying surface bring about changes in the water environment. The surface of the city is mostly "impervious", which has the characteristics of large runoff coefficient, high yield and fast convergence. The occurrence of short duration of heavy rainfall, easy to cause waterlogging disaster, seriously threaten the safety of life and property of citizens. Urban roads bear the brunt of the flooding, becoming the most dangerous. In 2012, 77 people were killed in

the July 21 heavy rain in Beijing, 11 of them drowned on the road. ^[1]

At the same time, because the city ground "impervious underlying surface, as well as traditional to" row "give priority to the municipal drainage design patterns, pipes rainwater resources to be concentrated, platoon walk quickly, causing the deterioration of underground water level, ground subsidence, an acute shortage of water in urban soil, greening custody cost is high. The problem of urban water environment is mainly reflected in "urban waterlogging" and "urban water shortage". Urban Water Shortage and Waterlogging polarization has become an important factor restricting the sustainable development of cities. (Fig.3)

2.1. Urban water shortage in CHINA

According to 2015 China statistical yearbook, China now has 12 provinces (or municipalities directly under the central government) per capita water resources quantity under severe water shortages line, including nine districts (Beijing, Tianjin, Hebei, Shanxi, Liaoning, Shanghai, Shandong, Henan, Ningxia) water resources per capita is lower than 500 cubic meters, to extreme water shortage area. ^[2] In addition to Shanghai and Jiangsu, other areas of water shortage are in the north, mainly in north and northwest China. (Fig.4)

In order to ensure the normal growth of vegetation, a large amount of water is consumed every year. If city park green space per square meter every year green irrigation water 2tons of calculation, get rid of natural rainfall, Nanjing city park green irrigation water alone each year to 32 million tons,

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urban greening irrigation water use is high, brings great pressure to the city water. According to statistics, in 2012, Beijing's urban green water consumption reached 686 million tons, accounting for 19.0% of the total water consumption. ^[3]

2.2. Urban waterlogging in CHINA

According to China's ministry of housing and urban-rural development of 32 provinces in 351 cities in 2010 waterlogging situation survey, from 2008 to 2010, our country has 213 cities had different degrees of water waterlogging, accounting for 62% of the cities studied, waterlogging disaster city is more than 3 times a year has 137, accounts for more than 40%.

Through data analysis, urban waterlogging is common in both the southern and northern regions. According to incomplete statistics, Beijing, Jinan, Changchun and other cities in the northern region, as well as Wuhan, Changsha, Nanjing, Guangzhou and other cities in the south have suffered serious waterlogging disasters. It has universality and frequency. The urban waterlogging in the northern regions mainly occurred between June and August, and the southern cities were concentrated in May and September. The time of occurrence is relatively concentrated. (Fig.5)

The expansion of urban construction, make originally which has the function of natural water, flood peak depression, mountain pool, lake, reservoir damaged by artificially filling or filled with, for it greatly reduces the storage and distribution function of the city. The increase of the urban hardening area and the decrease of green space area resulted in

the gradual reduction of the seepage surface of the city, the increase of the surface runoff and the acceleration of the confluence, thus increasing the risk of urban waterlogging disaster. At the same time, it greatly reduced the water storage function of the underside of the city, resulting in water shortage in the city. (Fig.6) (Fig.7)

3. LID TECHNOLOGY RESEARCH

3.1. Characteristics of urban green space water environment:

As a sponge body, urban green space has strong infiltration capacity and water storage capacity. Its runoff coefficient is generally 5% to 15%, and the slope of green space drainage is generally 0.5-1%. Urban green space drainage is given priority to with surface drainage (i.e., use of green space of undulating terrain slope to make rainwater collection by oneself, again through the ditch, valley, mountain stream to organizations such as the guidance, into nearby bodies of water or to the nearest urban rainwater pipe), at the same time combining ditch drainage and drainage pipe as the supplementary means; The capacity of urban green space for rainwater is affected by soil properties, soil water characteristics, saturated conductivity, rainfall characteristics, etc. ^[4] The larger the soil permeability, the smaller the runoff. Vegetation can intercept rainfall, the strength of the degree of the intercept and vegetation types and climate types, plant species, plant canopy structure, closely related to rainfall intensity, etc.

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3.2. Urban green space LID strategy:

Urban green space LID strategy:

1. Protect the original green Spaces, such as forests and grasslands in and around the city;
2. Enhance the urban green space and urban water system and surrounding ecological base, build the network and scale of urban green space system structure, strengthen the rain flood regulation function of green space;
3. Through the catchment and storage means, strengthen the entrapment of green space and the surrounding land runoff rainwater and storage, and slow release into the soil around it;
4. Consider vertical design of green space landscape and drainage, guide the green catchment and collection of water;
5. Choose the sponge facilities, given the, runoff from itself and the surrounding through the overflow emission system and the urban storm sewer drainage system and rain runoff discharge system fully cohesion;
6. Choose plants combined with moisture conditions, appropriate chooses resistance to salt, submergence tolerance, carrying capacity emphasize native plants. (Fig.8)

4. Xuzhou city park LID practice

LID development technology is also called "sponge urban construction" in China, with the same research object and the construction goal, in the technology has been developing rapidly in China, won the strong support of the Chinese government. Xuzhou San Huan west road greening "sponge city" pilot project: including Xiang Wang road node and Han Shan road node.

4.1. Park green space -- design of the sponge green space of Xiang Wang road in Xuzhou city.

Xiang Wang road node sponge green space is located in the northwest of Xuzhou city, Xiang Wang road and San Huan west road. The total area of this project is 12545m². Considering the Xuzhou hydrology and rainfall conditions, the field into a natural savings, natural purification, natural irrigation and rain refinement using intensive green sponge, using both the construction waste venue and surrounding roads demolition and construction waste materials as cavernous cavity packing, at the same time for real-time monitoring of field ground water environment and collecting rainwater refines the use and management. (Fig.9) (Fig.10)

4.2. Park green space -- design of the green space of Han Shan road in Xuzhou city.

According to the vertical situation of the site, the site should be designed as a seasonal rainwater garden, and the rainwater retention and purification process can be realized. On a vertical processing, be natural rainwater collection in the field in central low-lying areas, through vegetation, sand and gravel, tectonic structure, such as natural sponge cavity filling will collect, purification, precipitation, rain after purification of water through the soil natural penetration, so as to achieve the water retention, accumulation, purification, and covering the role of groundwater. (Fig.11) (Fig.12) (Fig.13)

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5. APPLICATION AND DISCUSSION

5.1. LID design philosophy 1: System Optimization

According to City waterlogging and green Water shortage problem, promote to build the Integrated Water Management System in specific climate geographical environment of the City ("Water Collection - Water Utilization" Integrated Rainwater Management System), cut the surface runoff and accumulated Rainwater Utilization fully organic combination, forming an effective Rainwater Collection processing, centralized distribution, transfer, purification, rain slow-release function such as irrigation System, to effectively solve the City waterlogging and greening Water shortage, Achieve more urban rain Water, Landscape, ecological Design target of the coupling (Achieve the Multiple Design Targets of Integrating of Rainwater, Landscape and Ecology in City Road).^[5]

5.2. LID design philosophy 2: Adjusting Measures to Local Conditions

Significant difference exists among Different Location of the city (There are Obvious Differences among Cities with company's Geographical Location), for urban sponge system design, such as rainfall, soil properties, the terrain and the surrounding water system is the precondition of sponge system, management mode at the same time, also need to take into account such factors as aesthetic habits. In the current domestic under the urban green space application more recessed green technology as an example, the recessed green space with supplementary groundwater, regulating runoff, flood

detention and reduce runoff pollutants, and other functions, but also is affected by the underground water level, easy to assemble pavement has less waste, green, soil matrix is difficult to replace such limitations. Therefore, how to construct urban road sponge system in high water level non-permafrost regions must be adapted to local conditions.

5.3. LID design philosophy 3: Taking Advantage of Nature

The outstanding part of city waterlogging problem is due to the traditional drainage design focus too runoff to deal with the conflict is centralized, and uses the “源头分散、化整为零” (Source Dispersion and Break Up the Whole Into Parts) of the design can achieve twice the result with half the effort, to part not only alleviate the urban road drainage pressure, but also solve the urban road green belts pressure, but also solve the problem of the urban green are arid, restored the natural water cycle process of the city.^[6]

5.4. design philosophy 4: Qualitative Research

The whole process of system construction and research is based on quantitative research, using GIS and SWMM software to comprehensively analyze urban road vertical and water environment; Through quantitative research, scientific design pavement, rainwater transmission and storage system; The real-time transmission system of automatic monitoring devices such as sensors and Internet of things; Write special computer program and mobile APP, and monitor system operation through intelligent

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terminal equipment. Quantitative research to support the analysis and evaluation of water environment of urban roads, and scale and design facilities, sponge, sponge system and performance evaluation, etc., and improve the objectivity of sponge of city construction, scientific and accurate, quantitative research is of great significance for the urban construction of the sponge. (Fig.14)

6. CONCLUSION

Precipitation, underlying surface conditions, differences between different cities, urban water environment is different, city water problem is obviously not a strategy, the model can solve, sponge city construction must be for day, adjust measures to local conditions, based on the system architecture, the global understanding of sponge city essence collection of ooze water, drainage, water storage, water purification and water into an organic whole, solve the problem of urban water environment as a whole.

ACKNOWLEDGMENTS

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APPENDIX

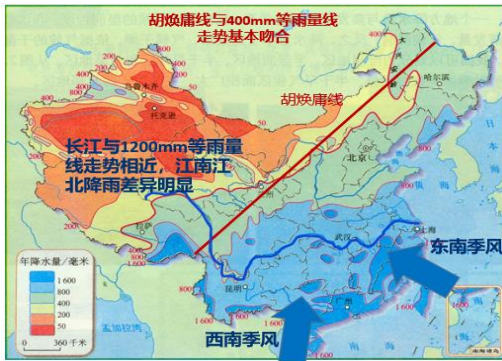


Fig.1. Hu huanyong line and the annual rainfall isoline of China.

苏北地区城市普遍降雨量小于蒸发量

城市	年均降雨量(mm)	年均蒸发量(mm)
徐州	831	1795
连云港	802	1469
宿迁	910	986
淮安	970	1500
盐城	976	1387

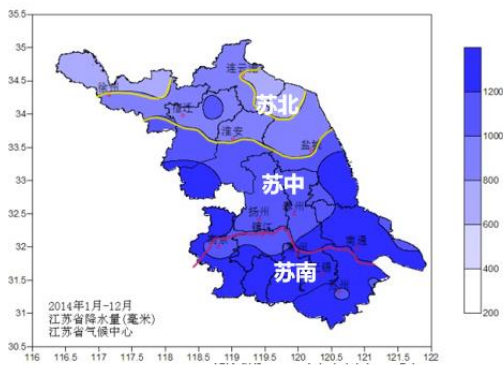


Fig.2. Precipitation distribution map of Jiangsu province in 2014.



Fig. 3. Urban Water Shortage and Waterlogging polarization.

城市	全年降水量 (毫米)				全年蒸发量 (毫米)				城市缺水
	全年	夏季	冬季	全年	全年	夏季	冬季	全年	
北京	203.2	18.6	80.0	272.2	1021.4	127.4	100.0	100.0	100.0
天津	114.4	11.4	55.6	76.1	1794.4	600.0	202.0	203.0	1074.3
上海	1862.0	1110.0	614.4	2987.1	1760.4	179.4	430.2	2000.1	1000.4
广州	1837.0	207.6	220.3	2457.9	1990.0	1990.0	403.0	403.0	403.0
深圳	1485.0	123.7	82.3	1691.0	363.6	370.7	96.7	91.0	4386.0
西安	580.0	201.0	130.2	911.2	642.0	642.0	121.0	121.0	2100.0
成都	944.0	614.4	206.4	1360.8	2007.7	2006.5	606.2	605.1	3140.5
武汉	1120.0	40.1	70.0	1230.1	1213.1	1213.1	204.4	204.4	3401.1
南京	47.1	40.1	70.0	157.1	1720.0	1720.0	506.4	506.4	3673.0
杭州	2000.0	200.0	100.0	2300.0	4462.0	4462.0	906.1	906.1	14000.0
昆明	1100.0	110.0	217.0	1427.0	301.6	301.6	301.6	301.6	1000.0
拉萨	1210.0	1210.0	300.0	1510.0	686.4	686.4	104.7	104.7	1000.0
乌鲁木齐	1000.0	1000.0	200.0	1200.0	790.0	790.0	349.4	349.4	1000.0
海口	1484.4	76.6	130.0	1691.0	10.1	0.2	21.3	19.4	100.0

Fig.4. Urban water shortage analysis table.

时间 TIME	城市 CITY	人员财产伤亡情况 LOSSES
2011年6月23日	北京	交通瘫痪, 2人死亡
2011年7月3日	成都	2人遇难
2012年7月21日	北京	77人死亡, 经济损失116亿 (其中11人在道路上溺亡)
2013年5月15日	厦门	5人死亡, 经济损失2500余万
2013年8月30日	深圳	2人死亡, 经济损失5000万元
2014年3月31日	深圳	2人死亡, 200余处积水内涝
.....		

Fig. 5. Statistics of waterlogging losses and deaths in Chinese cities in recent years.

内涝	事件数量 (件)			最大积水深度 (mm)			持续时间(h)			
	1-2	≥3	总计	15-20	≥20	总计	0.5-1	1-12	≥12	总计
城市数量	7	137	213	58	262	320	20	200	57	277
城市比例	2.2%	40%	62%	16.5%	74.6%	91.1%	5.7%	57.0%	16.2%	78.9%

Fig.6. Waterlogging statistics of 351 cities in China in 2008-2010 years.

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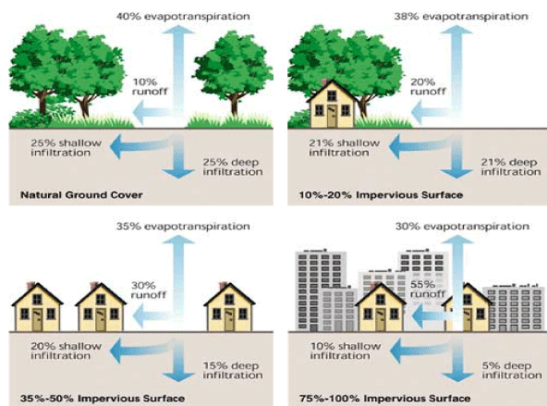
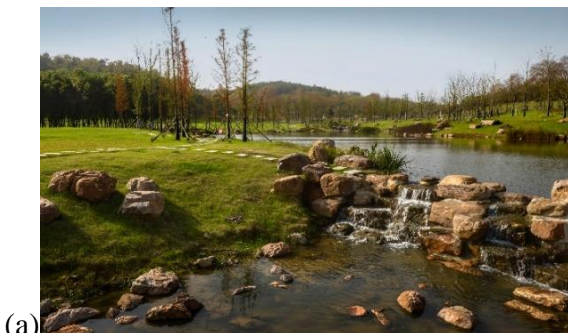


Fig.7. The influence of water evaporation, osmosis and loss of water under different proportion of water in city.
 (a) natural surface,
 (b) 10%-20% impervious underlying surface,
 (c) 35%-50% impervious underlying surface,
 (d) 75%-100% impervious underlying surface

Fig.8(a)(b). The team carried out the experimental research in the green space of the Niushou mountain park in Nanjing.



Fig.9. Xiang Wang road node Landscape design plan.



(a)



(b)



Fig.10. Xiang Wang road node sponge green space construction process and completion effect.



Fig.11. Han Shan road node Landscape design completion effect.

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Fig.12. Han Shan road node Landscape design plan.



Fig.14. Water environment measurement and control system of Xiang Wang Road.



Fig.13. Han Shan road node sponge green space construction process and completion effect.

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Nanyang Technological University of Singapore – Biophilic Campus in the Making

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Abstract

Formed in the year 1991, Nanyang Technological University of Singapore (NTU) was sitting on the old campus ground of former Nanyang University built in 1956. The 200 Hectares Yunnan Garden Campus is the largest (by land sizes) and oldest university campus in Singapore with rich cultural and heritage value as well as generous natural parkland-like landscape. One of the most memorable and distinctive features of Yunnan Garden Campus is its abundant and varied landscape. These include avenues of shade trees beside streets, large open spaces, primary forest along the northern and western edges of the campus, the meticulously designed environment of the iconic Yunnan Garden, and informal planting that surrounds Nanyang Lake. This diverse collection of original landscape is neither substantially integrated nor well connected. Over time, the original continuous landscape has been fragmented by the construction of roadways, buildings, pathways, and other infrastructures. The ecology of these isolated landscape patches was further degraded by a limited variety of plant species, the prevalence of introduced plant species, and the disruption of the original groundwater and surface water patterns. The proposed master plan in 2010 is driven by the key strategy to address ecological fragmentation by stitching the natural system back together, based on modal of “patches, corridors, and matrices. Blue and green landscape corridors were introduced as part of the essential framework of the campus masterplan connecting the scattered greeneries around the Campus. The idea was first tested in the Pioneer and Crescent Hall Project in year 2012. The project was completed in year 2015 and had brought biophilic living to reality.

Keywords: Ecological fragmentation; Natural System; Patches Corridor Matrix; Biophilic

1. NTU Yunnan Campus Masterplan 2010

The 2010 Campus Masterplan values the significance of the natural environment of the Yunnan Garden campus. One of the key objectives of the masterplan is to enhance and reinforce the university's identity as an eco-friendly and biophilic campus. Based on an ecological theory of 'patches, corridors, and matrix' developed by Richard Forman, the master plan outlines a long-term strategy to re-connect the fragmented patches of the landscape into a sustainable whole that will enhance the biodiversity of the campus. This approach includes the creation of an integrated network of green and blue corridors thru parks and green infrastructures for an environmentally sustainable and integrated landscape.

By adopting the ABC Water programs initiated by the Public Utilities Board of Singapore (PUB). The collection, treatment and conveyance of rainwater run-off and water conservation will complement the development of these integrated blue and green landscape corridors. This will require new and existing detention ponds, retention ponds, and other water bodies to collect surface water runoff for recycling and re-use. The ponds and water bodies will also enhance ground water recharge, and provide a habitat for birds and other wildlife. The masterplan had recommended for all existing and future proposed stormwater drains and drainage channels to be designed with the ABC Waters guideline in mind whenever feasible, to create naturalised water ways, minimising the quantity of impermeable concrete drains on campus.



Fig. 1. NTU Yunnan Garden Campus Masterplan 2010

1.1 Patches, Corridors, Matrix

Patches, Corridors, Matrix is a landscape and ecology theory developed by Richard Forman in *Land Mosaics: the Ecology of Landscape and Regions* (1995). It classified the natural environment in term of three basic spatial element, referred to as patches, corridors, and matrix.

There are several isolated landscape patches within the campus and surrounding environment. To connect these typically isolated patches, several landscaped corridors are proposed. For example, one of the proposed landscape corridor will link Clean Tech at the east of the NTU Yunnan Garden Campus to the parkland in the North Hill precinct, create a natural corridor adjacent to Nanyang Avenue and provide a continuous landscape connection leading from the new east west entry road

southwards to Yunnan Garden. The proposed corridor will also add extensive natural linkages at the campus periphery, expanding the size of the original ecosystem.

The reconnection of isolated patches will improve the health and fitness of both the patches and the landscape corridors. Both the corridors and the patches will be planted with native plant species to increase biodiversity. Wherever feasible, landscape corridors will extend across, above or below existing roadways, pathways and other barriers allow animals an uninterrupted movement. Boardwalks and pathways along the landscape corridors will create opportunities for interpretive nature walks. Pavilions and decks accessed from the boardwalks and pathways will provide further informal social gathering spaces, outdoor classrooms, and lookouts.



Fig. 2. Landscape Masterplan framework based on patches, corridors, and matrix theory. The corridors allow unimpeded flora and fauna movement between patches.



Fig. 3. Illustrative plan: The site's natural system provides a foundation for the Master plan's proposal. The ecological framework of the campus help determines the future development possibility. The corridors allow unimpeded flora and fauna movement between patches.

1.2 Habitat Corridor

Habitat corridors are land or water connections that permit uninterrupted, safe movement of animal across roads, walkways or other barriers. Habitat corridor will be a significant element in encouraging biodiversity by maintaining the health and fitness of plant and animal species. Movement within the broader natural systems will also lead to a more diverse and vibrant natural environment, better able to sustain itself. Habitat corridor was identified

as one of the essential components in enhancing the natural system of the Yunnan Garden campus. Whenever feasible, the existing and new development with the university should bear in mind the importance of creating an uninterrupted ecosystem and shall promote the enhancement of the biodiversity around the campus by taking into consideration the ecological aspect during the planning stage of the development.



Fig. 4. Section of a Habitat Corridor underneath a Roadway. This is an example of how habitat corridor can be part of the infrastructure for the campus while at the same time utilise as a safe passing corridor for small animals to move from one habitat to another.

1.3 Naturalized Waterways, Retention Ponds & Detention Ponds

The original surface water and ground water routes of Yunnan Garden Campus have been altered by several hardscape areas. These drain into some impermeable reinforced concrete storm water, roadside and building drain. While this drainage system are generally very efficient, it has a number of adverse environmental effects.

Existing and proposed new drainage system should be designed and adopt the “ABC Waters Design Guidelines”, to create a more sustainable drainage strategy. This will involve, where feasible, the creation of naturalised waterways and vegetated drainage swales.

The ABC Water Programme was started in the year 2006 by the Public Utilities Board of Singapore (PUB). It is the Singapore’s version of Water Sensitive Urban Design

(WSUD) program aiming at transforming all water bodies in Singapore into clean, beautiful and functional landscapes where the water could eventually be retained, harvest and reused for the water scarce country.

A number of new detention and retention ponds for the recycling and reuse of rainwater runoff will be created. All campus water bodies, including naturalised waterways, retention ponds, detention ponds and lakes will form a continuous integrated network of water elements. The naturalised drainage system has several benefits. These include habitat for native flora and fauna and the creation of social, recreation, and interpretive learning opportunities. The natural cleansing and filtering by water plants through biological uptakes will not only capture sediments and reduce the passage of pollutants, it reduces heavy metal and contaminants in the water system and cleaner water will be discharged.



Fig. 5. Informal walkway/ Social space set amid landscape corridor: Design includes pedestrian walkways, bicycle paths, open timber terraces or discrete sheltered pavilions.

1.4 Planting & Hardscape Strategy

The Master Plan's planting strategy is based on the re-creation of a native landscape of lowland rainforest species sustainable within this endemic environment. Fostering native flora and fauna will increase the landscape's biodiversity. A native landscape is also easier to maintain and will give the campus a distinctive character and sense of place.

Within the naturalised waterways and the retention and detention ponds, wetland plants known for their water cleansing and filtration properties, as well as for their slope stabilising properties should be used. These plants should also provide habitat for native animals and birds. The goal of the planting selection and design is to mimic a natural littoral edge.

Minimizing hard surfaces should also involve the transformation of exposed concrete roof surfaces and terraces using green roof systems. The impact of hard surfaces can also be reduced at ground level where new road paving, parking lots, pathways and plazas should be constructed, wherever possible, with permeable and porous paving materials.

1.5 Implementation of the Masterplan

The substantially integrated blue and green landscape corridor is an ambitious program of landscape program for the university. It will form a physical network as the backbone of proposed new built form on the university campus. It will be the fundamental principle and landscaping roadmap to follow through and implemented over the next 15 to 20 years.



Fig. 6. Nanyang Lake will be a storm water retention pond integrated with the broader system of on-campus stormwater to support native flora and fauna, as well as social interactive space.

2. Pilot Project – **Pioneer and Crescent Hall @ NTU**

2.1 *Project Overview*

The integration of a blue and green network was first tested in 2012. The landscape design of the Pioneer and Crescent Hall at Nanyang Crescent is a combination of the naturalised waterway, wetland and ponds surrounded by a native landscape that is sensitively integrated to create a dynamic equilibrium of nature and man-made. Inspired by the big idea behind the masterplan, the six residential towers designed by the architect sprawling over a 3.5 Hectare of land is making an analogy of the stilt roots of the mangrove tree sitting over the pool of natural water body.

An underlying principle of the landscape design is the landscape/ecological theory of ‘Patches, Corridors, Matrix developed by Richard Forman (1995). The deep topography depression of the site presents a unique opportunity for integrating ‘Active, Beautiful, Clean Waters’ features in the landscape design (ABC Waters Program). Existing concrete drains, stagnant water bodies and an isolated lily pond, are transformed and connected by a green and blue landscape ‘Corridor’ of natural stream and water cascade, to new ‘Patches’ of the cleansing biotope, retention and recreational ponds, rain gardens, and marshland.

The naturalised drainage system provides

a habitat for native flora and fauna, increasing the landscape's biodiversity. The natural cleansing and filtering by water growing plants capture sediments and reduce the passage of pollutants. The continuous network of water elements established through the site provided a natural setting for a variety of spaces such as seating decks, gazebos, boardwalks, amphitheatre and outdoor classrooms,

creating social, recreation and interpretive learning opportunities.

The fusion of landscape and architecture intermingling creates a spatial symbiosis between man and nature, resulting in a nurturing holistic environment that strikes the perfect equilibrium between study and play, rest and rejuvenation.



Fig. 7. Overall Site Plan of Pioneer & Crescent Hall at Nanyang Technological University, Singapore, Yunnan Garden Campus.

2.2 Key Observations of the Existing Site

Existing Lily Pond:-

The existing lily pond is a shallow pool of water with a depth of 500mm. There is no sign of algal bloom due to insubstantial Nutrients discharged through the inlet culvert and well-adapted water plants within the pond that are effective in removing nutrients from the incoming runoff.

Existing Open Earth Drain:-

Stagnant and muddy condition observed in downstream water body – the open earth drain. There are forming of algal bloom

found near to the pipe culvert, and the majority of the water body is stagnant. The muddy water is a result of a shallow water body with an unlined bed.

Existing Concrete Cascading Drain:-

Signs of erosion were observed at some parts of the shallow water body. This indicated that the existing water body might have experienced fast flows in the past. The fast flowing condition could be even more pronounced due to fast flow for incoming cascading drains and the absence of energy dissipater.



Fig. 8. Diagram illustrating key observations of the site.

The Impact of the Proposed Student Housing Development:-

- a. Runoff incoming into the water body is associated with the higher nutrient level and suspended solids compared to current grassed/vegetated surfaces.
- b. Water quality within the existing water body may deteriorate further, especially within those shallow water bodies downstream of the lily pond. This is because these shallow water bodies do not have settling capacity as well as limited phytoremediation taking place within them. Coupled with its stagnant condition, the risk of algal bloom is expected to increase.
- c. Water level fluctuation within the existing water body is supposed to be higher when more runoff is discharged from the new development.
- d. More erosion is expected to take place at the banks of the water bodies as more runoff is discharged from the new development.

2.3 Design Approach and Objectives

To minimise the impact of the development and to ensure proper water quality within the water bodies surrounding the development, the following approaches were adopted:-

- a. Water quality sampling and analysis were carried out to identify nutrient levels from the incoming culvert and drain. This enables a better design of ABC Waters Design Features.

- b. The current shallow water body was re-configured in term of their bed profile and shape to achieve the following:
 - Better settling capacity of the water body;
 - More shallow marsh, deep marsh or submerged marsh to be introduced around the water body as a buffer to reduce sediment from being discharged into the water body; as well as to promote nutrient removal by plants;
 - Better flushing by introducing cascading streams;
 - Separation of a large water body into various smaller water bodies, where each of them was designed as different ABC Waters Design Features, aiming to promote treatment train;
 - Energy dissipater (in the form of natural rocks) was introduced to dissipate energy for incoming drain so that to minimise soil erosion.

The ensure that the goal of the project will be achieved, the design team had outlined the following objectives:-

- a. To remove pollutants/nutrients from existing/new development before discharging into the water body.
- b. Encourage stormwater harvesting and reuse.
- c. Re-configuration of existing water body to enhance self-cleansing capability and encourage phytoremediation processes.
- d. The utilisation of water body as a lifestyle.

2.4 Key Design Considerations

Flood Control

- a. Proper by-pass system from ABC Waters design features must be provided and connected to the storm drain so that the surrounding area will not be flooded. As a result, an emergency spillway was proposed as a flow bypass of downstream wetland for events up to the 10-year ARI event.
- b. Minimum engineering requirements for surface water drainage must be met.

Performance Targets

- a. ABC waters features to be designed to meet the stormwater quality objectives
- b. Removal of 80% for TSS, 45% for TN and 45% of TP (for 90% of all storm events)

Erosion and Sediment Control

- a. Prevent sediments form construction

sites from flowing into drains during rain events. Proper slope gradient were considered during the design process.

- b. Employing soil stabilisation techniques such as bioengineering

Mosquito Control

- a. Prevent mosquito breeding

2.5 Design Implementation – *The Living Water bodies*

Based on the site topography, site characteristics and design intention, the following treatment train of ABC Waters Features is proposed to achieve sustainable stormwater management:

- a. Sedimentation Basin
- b. Linear Wetland
- c. Bioretention Basins (Rain Gardens)
- d. Cleansing Biotope
- e. Pond

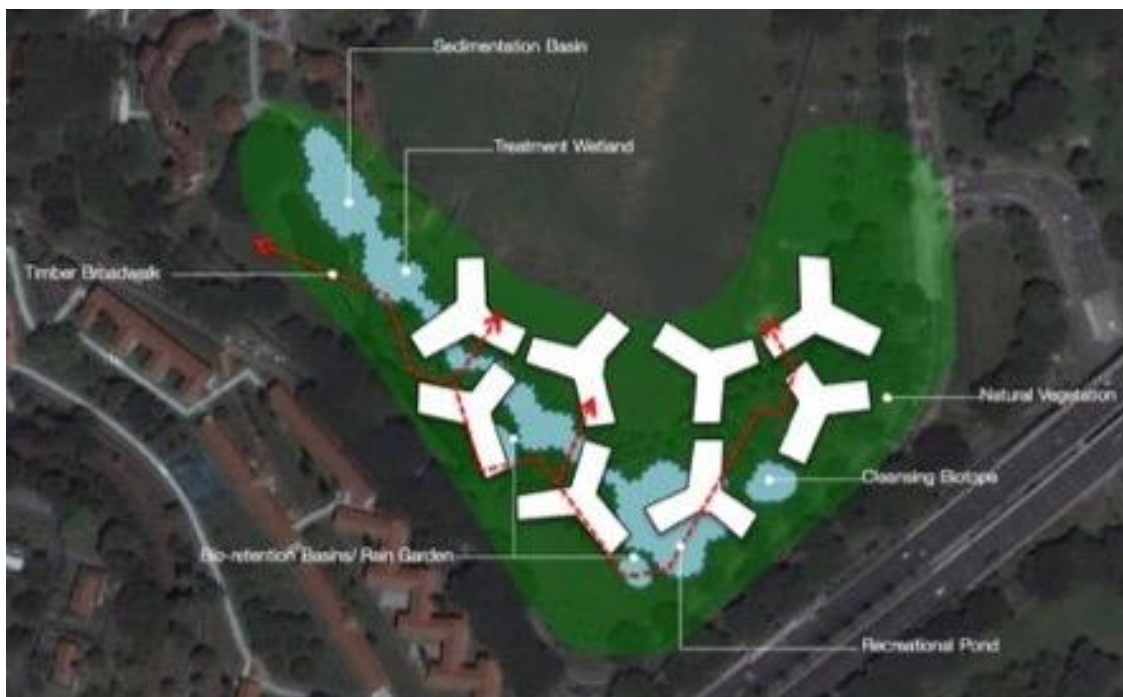


Fig. 9. Diagram showing the design principles and idea.

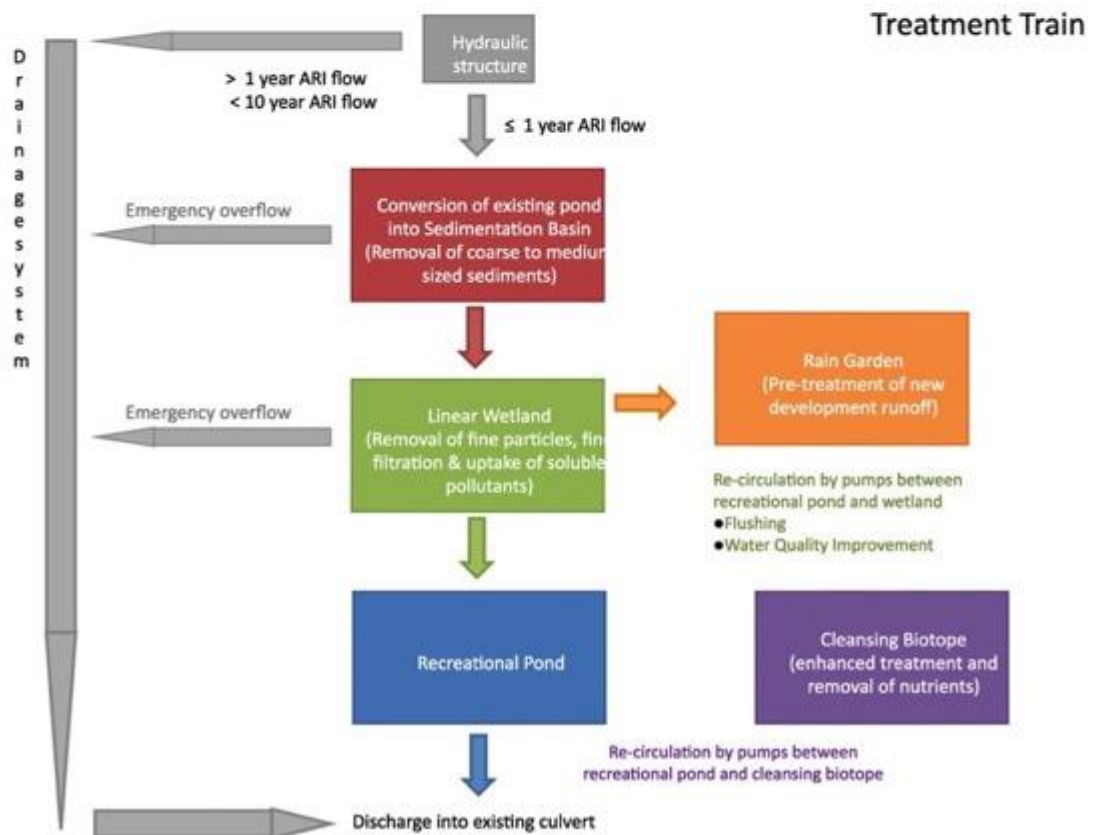
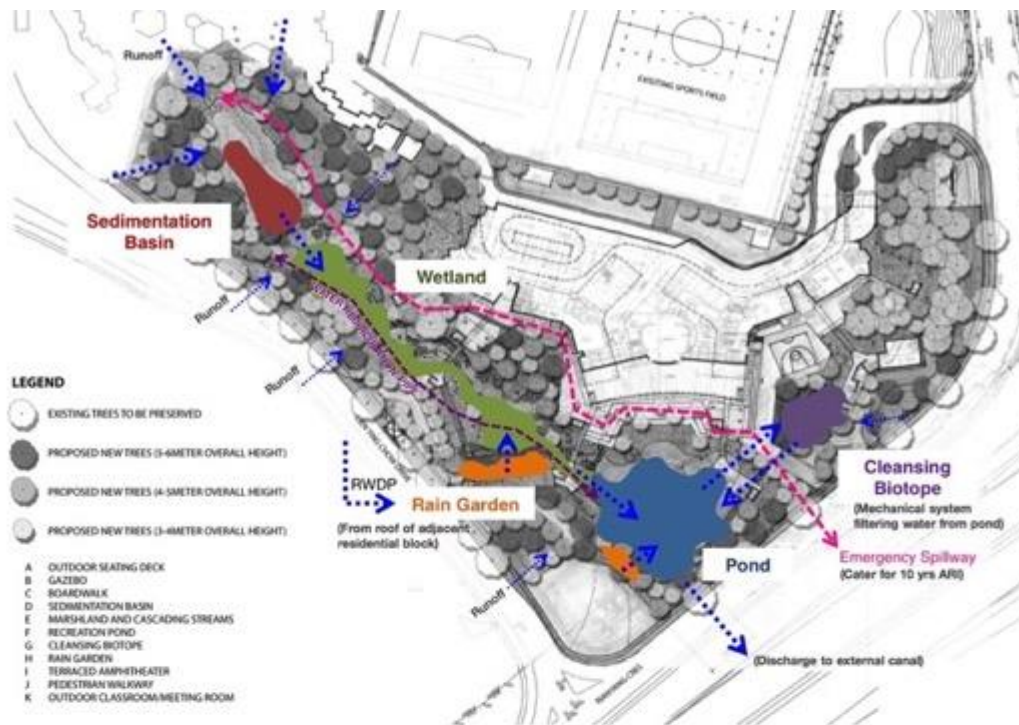


Fig. 10. Treatment train diagram illustrating the stormwater system designed for the landscape area. It explained how water was being collected, treated and conveyed.

Cont. from Point 2.5

Sedimentation Basin (@ RL+117.0)

Reducing sediment loads is an important way to improve stormwater quality. Sedimentation basins can form an integral component of a stormwater treatment train and are specifically employed to remove (by settling) coarse to medium-sized sediments from the water column. As such, the existing lily pond furthest and highest in terms of topography is proposed to be converted into a Sedimentation Basin, which will retain any coarse sediment before discharging runoff into a Linear Wetland.

Linear Wetland (@ RL+116.0)

The Wetland is a shallow extensively vegetated water body using enhanced sedimentation, fine filtration and pollutant uptake processes to remove pollutants from stormwater. Water levels rise during rainfall events and outlets are configured to slowly release flows, typically over three days, back to dry weather water levels. The relationship between detention time, wetland volume and the hydrologic effectiveness of the system were optimized to maximise treatment given the wetland volume site constraint. Plant material was carefully selected to ensure proper nutrient uptake.

Bioretention Basins/ Rain Gardens (@ RL+117.0)

The two Bioretention Basins/ Rain Gardens will pre-treat runoff from impervious surfaces of the new development and the rainwater discharge from the roof of the residential towers before discharging it into the Wetland and Pond.

The basins were densely planted with surface vegetation as a means of pre-treatment before they infiltrate/percolate through a prescribed filter media. During percolation, pollutants are retained through fine filtration, adsorption and allowing some biological uptake.

The Cleansing Biotope (@ RL+116.0)

The Cleansing Biotope, a form of artificially constructed wetland, consisting of nutrient-poor substrates that are planted with wetland plants which are known for their water cleansing capacity, is proposed in the eastern part of the project site. The water runoff is filtered through the substrate layers, collected by the underneath perforation pipes, which finally discharge the treated runoff out from the biotope system. The biotope is designed to provide higher treatment to the site's runoff by re-circulating water from the pond to the cleansing biotope and – after further treatment – discharging back into the pond thru mechanical system (Water Pumps).

Pond (@ RL+115.0)

The central pond adjacent to the canteen represents the predominant water body of the development due to its proximity to the new residential halls and gathering places. It is for that reason that the water quality present in this pond is of utmost importance and can only be achieved by a series of pre-treatment and re-circulation.

The introduced re-circulation between pond and the top of the wetland will not only improve the treatment of stormwater and therefore the water quality of the pond but only avoid any stagnant water by creating a continuous moving water body.



Sedimentation Basin



Wetland 1



Wetland 2



Recreational Pond

Fig. 11. Schematic section through the Sedimentation Basin, Wetland and the Pond. Breakout spaces and boardwalk were added as amenities to the dwellers.



Fig. 12. Sedimentation basin transformed from isolated lily pond as part of the "Active, Beautiful, Clean Waters" feature designs, contributing to sustainable water management system and increasing the landscape's bio-diversity.



Fig. 13. Night view of outdoor classroom (Pavillion by Architect) overlooking marshland and cascading stream.



Fig. 14. Outdoor seating deck and Gazebo with view of pond and cascading stream.



Fig. 15. A glimpse of the introduced natural system from the student hostel above. The integration of nature and built form was carried out with the aim of creating a biophilic living environment for the staff and student.

3. Conclusion

The master plan in 2010 had outlined the key strategy to address ecological fragmentation by stitching the natural system back together, based on modal of “patches, corridors, and matrix. As a result, integrated blue and green landscape networks were introduced as part of the essential framework.

The sensible design strategy represents a unique opportunity to create a cohesive, inclusive and high-quality private realm which complements the University campus and existing context, creating a peaceful oasis within the vibrant campus compounds. In between, what oneself did not realise is that the integration between nature and the existing/ new built form had slowly turned the university into a biophilic campus.

The pioneer and crescent hall project have laid down a good foundation and earmark as a successful precedent for similar projects in the future. This had given a boost of confidence to the campus community in believing that the key landscape principle is the one to live by.

More projects of similar nature of different scale will be implemented campus-wide over the next few years as part of the Masterplan's recommendation. For instance, the up and coming Yunnan Garden and Nanyang Lake Upgrading Project which schedules to complete by the year 2020. With the strong momentum and continuous efforts, coupled with careful implementation, a biophilic NTU Yunnan Garden Campus is not far from being a reality.

Acknowledgments

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Masterplan Graphic extracted from:
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Living in Sculptured Nature A Case-Study of Three Private Residential Development

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Abstract

The landscape design of outdoor communal spaces within private high-density residential developments (condominiums) is not known to the public at large, as they are private spaces, only known and used by the residents of the developments. But this space contributes to around 40-60% of the footprint of each development, and that amounts to a substantial area where the landscape enhances the residents' experiences with and connections to nature, and also makes a contribution to the environment.

The immediate experience of the communal landscape space is visual, auditory and tactile. Outdoor amenities such as swimming pools, children's playgrounds, gardens, and seating areas are usually integrated into the landscape design. When the design of such spaces takes on forms, textures and materials derived from nature or natural elements, the result is the creation of spaces that strengthen users' connections with nature.

The visual experience of the landscape is from near and also from a bird's eye view, as the high-density developments have residential units on high floors with views down to the landscape space below. The use of sinuous, organic forms in the design of landscape elements mimic forms found in nature, such as curved lines of rivers, waves, branches or leaves, enhancing the visual experience both from near and afar. Overall patterns of these curved lines weaving across the built landscape, intersecting with each other, giving rise to spaces in-between the curves that are bursting with colours of blue and green, provide arresting images reminiscent of nature. At times, the straight lines of the architecture or of a landscape element such as a walkway cut across the curves and organic forms, creating contrasts that heighten the sensory experience of the landscape.

The auditory experience is contributed by features in the built landscape that create sounds of nature, such as a waterfall, a bubbling creek, a water spring. Other sounds of nature are borrowed from fauna such as birds and insects that are attracted to the natural plant elements in the landscape design.

The tactile experience of the landscape comes from the use of natural elements or materials. Colours of blue and green are formed by the natural elements of water in the pools and planting that surround the outdoor amenities and spaces. The use of natural materials such as granite and timber, add to the tactile experience of the users.

Keywords: High Density; Urban; Landscape Design

1. Case Study No. 1 – The Panorama

In the Panorama project at Ang Mo Kio, the design and layout for the landscape gardens was conceived as a lush tropical garden environment that corresponds to the site. Inspired by the naturalistic contours of the site, the genesis of the concept is an abstraction and manipulation of the notion of contours, the landscape design has ‘ribbons’ of walkways and decks weaving across the central open space between the residential blocks, in both horizontal and vertical dimensions, creating a multi-layered and pluralistic environment, linking together different amenity zones.



Fig 1. Aerial overview of the sinuous landscape at The Panorama. Photo by Robert Such; Robert Such Photography.

The planning of the building blocks around the perimeter of the site, surrounding a large central landscape space, provided the opportunity for aerial views of the overall landscape from the residential units at various levels and also from the roof terraces of each block.



Fig 2. Night aerial overview of sinuous landscape at The Panorama. Photo by Takeo Sugamata; SWITCH.

The sinuous lines of the landscape weave across the site like ribbons, gradually flowing up and down along and across the center of the open space. The lines take on a 3-dimensional form, with a tree-top wall sweeping across the landscape, over pools, walkways, a playground, and lush planting beds, providing a varied experience of walking across these elements at different heights. The spaces between the lines are filled with a soothing composition of colours from natural elements of water (blue), planting (green), timber deck (brown), granite stones (yellow and gray), offering a rich visual experience.



Fig 3. Sinuous lines at landscape flow up and down. Photo by Robert Such; Robert Such Photography.



Fig 4. Lines take on a 3-dimensional form – a tree-top walk sweeps across, over a playground. Photo by Author; Yeo Seow Nan.



Fig 5. Organic forms expressed at an intimate level, with curved benches rising out of the floor. Photo by Author; Yeo Seow Nan.

The organic forms derived from nature are also expressed at a more intimate level, in a lookout deck with a stretched canopy, a mesh walkway that weaves between trees in a curvilinear form, down to even smaller details such as the curved benches that rises out of the floor at the roof terrace.



Fig 6. A mesh walkway weaves between trees in curvilinear form. Photo by Takeo Sugamata; SWITCH

The gentle bubbling of extensive pools in the central landscape space provides a calming auditory experience. A curved waterwall cascading from the ground level down the basement drop-off area creates soothing waterfall sounds that mask vehicular noises. Quiet reflective pools surround the drop-off area.

The tactile experience is crafted with a careful choice of materials. The lightness of the mesh railing of the treetop walk allowed users to feel close to the surrounding elements, and at the same time, fulfill authority-specified safety requirements. The detail of the mesh selected, weaving of metal in ribbon form, is consistent with the overall landscape form. Natural timber was selected for the main pool deck areas, outdoor dining spaces, lookout decks at the ground level and roof terraces, to provide a softer tactile experience as these are activity spaces where users spend more time, compared to circulation spaces finished with the harder granite material.

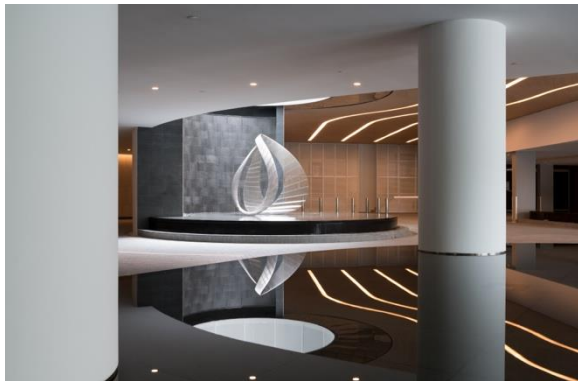


Fig 7. A curved waterwall cascades from ground level down to the basement drop-off area. Photo by Robert Such; Robert Such Photography

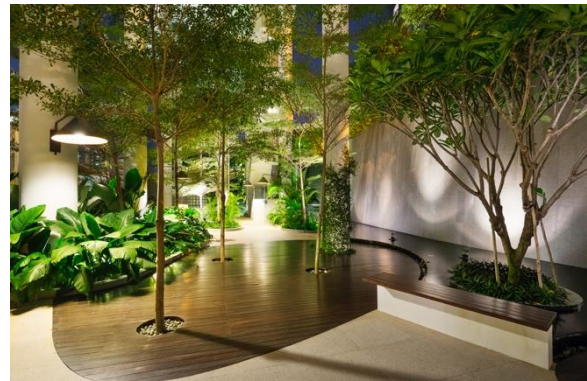


Fig 8. Amorphous shapes used in a timber deck. Photo by John Gollings; John Gollings Photography

The landscape area within the development is extensive, covering 75% of the site area. Half of this landscape area is green, where a large variety of plant species (around 25 different trees species, and 70 shrub species) were used to increase the biodiversity of the site.

Nature seemed to take over the architecture in this development, where climber plants scale up the façade of the building, cling on to and wrap around columns at the 1st storey terrace, transform an entrance wall to soft green and turn into a thick green hedge wall around the tennis court.

2. Case Study No. 2 – Helios Residences

The landscape design for the Helios Residences is composed of a series of garden terraces with water elements that negotiate the vast level differences of the site. Each of the garden terraces has different water elements to create a unique spatial character and provide a soothing auditory experience throughout the landscape.

Amorphous shapes suggestive of natural forms, are used in landscape elements at the different terraces, as planters, timber decks, skylights in an overhead pool and a large reflective pool in the middle of the drop-off plaza.



Fig 9. Climber plants wrap around the façade of the building. Photo by John Gollings; John Gollings Photography



Fig 10. Nature takes over the architecture, with climber plants scaling up the building. Photo by Goh Weixiang; STX Landscape Architects

2.1. Central Waterwall and Urban Forest of trees

The overall organization and composition of the landscape is based on a central waterwall along Cairnhill Circle road. The dramatic 6m high waterwall has water gently rippling down its surface and it drops to 9m and subsequently 12m as the site levels drop. Water from the waterwall flows down into a continuous base reflecting pool, which wraps around the entire length of the ground storey lobby and landscape terrace.

The water level is the same as the lobby floor level, making the pathways and lift lobbies appear to be floating on the surrounding water body.

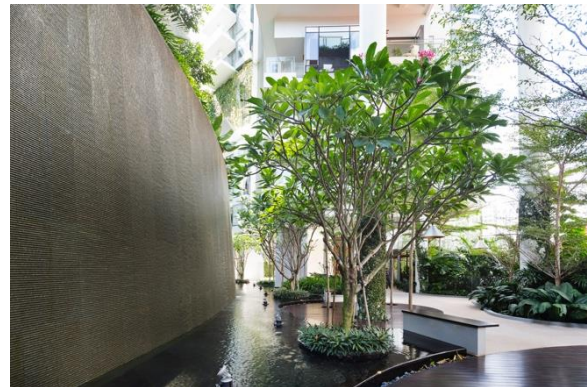


Fig 11. Dramatic waterwall with water gently rippling down into a base reflective pool that wraps around the ground floor lobby and landscape terrace. Photo by John Gollings; John Gollings Photography

The landscape terrace at the 1st storey is based on the concept of an urban forest of trees. Trees extend out of the terrace among columns covered with the *Ficus pumila* climber.



Fig 12. Nature takes over architecture with climber plants scaling up the building columns. Photo by John Gollings; John Gollings Photography

Amorphous-shaped planters are located in the reflecting pool, and repeated in the timber deck areas, creating various pockets of spaces for activity, linked by a sinuous pathway and the surrounding water body.

Overhead, an amorphous-shaped skylight hovers from the pool above the terrace. The terrace links to the Multi-Function Room Terrace at a lower level. At the Multi-

Function Room level, there is a balcony overlooking a reflecting pool and surrounded by waterwalls.

There is a flight of stairs leading down to an open-to-sky timber deck, which serve as a BBQ area. A green mesh wall with *Thunbergia grandiflora* climbers terminates the axis of the central water wall. Beyond this green wall is the tennis court.



Fig 13. An urban forest of trees reaches out from the 1st storey landscape terrace to the cantilevered pool overhead. An amorphous-shaped skylight frames a piece of the sky. Photo by John Gollings; John Gollings Photography



Fig 14. Nature takes over architecture, with creeper plants cascading down a high wall on one side and creeper plants forming a thick green wall around the tennis court. Photo by John Gollings; John Gollings Photography

2.2. Cairnhill Road Entrance

At Cairnhill Road, small side gate entrance is framed by walls fully covered by the *Ficus pumila* climber, like an entrance to a secret garden. After the green wall is a still reflecting pool framed by green hedges. A path leads across the reflecting pool, through a green veil of vines planted on vertical cables, into the lift lobby.

The waterfeature at this level symbolically connects to the central waterwall and reflecting pools at the ground storey.



Fig 15. Entrance to a secret garden - climber plants cover a low entrance wall. Photo by Author; Sherman Stave

2.3. Cairnhill Circle Main Entrance Waterwall

The main entrance is approached along Cairnhill Circle road. Along the main approach drive is a long waterwall and reflecting pool with a row of bubbling water jets, which provides a backdrop for the entrance signage, which is placed in front of it. A row of palms run parallel to the waterwall.



Fig 16. A still reflective pool is framed by hedges and a green veil of climber plants. Photo by John Gollings; John Gollings Photography

2.4. Green Trellis at Main Entrance

The green trellis is similar in character to the vertical vine cables forming the green skirt of the buildings. It is composed of a series of 4.5m high steel fins along the

boundary wall. The steel tension cables span across the driveway and are spaced at 500mm apart. The trellis provides a veil of greenery yet maintains a sense of openness with the sky.



Fig 17. A green trellis provides a veil yet maintains a sense of openness with the sky. Photo by John Gollings; John Gollings Photography

2.5. Drop-off Plaza

There is a large amorphous shaped reflecting pool in the center of the drop-off plaza. The pool has similar amorphous shaped planters within it. These amorphous shaped planters are a repeated pattern in the reflecting pool under the towers.



Fig 18. An amorphous-shaped reflecting pool with amorphous-shaped planters marks the drop-off plaza. Photo by John Gollings; John Gollings Photography

The pool cascades down a 1.3m water wall along the driveway ramp leading up from the

basement. At the lower level driveway drop off lobby, the space is defined by a waterwall that serves to terminate the axis of approach from the main entrance.

2.6. Sky Terrace Landscape

At the 4th storey Sky Terrace, pockets of deck spaces below the building overhand are wrapped around with a green veil, providing cool spaces for various activities – children’s playground, children’s pool and seating spaces. Waterwalls, water veils and bubbling waterfeatures animate these spaces.

The intimate pocket decks lead on to an infinity swimming pool that opens up to vast views of the surrounding skyline.

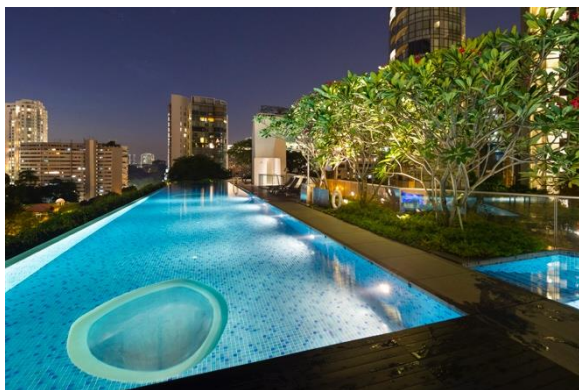


Fig 19. An infinity pool opens up to the vast views of the surrounding skyline. Photo by John Gollings; John Gollings Photography

3. Case Study No. 2 – Belle Vue Residences

The Belle Vue Residences is based on an archipelago concept where buildings and islands of amenities ‘float’ in a water lagoon.

The landscape of the Belle Vue Residences is a contemporary and exclusive setting for living in an urban forest. The unique landscape feature is its seamless fusion of nature and managed water to create a central “lagoon” around which the

buildings metaphorically branch out. Units at ground floor enjoy water and planting just outside their living rooms or bedrooms. Reflecting images of nature and sky on the water surface create a calm, idyllic setting.



Fig 20. Overview of the landscape at Belle Vue Residences, based on an archipelago concept. Photo by John Gollings; John Gollings Photography

The lagoon consists of several separate water bodies that appear visually as one main water element. The water bodies making up the “lagoon” are: a 30m lap swimming pool, Jacuzzi area, aquatic pond and mirror reflecting pools.



Fig 21. Communal landscape appears as extension of private enclosed spaces, with natural planting or water edges. Photo by John Gollings; John Gollings Photography

Naturalistic forms flow through the central landscape space, with amorphous-shaped islands scattered on the “lagoon” and have planting that drapes over the water

edges to enhance the naturalistic impressions. The largest island contains the children's pool and playground.

The strong relationship of indoor & outdoor spaces for the units are reinforced in the form of private enclosed spaces and communal landscape islands which appear as extensions of indoor spaces with natural planting / water edges. The strong indoor & outdoor relationship is also reflected in the clubhouse design, where amenities and landscape are seamlessly integrated within a tropical garden setting.

Pedestrian pathways are formed by broad sweeping arcs that correspond to the flow of the architecture. The paths connect major spaces such as drop-offs, common lift lobbies and activity areas. Where the arcs intersect, they form punctuations in the landscape addressed by specimen plantings.



Fig 22. Naturalistic forms flow through the central landscape space, with amorphous-shaped islands, scattered on the water "lagoon". Photo by John Gollings; John Gollings Photography

The landscape area of the site is extensive and covered around 65% of the site, including both hardscape and softscape elements. Around 30% of the site area is green and planted with a large variety of plants. In consideration of several shady pockets in the development, a wide variety of lush, shade-tolerant plants were selected that can thrive in

such an environment and provide sufficient screening between public and private spaces.

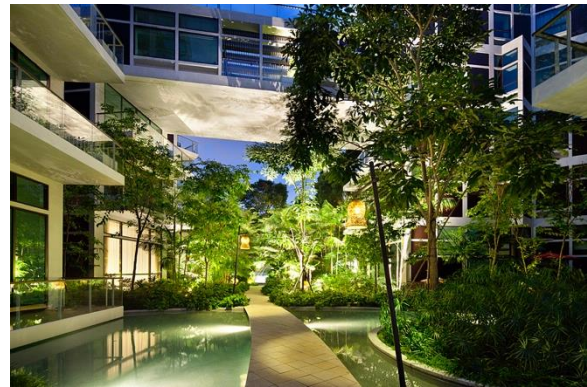


Fig 23. A wide variety of lush, shape-tolerant plants provide screening between public and private spaces. Photo by John Gollings; John Gollings Photography.

In all, the 3 selected projects have different characters and all sought to engage the human senses to nature, with a range of visual, auditory or tactile experiences. The presence of water, the use of biomorphic forms and patterns, a dialogue of complexity and order, come together to create a sense of Living in Sculptured Nature

Intertwined Human Settlements and Natural Environment—A case study of reclamation and creation of Wanqingsha Island

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^a *The Kong*

Abstract

Land reclamation is a major way remaking nature. Following the urbanized advancement, large-scale reclamation projects are carried out in land-scarce coastal nation and city to create new land for urban construction from the sea in a short time, including Hong Kong and other large cities in the Pearl River Delta (PRD). However, the quick acting of reclamation mode has also been controversial for the negative environmental impact. Meanwhile, there still existed another mode of long and slow reclamation activities in PRD for rural settlements, which seems more environmentally friendly and create a diversity of landscape. By choosing Wanqingsha island (万顷沙) as case, this paper will observe and analyze the 200-year history of shaping the island and tries to reveal how the reclamation activities transformed the natural environment and what kinds of settlements and landscapes they created.

Wanqingsha island that located between the Jiaomen waterway (蕉门) and Hongqili waterway (洪奇沥) at the estuary of the PRD now belongs to Nansha District of Guangzhou as an important agricultural production base and popular wetland tourism destination. With continuously reclamation activities taken by different groups of people, it gradually grew from the small and natural sandy shoal at Pearl River estuary in Qing Dynasty into the presently coastal town. The paper combines field research with literature review and constructs a historical narrative through three levels: social, ecology and morphology. It shows that the interventions of human not only produced linear settlements which related to the reclamation methods but also formed a mosaic of diverse landscapes including farmlands, fish ponds as well as wetlands. It also illuminates that during different stages of producing reclaimed land, the residents shifting the livelihood to respond to the changing natural environment.

Based on the case of Wanqingsha island, the paper argues that during the long and slow reclamation, the human settlements and the natural sand island intertwined together to grow and differentiate over time, like a life entity. The superposition of human and natural energy identified distinctive time periods which projected spatially and formed the patchy, time-varying diverse landscape. By doing so, the paper not only makes it significant to rethinking the relationship between human beings with the natural world but also sheds new light on the future urban design and reclamation projects.

T I A N M e n g x i a o , A r c h i t e c t u r e D e p a r t m e n t , T h e U n i v e r s i t y o f H o n g K o n g .

Keywords: Reclamation, Wanqingsha Island, Settlement formation, Landscape

1. Introduction

Under the influence of both natural geographical changes and reclamation activities, the Pearl River Delta (PRD)

which was originally limited to the river mouth has continued to grow since the seventeenth century, extending into the ocean and forming new islands. (Fig. 1).

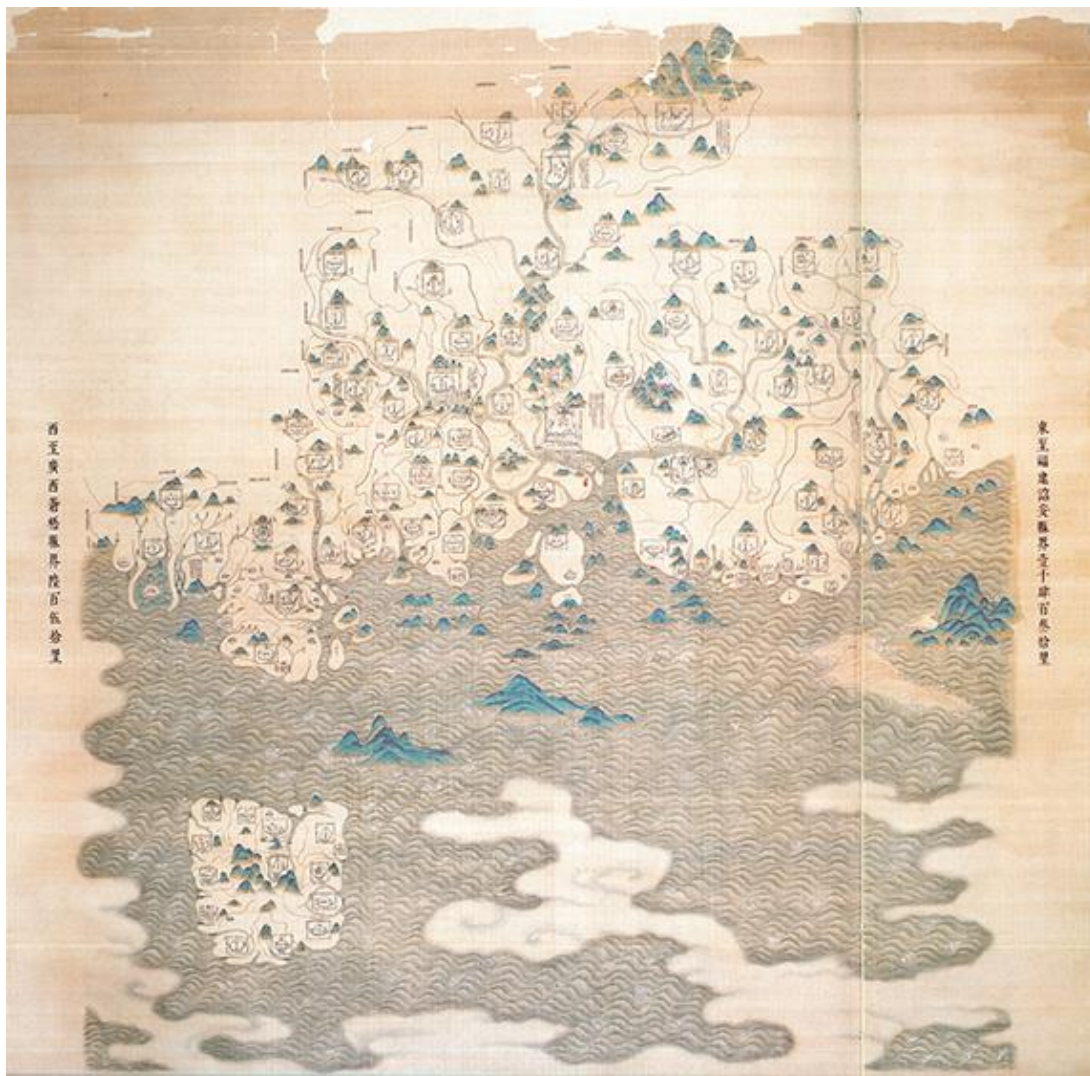


Fig.1 Map of Guangdong Province in 1692 (Thirty-first year of Emperor Kangxi in the Qing Dynasty). There were lots of islands on the Pearl River Estuary at that time. Source: Zhongguo di yi li shi dang an guan 中国第一历史档案馆 Guangdong Li Shi Di Tu Jing Cui 广东历史地图精粹 (Beijing: Zhongguo da bai ke quan shu chu ban she, 2003), p24-25.

Unlike the contemporary large-scale reclamation projects which create new land for urban construction from the sea in a short time, the historical reclamation of land for agricultural production and rural settlements on the Pearl River Estuary was a long slow processes. Over this long period of time with great dependency on natural

reclamation, residents adjusted their means of livelihood to respond to the changing natural environment during the different stages of land reclamation. Apart from its effects on the natural environment, the slow mode of reclamation also influenced the society and the formation of the settlements. This intertwined relationship between



Fig. 2. Map of Pearl River Estuary. It shows the Wanjingsha Island is located in the middle of Shenzhen, Dongguan, Zhongshan and Guangzhou, which are important cities of the PRD.
 Source: Illustrated by the Author.

human beings and the natural environment is represented clearly by the evolution of Wanqingsha island.

Located between the Jiaomen Waterway and the Hongqili waterway at the estuary of the Pearl River and now forming part of the Nansha District of Guangzhou, Wanqingsha is an island with flat topography and complex hydrology, including twenty-one parallel waterways and two towns. Continuous reclamation activities created the island from an original small and natural sandy shoal in the ocean at the end of seventeenth century into the presently coastal town settlement (Fig. 2). During these 200 years of development, the pattern of growth indicates a similarity in the reclamation process conducted by different groups of people. Furthermore, in the process from the initially formed land to the

area still under development today, various landscapes and production modes have adapted to the different stages of reclamation process, and these have co-existed on the island simultaneously (Fig. 3). This is an excellent opportunity to demonstrate the interaction between nature and human development over diverse historical periods as well as to reveal how the reclamation activities transformed the natural environment and the kinds of settlements and landscapes that were created.

2. The Geographical background and the creation of land

The system of the Pearl River primarily consists of three rivers, the East, the North, and the West, converging into the delta, splintering into a dendritic pattern of estuary

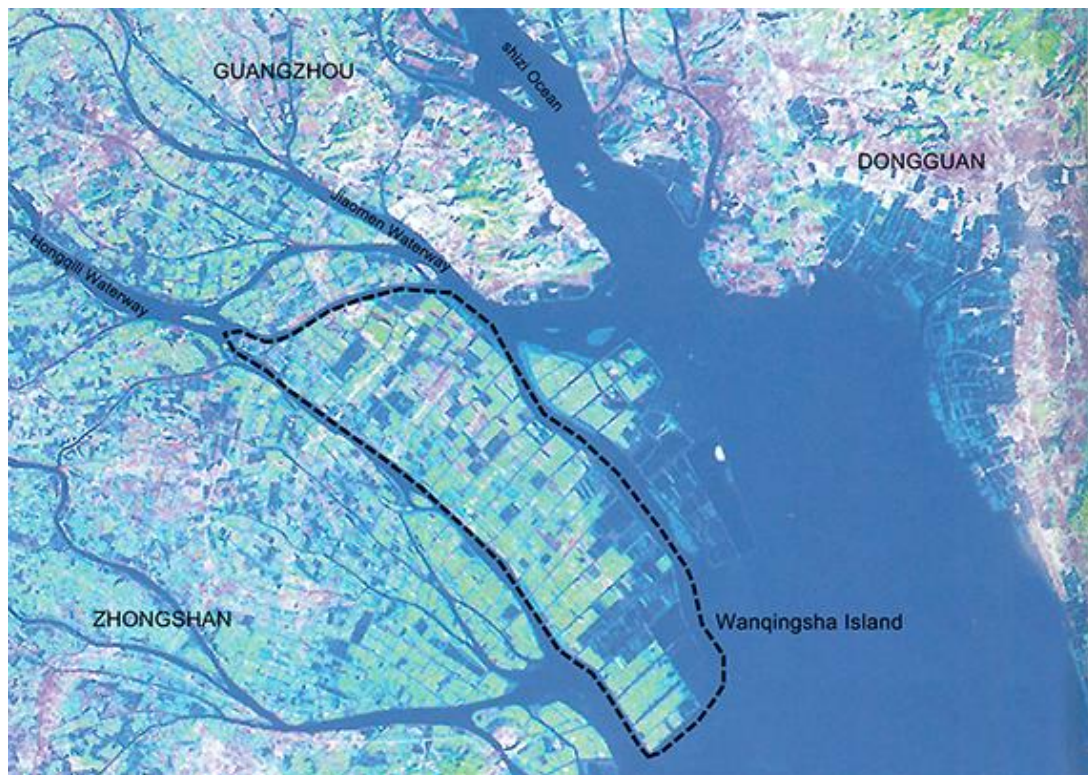


Fig. 3. Satellite imagery of Pearl River Estuary in 1998. It shows the paralleled waterways, the ongoing reclamation lands and the mosaic-like green landscape of Wanqingsha Island. Source: Dongguan Li Dai Di Tu Xua 东莞历代地图选 (Dongguan: Dongguan shi zhen xie wen shi zi liao wei yuan hui, 2006), p128.

waterways and then emptying into the South China Sea.¹ The alluvium brought down by the rivers filled in the bay and created the upper reaches of the delta at a very slow pace. It was only through human action,

dike construction and reclamation, that the increase in size of the Pearl River Delta began to quicken.² The courses of the North and the West Rivers changed frequently, and the earliest levees were built precisely in the



¹ R o b e r t F i g . 4 . C o a s t l i n e E v o l u t i o n i n t h e P e a r l R i v e r E s t u a r y . M o s t a r e a o f t h e W a n q i n g s h a I s l a n d w a s o c c u r r e d a f t e r s e v e n t e e n t h S i l k C e n t u r y . S o u r c e : A m e n d b y t h e A u t h o r b a s e o n Z h a o H u a n t i n g 赵炳庭 Zhu Jiang He Kou Yan Bian 珠江河口演变 (Bei Jing: Hai and Bian chubanshe, 1990) *Late Imperial South China* (Cambridge: Cambridge University Press, 1998), p 30.

² M a r k s , 3 2 .

areas towards which the changed water courses directed their discharge. After the Song dynasty, the flow of the rivers stabilised with the help of the dike building and sediment settled further downstream which created underwater sandbanks or shallow intertidal mudflats which become the natural foundation for reclamation activities. By the end of the fourteenth century, the sandy sediments had gradually extended to the present Pearl River estuary with dunes continued to emerge including the region of what was later to become Wanqingsha island (Fig. 4).³

The natural environment and the geographical conditions created opportunities that promoted the exploitation of sandy fields in the Wanqingsha area and the reclamation activities were first recorded in chorography at the end of the eighteenth century (Emperor Jiaqing, Qing dynasty). Powerful families from the neighbouring Xiangshan and Dongguan regions rushed to compete for land development in the mid-nineteenth century because of the quick growth of sandy sediment regions. In fact, the name of Wanqingsha region in Chinese means thousands of hectares of sand. In the ten years between 1838 and 1849 years, more than 145 qing⁴ sandy fields were enclosed and reclaimed with an average increase of 12 qing per year.⁵ In 1892, the

area of reclaimed land had reached 4000 mu⁶. At that time, Wanqingsha had begun to be recorded frequently in cartography (Fig. 5). In the blank space that originally represented the ocean, the name of Wanqingsha and the emerging shape of the island started to be shown. This shows that

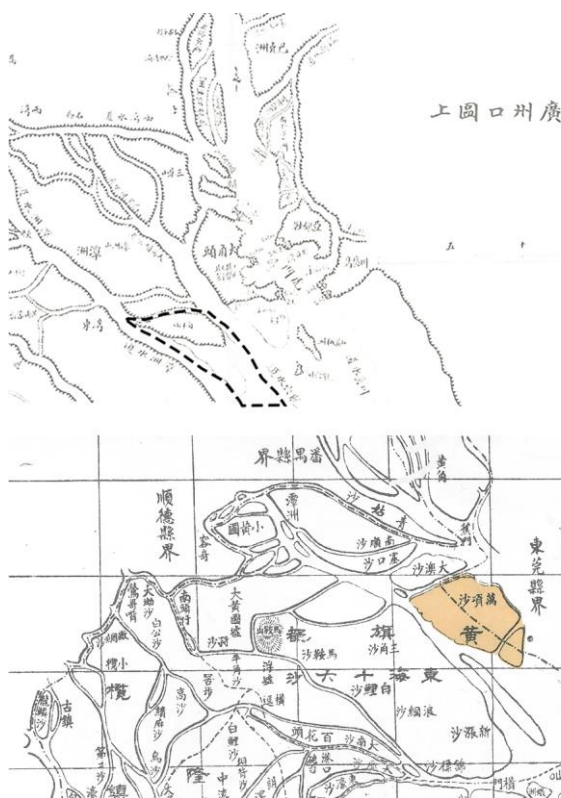


Fig. 5. Maps recorded Wanqingshad. Left one was in 1887 (Thirteen year of Guangxu Emperor). Right one was in the Xiangsahn County Chronicle.

Source: top: Yan Hai Qi Shen Kou An Xian Yao Tu 沿海七省口岸險要圖. Cheng Peng 程鵬. In Guangzhou shi Dang An Guang 廣州市檔案館. *Bi Hai Lan Tian Wnag Nan Sha* 碧海藍天望南沙, (Guangzhou: Guangdong Ren Min Chu Ban She, 2009), p41. below: Wang Wenbing 汪文炳. *Xiangshan Xian Zhi Xu Bian* 香山县志續編, Juan yi 卷一, 1923.

Tian Wnag Nan Sha 碧海藍天望南沙, (Guangzhou: Guangdong Ren Min Chu Ban She, 2009), p3.
⁶ One mu = 0.0666667 hectares.

³ Guangzhou Shi Nan Sha Qu Dang An Ju 廣州市南沙區檔案局. *Nansha Da Quan* 南沙大全, (Guangzhou: Lingnan mei shu chu ban she, 2011), p3.

⁴ One qing = 6.6667 hectares.

⁵ Guangzhou shi Dang An Guang 廣州市檔案館. *Bi Hai Lan*

cultivable land and simple settlements might be formed in the area as Wanqingsha was no longer an area of sand which could be seen above the water in the low tide and would be still submerged in the high tide.

In spite of the considerable increase in reclamation during the middle and late Qing Dynasty, the reclamation activities based on natural dunes and marshes were still a long-term multi-stage process. In general, the formation of sand fields had five stages depending on the state of sediment and the depth of water. These were known as called as “fish swimming”, “scull-touching bottom”, “crane-standing”, “grass-spreading” and “reclamation”.⁷ Only during the “grass-spreading” stages could people cultivate grass to firm the sandbanks and promote the deposit of more sediment. Initially, the first three stages were almost completely dominated by natural shaping forces. However, during the period when vast reclamation took place in Wanqingsha, the passive waiting for the natural formation of sediment had changed to become the active exploitation of the sand which still submerged in the water with the

development of reclamation technology. Rocks were sunk into the stretch of foreshore to gather more sediment around the rock foundation and this promoted the appearance of a muddy surface which was suitable for reeds and the planting of grass.⁸ Meanwhile, the purpose and technology of dike construction also changed during the Qing dynasty.

In the early stages, levees, mostly built with mud and parallel to the waterways, were used to protect cultivated land from the flood. After the Qing dynasty, dike construction became a means for people to enclose sand and accelerate the deposit of sediment (Fig. 6). The building material improved from the easily destroyed mud into a combination of stones and earth. For the reclamation of Wanqingsha, the use of

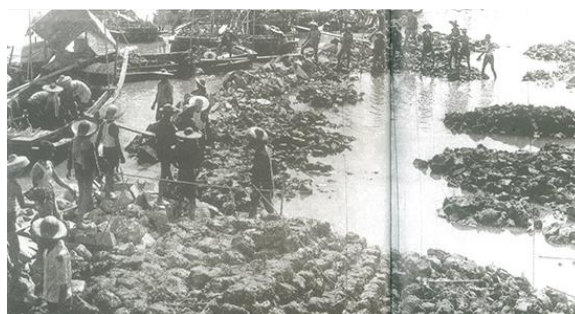


Fig. 6. Reclamation and building of dikes.
 Source: Guangzhou shi Dang An Guang 广州市档案馆 p8-9.

stone piles to construct the embankments was recorded. In other nearby areas during the same period, there is a record of detailed construction techniques that used rammed

⁷ The ‘fish swimming’ stage, when the depth of water was 2-3 m deep at low tide. The ‘scull-touching bottom’ stage, when water depth was 1-2 m. The ‘crane-standing’ stage, when water further decreased to about 0.2-0.3 m. The ‘grass-spreading’ stages, when most of the beaches were exposed at low tide and waterweeds start to grow. See Tan dihua 谭棣华. *Qing Dai Zhujiang San Jiao Zhou De Sha Tian* 清代珠江三角洲的沙田, (Guangzhou: Guang dong ren min chu ban she, 1993), p 7.

⁸ David Faure. *Emperor and Ancestor: State and Lineage in South China* (Stanford, Calif: Stanford University Press, 2007), p 274

earth together with stone masonry and grass reinforcement.⁹ This improvement in the technical methods made the dikes stronger to maintain the sandy fields during tidal movements and also increased the success rate of reclamation.

However, it is expected that although the reliability of the stone-built embankment was much higher than that of mud, the cost of constructing dikes had also increased considerably. Hence, although it was very attractive to create cultivatable land from the natural shoals, the long and slow process of reclamation was still a risky process. Thus, what motivated the developers who dominated the rapid and considerable reclamation of Wanqingsha during the Qing dynasty in spite of the high costs and considerable time required?

3. Power of reclamation and the

formation of settlements

By the 1680s, after the disorder related to social and political problems finally came to an end, the gentrified society on the Pearl River Delta returned to normal¹⁰. In the upper area of Pearl River Delta, the early settled clans reactivated the restoration of peaceful conditions and the revival of the economy supported these big families to expand their power and their property by carrying out land reclamation on the Pearl River estuary including Wanqingsha island. Thus, when discussing the shaping of the new island after the seventeenth century, it can be said that nature was one of the shapers and the magnates from the upper delta were the other.

As mentioned before, from the eighteenth century, the large clans from areas near Wanqingsha, such as Dongguan, Zhongshan

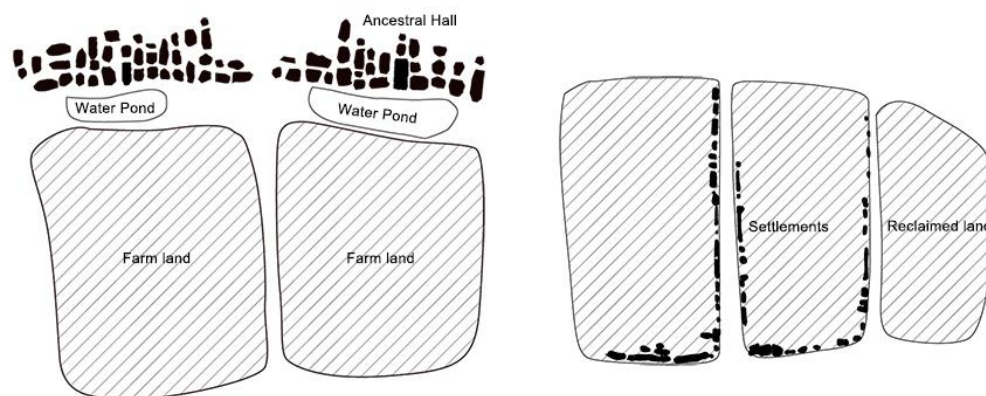
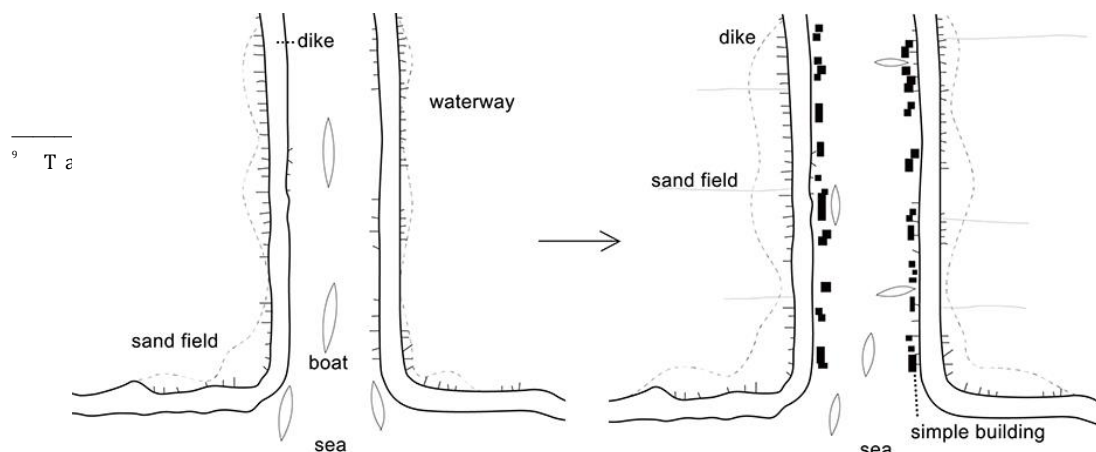


Fig. 7. Settlements pattern of villages dominated by clans (left) and settlements of Wanqingsha Island (right).
 Source: Illustrated by the Author.



IFLA World Congress Singapore 2018
 Fig. 8. The formation of linear settlements on Wanqingsha Island.
 Source: Illustrated by the Author.

and Foshan, began intense competition for reclamation. However, with these powerful clans, the newly created lands were more of a means to gather wealth and influence rather than to expand the living spaces. What the magnates needed was the power of control as well as the capital provided by the newly created spaces rather than the actual land to inhabit and cultivate. The most important thing for them was to claim the landholding and tax collection rights¹¹. Meanwhile, the increasing reclamation activities meant that the sands moved further away from the villages of the big families. Thus, the lineages who owned the land and had the right to collect the rent hired labour to build dikes, reclaim land, farm and harvest the land.¹² The persons who settled on the sands area were the tenants. These were the weaker villagers as well as the boat people who lost their living space because of the land reclamation and the disappearance of the ocean area. In this situation, the settlements formed at Wanqingsha were unlike the compact villages of the larger clans (Fig 7).

First of all, the settlements on the island did not have focal ancestral halls in the centre because the residents settled on the island did not belong to big clans. Second, since the initial purpose of building residential spaces was largely to facilitate reclamation activities and cultivation, the resulting settlements were scattered with more attention to the servicing of the reclaimed lands and the convenience of transportation. Therefore, most of the buildings faced the

waterways because boating was the main means of transportation (Fig. 8). Besides, dikes were the only lands with enough load-bearing capacity for construction until the reclamation finished, so the initial buildings usually rested against the embankments on one side with the other side standing in the water with supporting wooden pillars hammered into the river-bed (Fig. 9).

In Wanqingsha, all these reasons resulted in a linear loosely distributed configuration of settlements along the waterways and dikes. On the other hand, while the high profits and high risks of reclamation required investors familiar with the reclamation mechanism, the participation of large clans somehow ensured the capital for these operations and demonstrated their planning preferences. From the middle of the nineteenth century, Mingluntang from Dongguan dominated the reclamation activities on Wanqingsha island¹³. Even though in the following hundred and fifty years, the control of power changed several times, the majority could always be attributed to a single organization which contributed to the preferable organized reclamation activities. This is expressed by the settlements and landscape fabric of Wanqingsha island that evolved from the first waterway formed during the Qing dynasty to the twenty-first waterway now, with newly created land, and parallel rivers which commenced at the beginning of the reclamation and got caught in the middle of the levees, stretching from northwest to southeast in an orderly manner.

¹¹ Faure, 137.

¹² *Ibid.*

¹³ Guangzhou shi Dang An Guang, 170.

(Fig. 10).

4. Changing of livelihood and production mode



Fig. 9. Residential building standing on the wood pillar. Left one is the simple shed standing on the water in the Republic of China era and the right one are buildings in Wanqingsha Island which facing the waterway and have wooden stairs to access water front.

Source: Right: Ruiling Wu, 伍锐麟, Min Guo Guang Dong De Dan Min, Ren Li Che Fu He Cun Luo 民国广州的蛋民、人力车夫和村落 (Guangzhou: Guangdong ren min chu ban she, 2010). Left: Guangzhou shi Dang An Guang 广州市档案馆.



Fig. 10. Map of Wanqingsha record in in the Republic of China era.

Source: Dongguan Xian Shi Qu Quan Tu 东莞县十区全图 In Dongguan Li Dai Di Tu Xua 东莞历代地图选, p75.

Since the purpose of reclamation was a struggle for power and land, rather than to

create additional living space, the main feature was to declare dominion by enclosing the sand with stone. Inside the enclosed dike system, the water-rich sandy field slowly drained and changed into farmland while outside the dikes, the Pearl River kept bringing more sediments to form more sandbanks. In comparison with the method of filling the areas with large amounts of rocks, clay and draining the wetlands, the impact on nature by this slow and long-term reclamation mode is less pronounced. The long process provided a buffer for the transformation of nature, and also prompted the residents to develop different production methods based on the condition of the reclaimed land.

In the early stages, the dikes surrounded a salt-water area. *Cyperus* or reeds would be planted in this area, which increased the stability of the dikes and improved the salinity and alkalinity of the water and the soil. After several rounds of planting grass, the land would be suitable for planting

crops. In the early years, due to the food shortages, rice was the primary crop. With the development of agriculture and integrated farming, the dike-pond system with fishpond and mulberry dikes as well as fishpond and sugar cane dikes was developed. Thus, from an early stage in the reclamation process, the enclosed areas were utilised for aquaculture (Fig. 11). This was followed by the setting up of the dike-pond systems. When reclamation reached a certain extent, the partly dewatered wetland could be used for wetland planting with crops such as water chestnut and lotus roots. Eventually, the land would finally have enough load-bearing capacity for the construction of buildings.

The settlements expanded with the land and the population increased. Settlements that originally distributed linearly along one side of the dike first extended to both sides, then expanded outward layer by layer. Previous dikes now became roads in the villages. Since the reclaimed land was lower than the



Fig. 11 Sugar Cane and banana agricultur in Wanqingsha Island.

Source: Guangzhou Panyu Qu Wen Lian 广州番禺区文联 *Wan Qing Sha Tian Wan Juan Hua* 万顷沙田画卷 (Guangzhou: Panyu qu wanqingsha ren min zheng fu), 2004, p24-25.

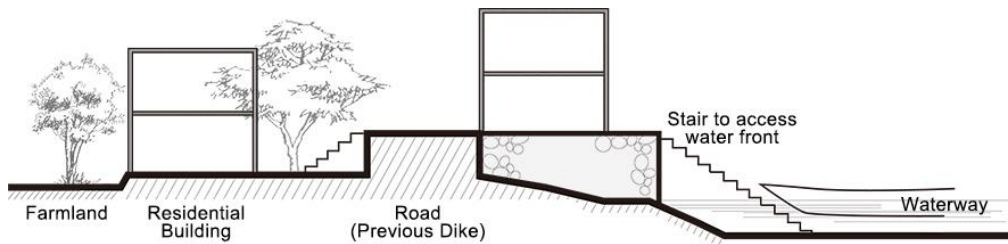


Fig. 12. Section to show the relationship of residential buildings, dikes and the waterway currently.
 Source: Illustrated by the author.

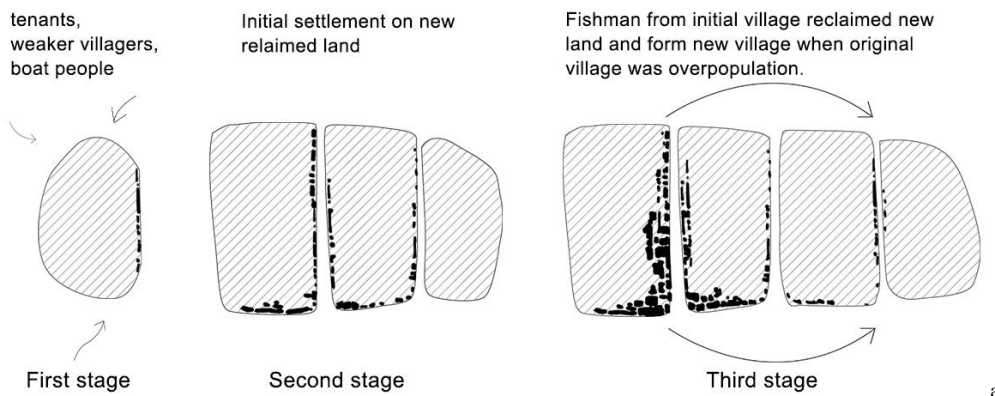


Fig. 13. The separation and expanding of villages.
 Source: Illustrated by the author.

dikes, in the villages it can be seen that the roadside buildings have a one-storey height difference from the road, while the waterside buildings are level with the road (Fig. 12). Inhabitants in the waterside houses reclaimed land from the waterway on an individual basis whenever they needed additional living space, and this resulted in many small building foundations. Furthermore, it is recorded that as settlements along the waterway were approaching saturation, some people would separate from the villages and participate in new reclamation activities, most of these being fishermen. New reclamation activities would establish new living spaces and form new settlements (Fig. 13).

This shows how as the state of the reclamation of land changed, the way the

people used the land also changed. In this situation, the development of agricultural ecology, the formation of settlements, and the transition to reclaimed land are combined organically. For Wanqingsha island, from the first waterway as the earliest reclamation to the twenty-first waterway as the latest reclamation in time, agricultural production and the network pattern of the waterways reflect the adaptation to the natural condition of the different reclamation stages. In the early reclaimed areas, the area from the first waterway to the sixth has a more dense settlements and serves as the town centre and agricultural trade centre. The middle stage area from the sixth waterway to the eleventh has more agricultural development. The location from the eighteenth waterway to the twenty-first is still in the early stages of reclamation, and

here the residents engaged in the fishing industry (Fig. 14).

As a result, the artificial dikes changed the

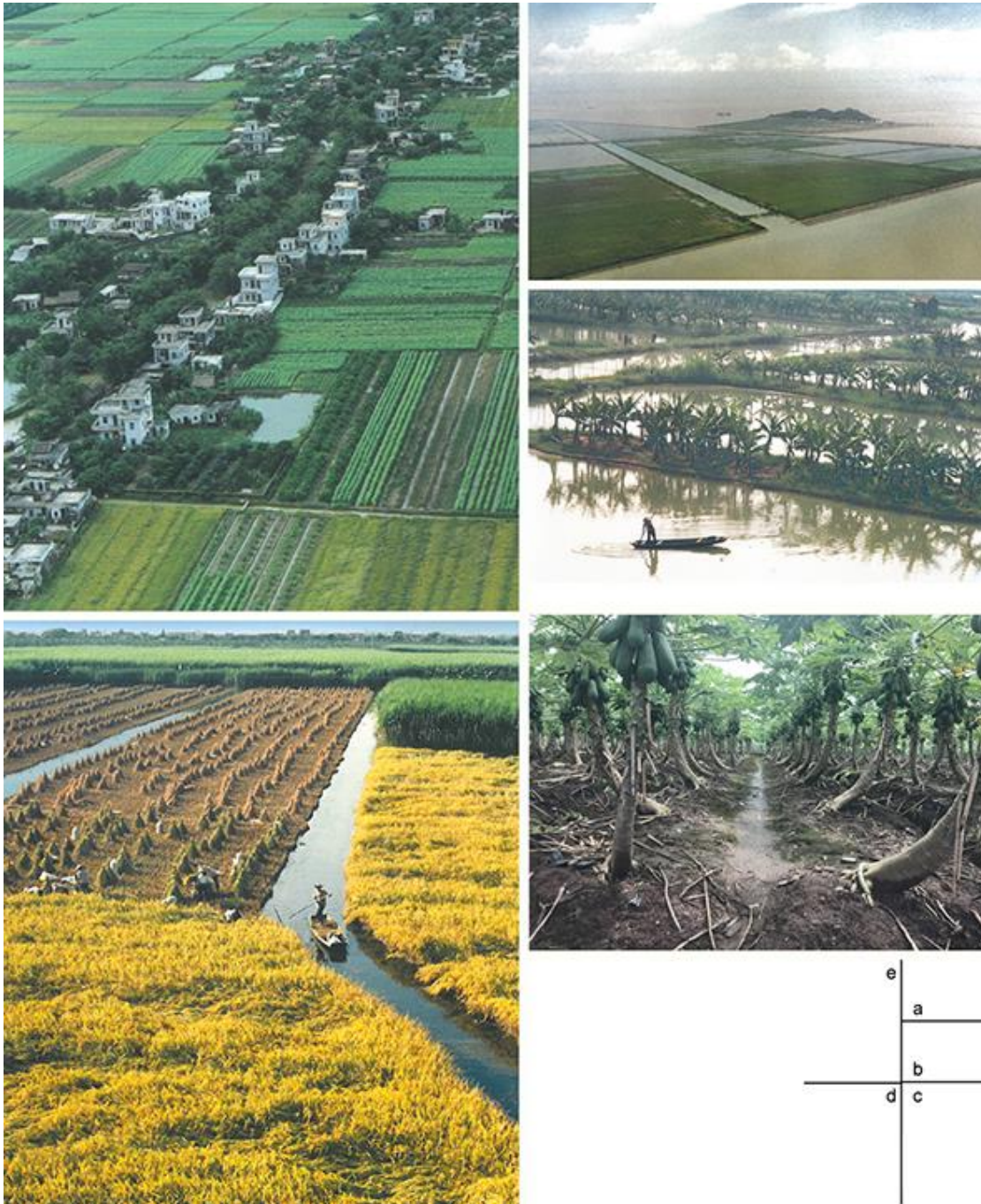


Fig. 14. Settlements and diverse landscape of Wanqingsha Island. 12-a shows the beginning of reclamation which include the waterways, the wetland and the grass planting. 12-b shows the dike-pond system that the banana trees are planted on the dikes enclosed the fishponds. 12-c shows the papaya plantation on the new created farmland. 12-d shows the rice cultivation on the first reclamation area of Wanqingsha island. 12-e shows the linear distribution of settlements along the waterway and the already formed farmlands on bothsides of the village. *Source:* 12-a, b, d, e in: Guangzhou Panyu Qu Wen Lian 广州番禺区文联 *Wan Qing Sha Tian Wan Juan Hua* 万顷沙田万卷画 (Guangzhou: Panyu qu wanqingsha ren min zheng fu), 2004. 12-e: Photograph by the Author.

natural environment, and the original ocean area became islands. Nonetheless, over a long period of reclamation, this change is an adaptation and utilisation of the environment rather than an invasion. Even though the growing island shaped by an organic combination of artefacts and nature changed the marine ecology, it also formed a new wetland environment. As the eighteenth waterway reclamation proceeded, the new wetland attracted wintering birds and finally became a long-term gathering place for them. This kind of island building and reclamation is not free from effects on the environment. However, in comparison with the more rapid reclamation mode, it seems to be more eco-friendly. In contemporary times, an age of rapid urban development and construction and land shortage, can we find a more appropriate way to bring together different modes to combine cities and the environment?

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Growing as Human -Field Office in Yilan, Taiwan(China)

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Abstract

In the early 1990s,Taiwan like many core cities in mainland China, the aesthetic of the industrial revolution advertised by mechanization became the powerful impetus to urbanization. At the same time, it aroused some reflection from architects. Huang Shengyuan is one of them. He and his Field Office reflect on the relationship between urban practice and the natural pattern from the perspective of time, thinking about the linkages from the early single living units to today's urban scale and between architecture and man and nature, and hope to practice a Naturally, companion design complying with the law of growth, therefore, he chose Yilan, so that the building back to nature. The backward industrialization and urbanization of Yilan provided a hotbed for the ideal of Huang. The accumulation of more than a decade has led to the city's transformation. However, Huang 's practice also stimulated intense discussion of "Criticism of Pastoralism" and avoided the objective problems at the urban scale. This is a special case. Whatever, the practice of Field Office, in a dystopian position, shows us how cities can grow like mankind over time and this may be a special meaning of the Biophilic City. As a result of the challenges we facing, we need to explore more deeply. This paper is subsidized by NSFC project which is named as <Research on Technical System of "Downtown Factory" Community-oriented Regeneration in Yangtze River Delta Region>. (Grant No.51678412)

Keywords: Growing city; urbanization, time; Criticism of Pastoralism,

1. From the Past to Now-Huang is in Yilan

1.1. Connectivity between City and Nature – Building Map of the Field Office

There are two natural opportunities for connecting Yilan to nature.

One is geographical. From a geographical point of view, we are usually used to see Taiwan as three parts: Taipei, Taichung and Tainan, and Yilan is located in northern Taiwan. However, divided by natural north and south ridges, Taiwan is divided into east and west. The west is a central area of a highly modern city facing the mainland. The eastern part is backed by a mountain ridge. The ocean and nature are isolated from each other. Yilan is the largest and most concentrated one. The land has the typical nature of natural habitat. Judging from the natural location of Yilan itself, it is a triangular area surrounded by two ridge lines and a coastline, naturally blocking the convenience of connecting with the outside world. Yilan has the necessity of connecting with nature.

(Fig.1)

Time is another important opportunity for mutual feedback between nature and Yilan. Huang Shengyuan's connection to the urban space in the past 20 years has made Yilan an overall harmony. From the results, this is a metaphorical echo of the "urban acupuncture" put forward by Malarias in Barcelona's urban regeneration strategy in 1982. However, if the "acupuncture city" is a result-oriented urban layout, Huang's team is a process-oriented free connection. Time

is an important starting point to understand Huang Shengyuan's team work. Time is not their enemy but a friend. They almost took root in the land of Yilan. Many of the cases continued for a long time. They covered half-to-none and they had no funds. After many years, when they were about to be forgotten, they found some funds and the construction site moved again. stand up. They seem to be playing the next big game in Yilan, step by step to get the whole game. When the energy isn't going to be used, it's time to use the energy on the other side and wait until after some time, the interesting thread of the game is slowly seen. , And as the roots of the dense network deepen the cornerstone of Yilan, slowly changing the appearance of Yilan, and self-growth.

How exactly do people realize that they are in a certain domain? Is there a kind of metaphorical border in the modern Yilan built by people who see through certain qualities, which encloses the Yilan 's place, and at the same time continues to radiate outwards while building people's belongings? Urban image theory believes that people's understanding of the city and the formation of the image is achieved through the observation of the city's environment. The various signs of urban form are symbols for people to identify cities, and people form feelings by observing these symbols so as to gradually understand the nature of the city. The more clear the symbols and structures of the urban environment are, the more people can identify cities and bring about psychological stability and ownership. Huang Shengyuan constructed the appearance of Yilan one by one through his

own practice. In the middle of Tian, these symbols are not just buildings.

(Fig.2)

1.2. Landscape-oriented

If you want to seek the connection and connection between things, the bridge is not the best carrier. When we tried to discuss the connection between man and nature, the Jinhai plank road showed a strong contrast and led people to nature in the way of landscape.

(Fig.3)

In the "waiting" scenario we describe, distance is the most central expression. "Bridges allow rivers to go their own way, and at the same time provide roads for people who will eventually die, so that they can travel to and from the two sides of the river... The bridges on the highways are braided as calculated, as long as possible in the length of the traffic network. In addition, the bridges travel back and forth with the rushing or slowing people, making them reach the other side and reaching the other side as a deceased. Heine grid gave the bridge meaning, but now it connects the other side. Bridges have little sense of distance. All forms of transportation have gradually ignored the distance. The way people get to the other side is greatly enriched, and time is infinitely efficient. Nowadays, we can ride on cars and rush on high-speed mixed-energy soil bridge decks. Everything is quick and convenient, and of course, there is no general expectation and miss in the past. The Jinhai Plank Road, on the other hand, restores the road to walking, slows people's pace, and at the same time reconstructs this distance, and introduces

natural elements to enrich people's senses. It is silently attached to the side of concrete, filling the void of time and distance with the relationship between nature and human settlement.

The "free connection" of the Jinhai Plank Road has three manifestations: First, it is a confrontation with concrete. The Jinhai Plane Road hangs on the side of the original road, highlighting a binary opposition with a positive attitude. The machines and industries represented by highway bridges provide efficiency and speed while also disregarding the distance of people. The Jinhai Plank Road creates a quiet and private passage for the walkers. The residents around the service station respect the visitors. Perhaps only the pedestrians who are slowing down are the true enjoyment of the Yilan River. Only under the shadow of the bridge will they resist the summer. They will stay on the lawn and listen to the flow of rivers. The second is the scale of the person. "The road is narrower, the talents will meet; the light is dark, and the bird can rest." In the eyes of Huang Shengyuan, the encounter meets unexpectedly is more talkative than the others, and for this reason, there is no need to deliberately satisfy the needs of the function. , but care about the delicate seasoning of various scales, returning people to natural. The third is the echo of construction and nature. The most unforgettable sight of the Jinhai Plank Road is the structural bars that are arranged on the outside and are arranged in rows. They sway in the wind and make up the special metallic silk flowers on the Jinhai plank road. In addition, planting plants are planted on the edge of the whole plank road and introduced

into the climbing vines. The drip irrigation and spray systems involved at the same time can also be used to regulate the microclimate and increase the mood of the wind and clouds. The non-ordered galvanized grille, wood, and weather-resistant steel plate used in the bridge deck are more transparent when approaching the center, giving pedestrians a vague sense of danger and focusing more on the water surface, tending towards nature.

Since then, the Jinhai plank road has been guided by the landscape and has established a “bridge” between man and city and nature.

(Fig.4)

1.3. Space Shape (Positive Space - Negative Space)

"Land on the ground" is also returned to the land. The non-architecture mode shows the connection between the field and space.

Luodong Cultural Square is a model of Huang Shengyuan's practice. Before this, various local governments set up cultural centers under the guidance of cultural policies, including auditoriums, libraries, and galleries. However, cultural centers are often a large black box, which is far from the people's lives. In this context, Huang Shengyuan took the lead in breaking this silence in the form of a "shelving." In the case of 90m X 90m and a net height of 18m, the Luodong built a long period of “construction rate.” In this real plane, “Yellow” is a function that is twisted in the air and twisted and combined. The amount of energy that attracts free entry and exit and

spontaneous activity makes this original energy that was inherent in the night market and is further stimulated during the day. On the south side of the site, "Huang" uses design contrasts to create a level difference in a flat field, nesting complex, undulating space systems, and the crowds of sports and leisure here, in this dynamic venue. Find out how you exist here.

(Fig.5)

Restitution and utilization are the two core elements of this case that focus on the “ground”. Restitution often metaphorizes a revolt. In today's group of architects who return overseas and have strong ideas for the local community, most of them have some rebellion and confrontation. When the policy is stimulated, there will always be a strategy of stress. However, under the background of individual heroism, this kind of confrontation is often presented in novelty, and under the slogan of Futurism, it preaches a clamor for controversy. Each of them publicized their own "goodwill," and hoped that this "goodwill" could one day be understood and "impressed" around them. In the end, in those voices of advocacy and crusade, they pushed to the cusp and formed an isolated core. What waits for these is the support and criticism of those multi-core and globalization. They refused to return to themselves and saw something outside the building. At the moment, the "useful use" implies a positive intervention, and it is expected that the architects will be able to present themselves when they return to this place.

2. From Now to the Future-Practicing in Urban

2.1. Isolated Architecture

Today's cities are a collection of buildings.

(Fig.6)

If we take a look at today's cities from the standpoint of Yilan, we can quickly understand why Huang Shengyuan is controversial. First of all, it is the degree of development of the city. Although the development of Yilan is based on a moderating, slow-warming approach, most of the inland cities that are isolated from nature, or small cities that are surrounded by cities, bear the brunt of the efficiency of urban development. . Whether in the past 90s or today, no one would talk about feelings on the basis of material scarcity. In the following 20 years, when the deterioration of the environment brought about by the rapid expansion of the city and the accelerated way of life have allowed more and more people to reflect on their own circumstances, people are looking around. Huang Shengyuan and his Yilan can enter people's vision.

The second is the scale. We have talked about the city connection of Yilan. In fact, it is a kind of recognition and urban image. People get stability and find their own attribution and value. So, how to construct a modern metropolis image of the city so that people can gain self-identity in it, not self-loss? Kevin Lynch once outlined the five elements of the physical environment in his book: roads, borders, regions, nodes, and markers. However, with the current

expansion of the metropolitan scale, it is difficult for us to control the overall situation. Cities are constantly being deconstructed by partitions. We can integrate a certain area and show it on the ground, but when we put together, we will no longer have an overall urban outlook. When we compare the urban fabrics and skylines of Barcelona's new and old cities, Beijing, Shanghai and Paris, we have to conquer the courage and courage of Osman. In an over-scale urban environment, this gradual progress from bottom to top is inevitably one-sided and inefficient, and there is the danger that one day will finally be destroyed by a certain personality.

The third is the relationship. Does the city's space respond to each other and must use architectural methods? If our answer is yes, it is perhaps in cities where the stock is overflowing. The interface of the city is entirely determined by the architecture. However, there is still a gap between buildings and cities. It seems to have become an unclaimed gray space. It is neither a city nor a building. It is a barrier erected by hedgerows and fences, and it rejects the infiltration of the two. When constructing the boundaries of the city's core area, the buildings are always on the sidelines and stand tall and self-possessed. With various gestures and reasons, they shrink their own bodies and carry their own walls. Fortunately, Luodong Cultural Square also showed us the negative answer.

(Fig.7)

(Fig.8)

2.2. *Landscape and Decoration (and Gardens)*

In the practice of Huang Shengyuan's local practice, landscape is a kind of flexible medium that exists in the earth and presents the freehand drawing that distinguishes it from the western thinking based on rational thinking and the oriental "garden".

According to Professor Zhou Yi of Tsinghua University, "Utopia is a set of abstraction that overrides the reality of the real world by thinking and detachment from the real world. It is in conformity with the abstract rules of rational principles, with perfect organizational order and optimal operating efficiency. A highly harmonious and self-contained vision of integrity." With the help of Utopia, Western landscapes tend to exhibit a strong geometric composition, narrating clear logic, and providing a form template and design paradigm. In the oriental gardens, even Japan's dry landscape courtyards are seeking a spiritual synesthesia and resonance. They don't care about the form, but they care about an order and the atmosphere in which they live and the perception of the field.

(Fig.9)

For Huang Shengyuan, the "being" in the earth is not an abstract speculation in the concept, but a real material world with five senses and physical body. These are closer to the appeal of the oriental gardens, but they emphasize the participation and dynamic changes of the viewers. Furthermore, unlike gardens, the creation of landscapes is often an open environment. It is an open gesture that welcomes the

inclusion of all kinds of elements, together influences, and creates a sense of place in this place. Therefore, we see that in the design of the Field Office, the landscape encourages people to perceive the building (non-architecture) subject in a supporting role and extends around to connect with several other cases. When this extension expands again, it will find itself incorporated in a great natural pattern.

2.3. *Group People in Taiwan for Urban Innovation*

The essence of the city is its concentration. The city is formed by agglomeration and it is also reformed by agglomeration.

In these 20 years, Taiwan has not only Huang Shengyuan. After the great earthquake in 1999, Xie Yingjun came to the disaster area with the spirit of "Utopian Realism" to help residents rebuild. In the first time, he built a temporary resettlement area for the Thao people. The firm also moved to the disaster area and set up next to the resettlement area. He used the same materials to build the team into the disaster area, and later turned the disaster area office into a large base. Develop a set of construction methods that the residents of the group can build on their own. In order to complete their own homes in a collective manner, such a mode of modular design and a simple construction system enables all people to gather together and complete their own modernity.

Over the years, there are still many people who are tangling with the uniqueness

of Yilan. The criticism of Huang Shengyuan cannot be used as a paradigm for urban improvement. However, Yilan has never been given the status of city in fact, but is constantly building its own ground". From the author's point of view, the greatest value of Yilan lies in its emergence as an Yilan, which presents the characteristics of this place at this time, which can be clearly recognized, identified, and recognized by people. From a historical point of view, compared to classicalism, modernism, or postmodernism, etc., the current era has yet to form a core of convergence. The timeline is uneven, and the leap of development has made everything intertwined. Together, chaotic. We seem to have many groups, but we have never owned a "Texas Mounted Police." We seem to have held many meetings but never built IBA; we seem to be looking for a way out, but we don't clearly distinguish it from Outside of the core of those doctrines, their own situation and pursuit. We have indeed converged and converged over all previous eras, but we have violated the rules and principles of colonialism. Perhaps we need another dimension to guide us.

(Fig.10)

3. Urban Reformation in Passive Way

Another dimension of guiding urban change is urban events. If Huang Shengyuan enters Yilan from the boundary of time, in the 1990s, with the reunification of the two Germanys, the disintegration of the Soviet Union, and the end of the Cold War, all major issues left over from the Second World War have finally stabilized, and the entire world has entered the recovery of the

city. development stage. Until the beginning of the 21st century, people used the vast range of science and technology previously used in warfare on the construction of cities. Taking China as an example, Hong Kong and Macao have returned in succession, heralding the initial victory of one country, two systems. In the subsequent development, in 2011, the rate of urbanization in the Chinese mainland exceeded 50% for the first time, reaching 51.3%. This means that China's urban population exceeds the rural population for the first time, and urbanization in China has entered a critical stage of development. In these 20 years, human beings have gathered all their previous efforts, which have greatly consumed the cost of the earth's resources and reconstructed cities that were almost disturbed by post-war issues. Huang Shengyuan also took this opportunity to extend a helping hand to the almost defeated Yilan.

American architecture critic Giedion put forward the concept of "time-space-building" at the beginning of the 20th century. It was a sense of time when the speed of maneuvers brought unprecedented shock to mankind. The expression of "events" was "new" and "old". "Drawing a clear fault between them, if not, there is nothing special to highlight the new era, although there is still a gradual transition between them. When we are looking for a wedge, everything is compressed to the extreme.

(Fig.11)

4. Conclusion

Huang Shengyuan is not an ambitious architect, but like a repairman, he repairs buildings in each cracked area, builds a landscape, and finally connects the city. Every supplement in Yilan has its own imprint on later generations. There are some common attributes and tendencies. Where people's footsteps have been accumulated, the characteristics of human nature here are presented. If we stand at the perspective of Huang Shengyuan, we can describe that there is an essential difference between home and studio, that is, so-called townships and cities have caused substantial differences due to different stocks. This is why Huang Shengyuan has influenced people's thinking about the city but still has to be questioned. It's wise to slow down your own pace. Slowing others down is critical.

In the construction of nature, there is no need to discuss the attributes of "in the ground." Today we discuss "on the ground" because people are in the cities and the cities are in nature, replacing the attributes we have in the region. In fact, we do not have to break through this framework, or establish a system to demolish this "wall." If the scale and the pursuit of humanity are really expressed here, cities can serve as a place where such people can gather, and they can express the relationship and position between nature and human settlements, presenting the "the way that a dead person will exist in the earth." Human nature cities can grow naturally like humans.

(Fig.12)

Acknowledgments

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Appendix



Fig. 1. Yilan Building Map of the Field Office.

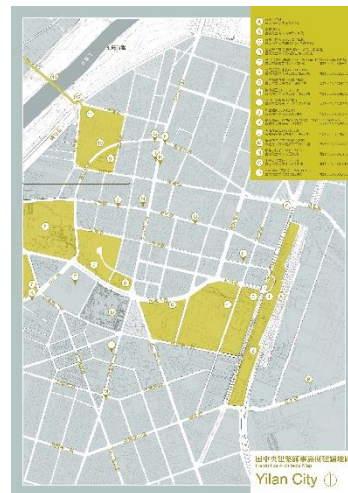


Fig. 2. Building Map of the Field Office



Fig. 3. Jin-Mei Pedestrian Bridge across Yilan River -1

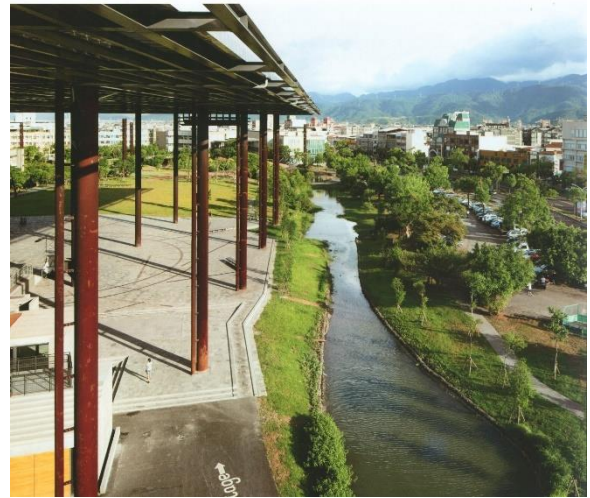


Fig. 5. Luodong Cultural Working House-1



Fig. 4. Jin-Mei Pedestrian Bridge across Yilan River-2



Fig. 6. Los Angeles

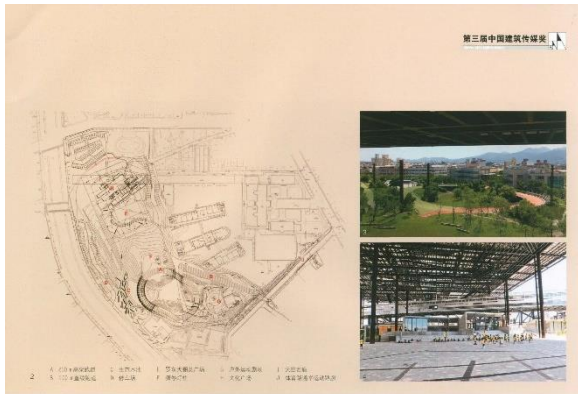


Fig. 7. Luodong Cultural Working House-2

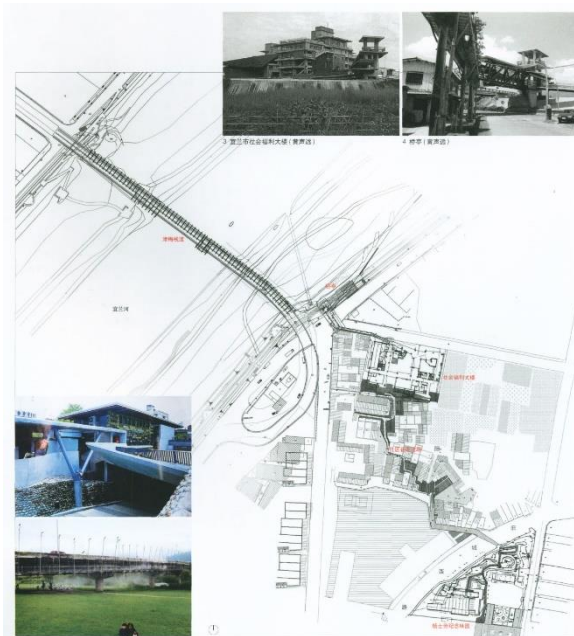


Fig. 8. Urban Connection by the Field Office



Fig. 9. Cherry Orchard Cemetery Fly-over Bridge



Fig. 10. Xie 's Construction in the Earthquake in 1999



Fig. 11. Siegfried Giedion <Space, Time & Architecture>



Fig. 12. Working in the Field

Reclaiming Landscape as Critical Framework for New Town Renewal: Case Study of Shanghai Nanqiao New Town

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Abstract

This paper addresses landscape-based strategies for urban new town revival in China. Urban new towns have been planned and built in an incredible speed in the last twenty years in China. Suffering the low quality of building design, inadequate infrastructure and taking no count of the value of nature in the planning, design and managing; New Town Renewal is an inevitable challenge for repairing our urban and nature environment in fast growing cities like Shanghai.

This paper examines landscape as a critical framework for New Town Renewal in a Chinese Context. First, the paper will claim New Town Renewal as an emerging crises and opportunity for city design, especially landscape urbanism; a brief review of new town planning evolution will be presented here.

Second, the paper will use a recent urban design practice in Nanqiao New Town near Shanghai as an example, to demonstrate the necessity and leading role of landscape architecture in New Town Renewal practice. In this case, a 32acres industrial campus built in 2000s is seeking for an urban design framework to be revived from low-end manufacturing upgrading to a mixed-use development, comprising a combination of office and laboratory buildings, that are home to several biotechnology companies, retail areas, rental apartments, and parks and open space. There key strategies are proposed here: First, with landscape and built structure layered overlay, a MULTI-LAYERED spatial structure is provided here, which view the entire campus as a living arena of processes and exchanges over time, allowing new forces and relationships shifting through and across the urban field; Second, the GRID SYSTEM as an effective field operation, is extending the framework for a wide range of flexible and changing development over time, enable people to provisionally stage a site for various and shifting programmatic events; Third, the proposal came to a whole repertoire of “Gateways, Viaducts and Reservoirs”, each finding new expressions making landscape as operative techniques to urban spatial notation.

Last, the paper would further claim that as more and more urban new town facing repairing in the future, landscape architecture have more opportunities and will play an increasing important leading role in improving daily human living quality in urban environment. This paper is supported by NSFC project. (No. 51678412).

Keywords: New Town Renewal; Landscape Urbanism; Built Environment; Multi-layered; Grid System; Gateways

1. Introduction: New Town Renewal in China

Urban new town has been planned and built in an incredible speed in China in the last twenty years. One major commendable achievement is the suburban planning and design. Chinese cities used to be product of Soviet planning practices and aesthetic preferences (Kuan & Rowe, 2004), but the open-door policy and the introduction of market mechanisms was pushing cities to experience the huge physical transformations (Friedmann, 2005; Lu, 2006; Xue, 2006, 2010)^[1]. This enormous achievement in the last twenty years has created new towns and districts at an accelerated rate unknown before.

On one hand, any urban planners, designers, and scholars must be humble in front of this historic process of urbanization with unprecedented scale in human history. But on the other hand, the simplicity and standardization make those new towns a well-known product, economic to construct and easily accepted by the construction industry (Shane, 2013)^[2].

The new town construction in China has followed the Industrial Model, as in the British planner Ebenezer Howard's Garden Cities of Tomorrow (1898) or in Le Corbusier's City of Three Million (1922), just like what Lynch(1981) called "the city as a machine". More often, the newly-built urban district was driven by market force, manufacturing services, housing need, and strong municipality ambitious, and was shaped on where used to be factories, warehouses, villages and farmland, with extremely low relocation cost and in

unprecedented speed. With ambitious to show a model city or how city should be shaped in future, they absorbed Perry's (1990s) conceptualization of the Neighborhood Units and what Lynch proposed Eco-city (1983) in the master plan. However, creating new town from an agricultural base has never been easy as the sprawling city in both European and America demonstrated. Suffering the low quality of building design, inadequate infrastructure and taking no count of the value of nature in the planning, design and managing; New Town Renewal is an inevitable challenge for repairing our urban and nature environment in fast growing cities.

New Town Renewal has been attracted increasing attention recently. Not only in the ghost town like Ordos and Tianji Eco-cities, but also in the rethinking of the revival of metropolitan core. The Lujiazui experiment is a recent research lead by Prof. Cai Yongji in Tongji University, with a team of 11 undergraduates. Lujiazui Pudong exhibits the typical progression of Chinese urbanization from an under-developed area full of warehouses and farmland, into a symbol embracing globalization and modern metropolis with clusters of skyscrapers (Xue, 2011)^[3]. The vision of today's Lujiazui was created in the Lujiazui international urban design competition held in 1992. Though it was trying to absorb the latest urban planning idea from western world, this area was shaped as a mono-financial area, which excluded other functions especially daily activities at human scale. The main purpose of the experiment is to supplement the daily function to create a 24-hour's zone.

Students are trying to insert “complexes” with a height of 24 meter, which included a variety of spaces, theaters, stadiums and living facilities.

Lujiazui Experiment (see Figure 1) is a typical case reflecting the rethinking and exploration from urban planners, designers and scholars, with an Urban Acupuncture approach. This paper would further examine landscape as a critical framework for New Town Renewal in a Chinese Context.

2. Reclaiming Landscape as a Framework for Urban Design

Landscape has played double role in the current urbanization. One significant reason that landscape has gained increased attention is the failures of abovementioned universal and utopian trends in architectural and urban planning and design. Landscape has been a tool to resist homogenization of the environment while also heightening local attributes (Corner, 1999) ^[4]. Another reason is the increasing concern to ecology and environment. Based on the earlier ecological work of Ian McHarg (1969) to contemporary practice of Landscape Urbanism.

A significant difference for landscape urbanism in Western and China is that the massive process of deindustrialization have stressed the new demands of land-use planning and urban design in Western countries, while in China the main challenges comes from the severe situation

for repairing nature resource from the fast industrial expansion, the new tech industrial upgrade benefit from the informatization, and the urgent need for high living quality from new citizens. The latter requires an even high flexibility for the future industrial and urban revolution. Best case could be JCFO’s winning proposal for Qianhai Harbor, Shenzhen, which defined the five distinct and sub-districts by “water fingers”- a landscape infrastructure and parkland played the role as innovative framework for the urban construction (Figure 2).

In the last ten years, landscape has been applied as framework to both downtown revival and new town planning. Sasaki’s winning proposal to reshaping Suzhou Creek - historically one of Shanghai’s most vital water routes but later suffered severe pollution and neglect- into an urban and cultural watershed delineated by the recreational waterfront edges and urban frontage (Figure 3). Landscape, served as a dominated framework in the revival process, addresses vast physical and social gaps in the city’s fabric. Similar framework could be traced in JCFO’s master plan for the revival of Seattle Waterfront (2012), Highline in New York City (2003), West 8 for Toronto Central Waterfront (2006)

In the next section, the author will provide a recent urban design practice, which use landscape as framework for repairing new town crisis in Shanghai.

3. Case Study: Nanqiao New Town

3.1. Challenge from Urban Upgrading

Shanghai's industrial transformation and upgrading have driven the development mode from the former extensive, high-consumption, and high-pollution development to the new development mode of green, low-carbon, safety, and recycling, and build a green, low-carbon, safe, cyclical new model of urban industry. The base industry relies on East Beauty Valley on the west side to form an industrial chain based on beauty and health, and it becomes a bearing space for the development of the beautiful and healthy industry in East Beauty Valley and promotes the clustering and development of beauty health industry clusters in Fengxian District.

The site is located on the east side of Nanqiao New Town, Shanghai, China. The west side relies on East Beauty Valley is the industrial support for the site, while the affordable housing on the north and south sides serve as the consumer base. To avoid the traditional development mode that breaks the space and historical continuity, the design hopes to seek the survival and regeneration of urban space. The site attempts to be a promotion and extension of the landscape of the Tuannan Highway Avenue, which leads to a landscape-oriented design concept (Figure 4-5).

3.2. Landscape Oriented Urban Design

The urban design is landscape-oriented, and all content centers on the landscape design. The status of the site is mainly comprised of old workshops and multi-story

office buildings, and a small proportion of them are high-rise buildings. Based on keeping the original road network unchanged, most broken and obsolete buildings can be demolished and rebuilt, and some old buildings with certain values and integrity can be preserved and reconstructed.

Firstly. The spatial organization adopts a sandwich-type structure, where multiple landscapes form a continuous landscape corridor and are sandwiched into building groups (Figure 6). Secondly, the street landscape including the scale and skyline will be also taken into consideration while creating a friendly and favorable atmosphere. Lastly, different types of landscape applied in a spatial sequence can also be experienced through the interpretation of different season themes: such as cherry blossoms in spring, lotus in summer, ginkgo, and beech in autumn, and plum flower in winter.

3.3. Key Strategies:

a) Multi-layered Spatial Structure

A multi-layered spatial structure is constituted like a sandwich including different parallel layers as Rem Koolhaas did in the La Villette Park Competition. Inside the blocks, a series of U-shaped corridors will be embedded to connect ten plots in the base, and a slow-walking aerial trail will be set up for visitors to take a walk, rest and stay. With the sandwich-type planar spatial structure, the city interface which is more rigorous and closed, alternates with the interfaces within the cluster, which is relatively curved and open, and they rely on each other and support each other.

The urban design incorporates a series of functional blocks in a slow corridor, uses landscape-first design techniques, rationally utilizes natural ecological elements, and creates public open spaces around the landscape nodes to improve the overall living environment.

Within each block, there is a valley-shaped space with high middle and low sides. It could guide people and improve the efficiency of space use. It integrates production and living in the valley and combines theme-based cultural activities such as viewing, smelling, and eating, creating a festival-style production, and living atmosphere (Figure 6,8).

b) Grid system

The main building heights are set at 24m, 48m and 80m, and the elevation angle with the centerline of Tuannan Road is about 30°, 45° and 60° respectively, creating a pleasant street space scale (Figure 7,9).

Along the Tuannan Highway facade, mainly multi-story buildings below 24m, accounting for about 50%, have fewer openings and form a flat and unified urban interface. Along the inner street of the group, there are more openings available and accessible for visitors, creating a variety of inward walking spaces and a rich inner spatial experience. The building plan transforms in the 50m*50m module, which is friendly for pedestrians and potential for phased development, different heights showing different architectural forms. The basic modules are combined and coded to form a continuous, rich, and diverse urban space.

c) Gateways, Viaducts and Reservoirs

The landscape is divided into four types: ecological type, participation type, functional type, and water system. Each type contains different types of landscape nodes. Eco-type landscapes include grassy slopes, tree arrays, and green trails, providing activities that are close to nature. Participation landscapes include island-style activity venues, weekend bazaars, interactive sculptures, and other participatory landscapes that provide exchanges and communication for tourists. The functional landscape includes a stadium, an outdoor theater, a tea pavilion, etc. To satisfy visitors' needs for different landscape functions, the water system is the waterfront landscape, which can adjust the microclimate and provide people with a pleasant scale of hydrophilic activity platform, which will become the highlight of the landscape belt. Waterfront landscape can also be used as a low-lying wetland for rainwater collection. It uses the concept of a sponge city to regulate precipitation and delay rainwater. Through the provision of irrigation systems, the collected rainwater from wetlands can also be used for irrigation of landscapes throughout the site (Figure 10-12).

4. Conclusion

As more and more urban new town facing repairing in the future, landscape architecture has more opportunities and will play an increasing important leading role in improving daily human living quality in urban environment. Landscape, as a critical framework, with operational design tactics like layering, grid, gateway etc. could play a

significant impact on disciplinary limits beyond landscape itself, from urban guidelines to environment improvement, which is exactly needed by the new town renewal.

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Appendix:



Fig. 1. Lujaizui Experiment for New Town Renewal project lead by Prof. Cai Yongjie, exhibited at 2017 Shanghai Urban Space Art Season. The wood block is the new inserting 24m high enclosed blocks, trying to strengthen the daily function in this financial district. Photo by Yichen Zhu.

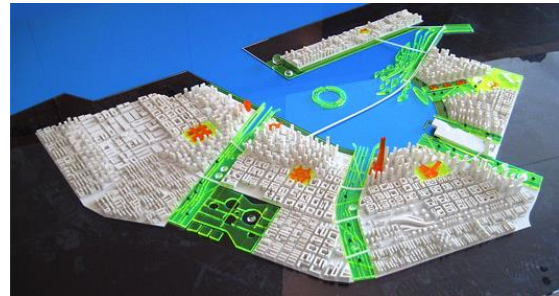


Fig. 2. JCFO's winning proposal for Qianhai Harbor, Shenzhen (2010). Source: Official website of James Corner Field Operations.



Fig. 3. Sasaki's winning proposal for Suzhou Creek, Shanghai (2016). Source: Official website of Sasaki Associates

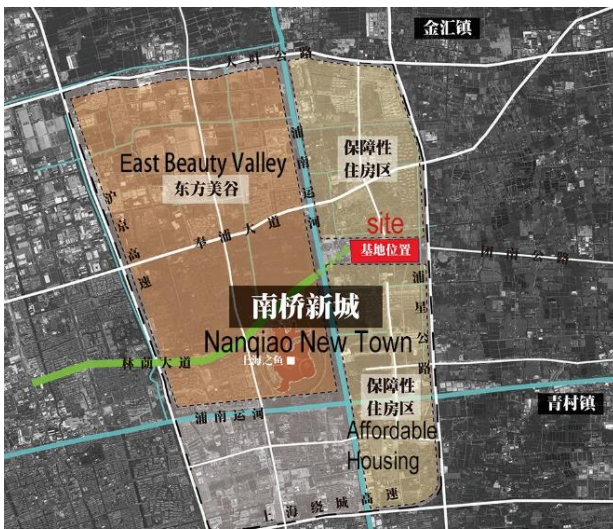


Fig. 4. Site Location in the Nanqiao New Town.



Fig. 5. The current industrial distribution of the site.



Fig. 6. The Multi-Layered Spatial Structure.

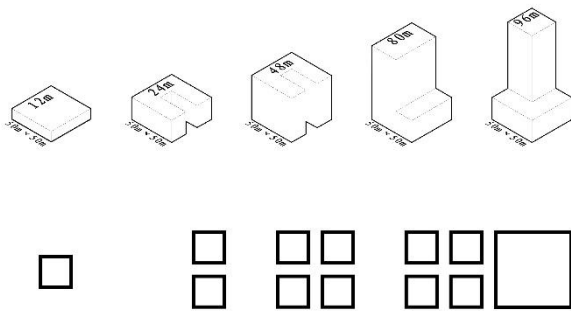


Fig. 7. The 50 *50 m Grid-system.

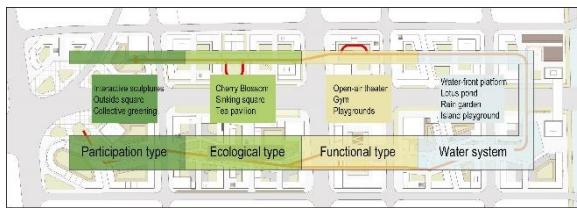


Fig. 8. The four basic types of landscape.



Fig. 11. The bird view of the renewed new town.

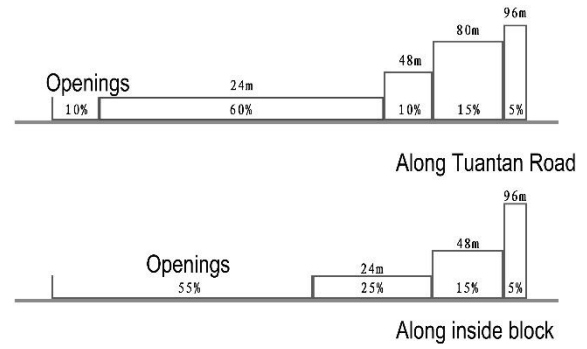


Fig. 9. The opening and height percentage along Tuannan Road and inside block.



Fig. 10. The master plan.



Fig. 12. The inside view of the viaducts.

A Comparative Study of Urban Ecological Functions of Flood-storage Landscape Parks - Take Landscape Parks Design in Harbin as Examples

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Abstract

The rapid development of Chinese cities has brought many problems to the urban environment, such as the decline of air quality, the pollution of urban water, the decrease of biodiversity and so on. The increase in urban population also places higher demands on urban landscape design, including a more complete urban surface runoff system. The global climate change has brought tremendous pressure on the urban water environment. Urban floods are common in China's coastal areas, although measures have been implemented to avoid disasters. The most common way to mitigate urban drainage pressure is underground piping systems but its disadvantage is expensive cost of constructing and complex maintenance. Urban floodplains are one of the best strategies to deal with the pressures of the city's water environment, both to relieve pressure from floods in urban rivers and to provide high-quality habitats or transit points for fish and migrating birds. More and more urban flood storage landscape parks are under construction in China, which undoubtedly provides a good solution for improving the urban landscape system. The construction of this kind of landscape park will help to enhance the vitality of the urban landscape and the attractiveness of the city, and this will greatly promote the economic development of the city. China's freshwater resources are in short supply. Most Chinese cities are facing a very serious shortage of water resources. Urban landscape design should give full consideration to the issue of water storage. Urban wetlands can assume the role of landscape preservation and rainwater purification, which is like a huge sponge. This article will take Harbin Qunli Wetland Park as an example. The project incorporates a large-scale rain and flood landscape management system with groundwater replenishment and providing rest areas for the citizens. This paper is subsidized by NSFC project which is named as <Research on Technical System of "Downtown Factory" Community-oriented Regeneration in Yangtze River Delta Region>. Thankful to the project owner Prof. LI Zhenyu who is the dean of College of Architecture and Urban Planning of Tongji University.

Keywords: Landscape, Flood-storage, Harbin, Park, Wetland

1. Introduction

The phenomenon of large-scale urbanization has caused enormous changes in the pattern of worldwide land use. The rapid growth of population has forced the city to expand, and the city has rapidly expanded its way of encroaching upon grassland, farmland, forest land, and wetlands. The upgrading of population capacity is also changing the original land structure. Land and wetlands, with their unique natural properties, are responsible for absorbing surface runoff in the ecological chain. Changes in land use patterns have shown a sharp decline in the proportion of green land, farmland and wetlands.

The process of urbanization in China is relatively fast on a global scale. In the process of urban construction, the constructors often pursue speed rather than having an overall concept, neglecting the quality of construction, leading to imperfect urban infrastructure.

Hard land and pipeline are relatively common practices in traditional Chinese urban construction. Drainage pipes can alleviate the trouble caused by urban rainwater and floods to a certain extent, but this method is not sustainable. Hard pipelines are less elastic, and when faced with rare storms or floods, the system is easily destroyed. In addition, the hard pipeline system is difficult to maintain, and it is very easy for the pipeline system to accumulate wastes from alluvial surface of the city, resulting in blockage of the pipeline system.

The establishment of flood storage landscape park is one of the important ways to build a sponge city. This method effectively uses the existing urban green space and carries out targeted sustainable landscape reconstruction. The establishment

of a flood storage landscape park effectively integrates man-made and natural resources, and deepens the natural self-adjustment capabilities.

2. Overview of City Flood-storage Landscape Park

2.1. Flood storage landscape park and city

Flood storage landscape parks were first produced in the United States in the 1990s and aim to control the runoff caused by impervious pavements in cities through natural self-regulating infiltration. Such landscape parks can effectively buffer the problems caused by the inability of rainwater to infiltrate, become urban sponges, and make adequate use of water resources for buffering. Stormwater stays in landscape parks, alleviating flooding problems in the city and at the same time providing excellent landscape benefits.

In cities with adequate water resources, flood storage landscape parks can rely on the original urban landscape resources, and construction is relatively time- and labor-saving. In areas with relatively scarce water resources, the construction of flood storage landscape parks is mainly in the form of constructed wetlands. The establishment of wetlands often requires a lot of resources and labor, and it is relatively difficult to use and maintain them in the later period. The key to building such a flood storage landscape park is to coordinate the relationship between the various links in the landscape biological chain, so as to construct a complete ecological self-circulation system. The relationship between soil, man-made, vegetation, micro-organisms, animals, etc., needs careful and detailed scrutiny.

2.2. *The function of flood storage landscape park*

Well-managed wetland landscape parks can effectively regulate the urban micro-climate. Under the background of global urbanization, reinforced concrete is gradually eroding the space of urban landscape green space. The city's large number of artificial thermal energy, buildings, and urban hard paved roads and other high-calorific bodies make the city more temperature-stable, with temperatures significantly higher than those in the surrounding suburbs. When the concentration reaches a certain value, it may affect the human body. The health of your life poses potential threats, such as inducing respiratory diseases, heart diseases.

The reduction of urban green space is one of the main factors that lead to the urban heat island effect. The construction of a flood storage eco-landscape park can effectively absorb solar radiation, and most of the solar radiation energy absorbed by the vegetation is used for the transpiration of plants and is converted to chemical energy in photosynthesis. Therefore, the construction of a flood storage landscape park can effectively reduce the urban heat island effect and reduce the ambient air temperature around it.

In addition, flood storage landscape parks can also effectively increase urban biodiversity. The constructed wetland and vegetation environment of the landscape park provide a unique living environment for microorganisms and small-scale aquatic animals and plants. The wetland animal and plant communities gather here, and humans and nature are able to live in harmony here. The forest area is mainly planted with water-tolerant plants, which are basically composed of trees, shrubs, and land. The wetlands are mainly composed of small

trees, shrubs, and herbaceous plants. The shallow water area is mainly planted with emergent plants such as reeds and cattails. These plants can be used to absorb heavy metals in water bodies to purify water bodies. When the flood storage landscape park is well maintained and operated, small mammals and birds also join the entire ecological chain, and the ecosystem is increasingly perfected.

3. Harbin Qunli Wetland Rainfall Park

3.1. *Urban Stormwater Resources in Harbin*

Harbin City is located in the northeastern part of China and is affiliated to the temperate continental monsoon climate zone.

After the founding of New China, Harbin entered the period of rapid urbanization and the scale and speed of urbanization accelerated. However, in the process of urban development, because the environmental protection issue has not been taken seriously, the environment of wetlands has deteriorated rapidly, and the area of wetlands has dropped sharply, functions have been reduced, and biodiversity has decreased. The ecological environment of urban water resources in Harbin faces great challenges.

Harbin has a total wetland area of 125,000 hectares, including a wetland park in Harbin City. In addition to the Qunli Wetland Park, there are two state-level wetland parks, the Sun Island National Wetland Park and the Baiyupao National Wetland Park. However, unlike these two wetland parks, the surrounding environment of the Qunli wetland park is the built residential community and the main urban roads, while the first two parks are themselves located in the natural environment.

3.2. Geographical Environment of Qunli Wetland Rainstorm Park

Located in Daoli District of Harbin, the Qunli Wetland Rainfall Park was completed in 2010. It is designed and completed by the Beijing Tumen landscape and is a typical urban stormwater park. The park is located in the central part of Qunli New District in Harbin, which covers about 300,000 square meters of ground.

The special feature of Qunli Wetland Park is that the plots are urban wetlands that do not remain much after the rapid development of the city, and are surrounded by urban expressways, large residential areas, and cultural and commercial areas. With the rapid and large-scale construction of Qunli New District, this wetland is indeed facing a great threat. On the other hand, Harbin itself belongs to the cold climate area, and the minimum temperature in winter is below -40°C . Therefore, the Qunli Wetland Park has an icing period of several months from November, and the depth of the water body must meet the requirements for winter for small fish.

3.3. Wetland Park Design

The Turenscape was entrusted by the local government of Harbin to protect this piece of wetland. The designer proposed a design plan for the rain-flood park on the basis of protection. In this program, the original wetland in the city has been effectively protected, and Park can provide excellent urban ecological services for the city.

1. Respond to the impact of cities - Isolation and Communion

The base is surrounded by urban roads. On the one hand, it is necessary to separate the city from the park. This can effectively

protect the ecological environment of the park. On the other hand, it also needs to integrate the park into the city and effectively exert the urban ecological function of the park.

First of all, in order to set up a hierarchical relationship between the park and the city, there is a height difference of 2~3m between the venue and the surrounding area of the Park. On the one hand, the elevation difference weakens the direct connection between the park and the city to some extent; on the other hand, this method also makes full use of the ups and downs of the original landscape, effectively reducing the amount of earthwork and reducing the cost of construction. And expenses. From the city to the interior of the wetland park and from the wetland park, two distinct landscapes can be felt.

Second, in order to make the wetland landscape better serve the urban residents, the wetland has a ring-shaped three-dimensional trestle bridge and two observation towers. The trestle bridge is placed on the wetland. The pedestrian streamline does not directly contact the wetland landscape. This approach effectively reduces the area occupied by the wetland, and it can also ensure that the living environment of plants and animals in the wetland is not destroyed. The winding path of the boardwalk provides visitors with more views of the wetland landscape and has become a new tourist hotspot in Qunli New District.

2. Urban stormwater collection

Since ancient times, the effective use of water resources has always been a topic that cannot be disturbed in the process of urban development. China's vast territory and abundant resources, the total freshwater resources ranked sixth in the world, but because of China's large population, per

capita water resources is only 2,300 cubic meters, the world average is about 10,000 cubic meters. Moreover, China belongs to the monsoon climate zone and the country has a vast territory. Therefore, the uneven distribution of water resources in time and space is very serious. Spatially, precipitation decreases from the southeast to the northwest. In time, most of the precipitation is concentrated in the months of May to September each year, and floods often occur. Therefore, China's water supply and demand contradictions are very prominent.

Urban rain-flood park is a sustainable means to deal with the contradiction between supply and demand of water resources. Rainwater harvesting at the Qunli rainstorm Wetland Park in the group comes from two parts. One is the catchment area of about 30 hectares of the wetland park itself, and the other is the rainwater collection of the special construction site in the north of the wetland park. This part of the rainwater includes the northern planning. The cultural and recreational land and the residential land and the collection of road rainwater connected to the park grounds. (Picture) The former integrates rainwater into the park's development area through the height difference of the wetland park itself, while the latter directly connects to the park's wetland bubble through the park's underground circular pipe. The collected rainwater will be directly used in the wetland. Park interior.

3.4. Influence of Qunli Wetland Rainwater Park on Urban Ecosystem

After completion, the Qunli wetland park has apparently begun to have a positive impact on the surrounding urban environment. This article mainly introduces its impact on the biological environment, the influence of the natural geographical

environment and the influence of the social environment.

1. Biological environment - enrich species diversity

Qunli Wetland Park formerly known as the black fish bubble wetland, at the beginning of the development of Harbin city, where once a paradise for all kinds of wild animals and plants, has a very complete wetland ecosystem. In the later period of urban development, the amount of water in wetlands has decreased and the ecological environment has begun to deteriorate.

The construction and improvement of wetland parks are of great significance to maintaining ecological diversity, which is mainly reflected in three aspects: biodiversity, plant diversity and animal diversity.

The plant community within the wetland has been dominated by reed ponds, continuing the original vegetation ecosystem. At the same time, there are as many as hundreds of other types of vegetation such as ferns and angiosperms within the wetland. The growth process of aquatic plants absorbs nitrogen, phosphorus, and other elements in water, and synthesizes plant proteins, thereby purifying water quality. Wetland plants have a dominant influence on the ecological environment of the entire storm-water park. The degree of development of the plant ecosystem directly determines whether the entire rain-flood park system can operate normally.

In terms of animal diversity, the Park is also a paradise for many species of creatures to inhabit and breed. On the one hand, Harbin is a must-see route for migration of migratory birds in the Far East. The ecological environment of wetlands can provide a suitable habitat for aquatic birds. On the other hand, micro-enriched wetlands provide a good living environment for fish.

The difference in most wetland ecosystems is that the body of water in the Qunli Wetland Park is self-contained, so the types of fish are relatively small.

2. Geographical Environment - Cycle Configuration of Water Resources

In addition to the natural rainfall received by the park itself, the design plan of Qunli Rain Flood Wetland Park collects rainwater mainly through four urban interfaces such as green areas, permeable pavement, squares, and parking lots to form multiple small-scale rainwater blisters. In the plan, rainwater pipes on the city road will also be connected to the park. The entire design of the water cycle has a strong organic nature. After being purified by aquatic plants, soil, and gravel, the rainwater will reach the standards of landscape water use and green water use and can be used for irrigation of urban vegetation.

However, in the actual use, there are certain problems in the purification and utilization of rainwater. In the initial stage of the park construction, the internal water resources of the park mainly come from groundwater. However, in the later operation process, the groundwater level in the city decreases rapidly, and the source of the water body is mostly supplemented by the Songhua River water system. Supplementary water is piped to the interior of landscape wetlands. However, there is a situation where water resources are not evenly distributed. Some waters have sufficient water and the water quality is relatively high.

3. Social environment - a multi-faceted industrial drive

The completion of the Qunli Wetland Rainfall Park has undoubtedly greatly improved the quality of urban life in the nearby areas. The park has provided a good

living environment for the surrounding citizens in terms of ecology, greening, environmental protection, water quality, atmosphere, and transportation. And work environment. At the same time, the construction of wetland parks has also accelerated the speed of urbanization in the surrounding areas. A large number of residential areas have come into being and the quality of residential properties is relatively high.

4. Examples of wetland parks adapted to local conditions

The construction of wetland rain-flood park is a relatively small category of natural destructive activity in human construction activities. Wetland park construction in different regions can basically adapt to local conditions and choose appropriate methods to protect ecological resources.

4.1. Caiyun Lake National Wetland Park

Chongqing is the capital of China's River City and Fog City. The terrain of the city is complex, and as a result unique urban landscapes have emerged. Caiyun Lake National Wetland Park The sanitary ware is located at the junction of Jiulongpo District and Gaoxin District in Chongqing City. It consists of two parts, namely Caiyun Lake and Taohua Stream. It is mainly used to treat the sewage generated in daily life. The wetland park is in a state of high ups and downs, and the height difference is complex. In the design of the park, the designers used the concept of "three-dimensional wetland" and constructed multiple elements such as wetlands, lakes, streams, ponds, and terraces into a rich one. The three-dimensional landscape system.

4.2. Liupanshui Minghu Wetland Park

Liupanshui is located in the Wumeng Mountain area of Guizhou Province in China. Because of the cool climate throughout the year and low UV radiation, it is also known as the cool city of China. In the “West-to-East Power Transmission Project” in China, Liupanshui, as an important node city, left behind a relatively serious problem of coal and steel pollution in the city. Minghu Wetland Park removes existing hard riverbanks by connecting different types of existing water bodies in order to restore the natural ecological functions of the water bodies. At the same time, Minghu Wetland Park has fully utilized the terrace landscape of the current terrain, and established a terraced wetland ecosystem in the elevation zone of the riverfront.

5. Summary

Although the urban rain-flooded wetland park has a great role in restoring the urban ecological environment and protecting water resources, it itself also has the characteristics of vulnerability and sensitivity. In the course of the operation of the ecosystem, the wetland park’s lifespan will be greatly shortened if it is not able to achieve a good balance in all aspects. Therefore, at the level of urban planning and landscape design, careful consideration and careful operation must be made.

Secondly, in the site selection and construction of urban rain-flood wetland parks, local conditions should be a necessary condition. Different urban areas have great differences in historical conditions, climatic conditions, geographical conditions, and biological species. How to distinguish primary and secondary relationships among many conditions, solve the most important

problems by solving major problems, and establish a sustainable and ecologically distinctive wetland park will also become an important aspect of the future construction of wetland parks.

In addition, although the Urban Ecological Wetland Park can promote the rapid development of the economy, culture and other aspects of the city to a certain extent and improve the quality of life in the surrounding residential areas, this is not one of the main functions of the urban rain-wet park. Economic and social benefits should be placed in a relatively secondary position or be treated as an additional urban welfare.

Finally, the operation of the wetland rain-flood park should also be given great attention. Although the construction of rain-flooded parks in the city has sprung up and more and more projects have been built, in the long-term perspective, parks that can operate better are not the majority. How to sustainably operate the urban rain-flooded wetland park so that it can serve the urban ecological environment for a long period of time requires the joint efforts of city decision-makers, ecological observers, and city builders.

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The Influence of Landscape Urbanism on Urban Development

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Abstract

Landscape urbanism is to understand the city as an ecological system. By building and improving the landscape infrastructure, the function of the infrastructure and the social and cultural needs of the city can be combined to make the modern city built and extended. James Corner has explained the concept of “Landscape” and “Urbanism” separately in his book.

First of all, the development of landscape infrastructure includes rain flood storage, pollution disposal, habitat construction, ecological corridor improvement etc. On the basis of this landscape ecology, designers provide diverse and recreational places to liberate people from the negative effects of congestion, pollution and noise, and enhance the quality of the city. Secondly, it is the concept that city is as a landscape itself. This ecological, natural-return and highly open city is the city of landscape. The power of urban growth and transformation is interpreted as the interaction between large scale ecological groups, regional waters and complex biological networks.

In short, landscape is the carrier of various natural processes. These processes support the existence and continuity of life. At the same time, landscape is also a vehicle for building and infrastructure. It provides an interface for integration and exchange between natural environment and infrastructure. Only by attaching importance to the role of nature in the city and the landscape urbanism can we create a city as a Biophilic City soon.

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Keywords: Landscape urbanism; Urban;Improvement; Infrastructure; Public space;Natural process

1. The background and definition the Landscape Urbanism

1.1. The background of the Landscape Urbanism

The middle of the twentieth Century, in the global capital of the city, some European countries' process of urbanization has increased, coupled with the rapid

development of the city brought a series of problems, such as noise pollution, traffic jam, small living space and the environment pollution caused by industrial activities. At the same time, with the development of urban economy, people's sense of leisure demand has also been strengthened. Leisure has become an important part of people's life. The traditional dense urban form has been weary of people. People are eager to live in low density. And it should be suitable for car trip, surrounded by large area of green and public space. Therefore, the emerging theories, such as landscape urbanism, are also born.

1.2. The definition of the Landscape Urbanism

Charles Waldheim is defined as follows in the "Declaration" in reference: Landscape urbanism depicts an approach to the reintegration of the existing order in the process of contemporary cities. In this process, the landscape architecture is the most basic element of urban construction. In many times, the landscape has become a window for the revival of contemporary cities, especially in North America, and an important medium for urban reconstruction. In this context, the practice of landscape urbanism takes a positive and effective analytical framework to deal with the

problems of the city. In particular, the landscape urbanism is most applicable when a large number of sites which was abandoned, polluted and left over by the city.

Landscape urbanism focuses on improving the urban blank area with the principles of spatial organization, dynamic interaction, ecological elements and key technologies, enabling the city to exist in a dynamic, healthy, strategic and continuous state. The process it emphasizes can adapt to the development patterns of different stages of the city, thus promoting a more relaxed and flexible natural process. This process is compatible with the complexity of urban development. At the same time, this flow, continuous form of urban development can also provide people with the continuous development and change of public leisure space.

2. The landscape urbanism is beneficial to the improvement of urban infrastructure

2.1. The types and significance of infrastructure construction

Infrastructure construction includes stormwater flood control, pollution treatment, living environment, ecological corridor based on the improvement of landscape ecology. Design staff provide a variety of entertainment to free people from the negative effects of pollution and noise, thus to improve the quality of the city. The utilization and treatment of water resources is an important link in the construction of infrastructure, and is very helpful to the improvement of the urban environment.

2.2. Potsdam square rainwater utilization

The famous case is Potsdam square, Germany. It is the most attractive place in Berlin. Its striking buildings include restaurants, shopping centers, theaters and cinemas. It is not only attracting tourists from other places, but also a scenic spot frequented by locals in Berlin. There are about 70 thousand tourists visiting here every day. The water landscape here is especially impressive for tourists. But most tourists may not know that Potsdam square is a model for rainwater utilization. All landscape water is from rainwater collection.

(Fig. 1.)



Fig. 1. Schematic diagram of the overall water circulation system

Because of the shallow groundwater level in Berlin City, commercial area is built not only increase the groundwater recharge, nor increase the emissions of rain. Therefore, developers using the following scheme of rainwater utilization: build the "green roof" to become the green lag of rainwater. On the one hand to prevent rainwater runoff, play a role in flood control. On the other hand, it makes the water's evaporation become fast to increase air humidity, and improves the microclimate effect. On the construction of roof which are not suitable to become the green space, the remaining rainwater will flow through pipes which has a filtering function into the main building and the total Square underground storage tank. After preliminary filtration and precipitation, and then the water go through the water pump in the control room and the filter. Part of it entering the building's reclaimed water system is used to scour the toilets and irrigate the garden grass on the roof. The other part is sent to the artificial stream on the ground to form a rainwater circulation system and complete the purification and filtration for the second time. And the underground water tank is equipped with the water quality automatic monitoring system. When the water surface is reduced by evaporation, the automatic system will supplement it by the water in the storage tank. (Fig. 2.)



Fig. 2. Water recycling process

Four waterscape systems of the north water surface, the water surface of the music square, the main surface of the triangle and the water surface of the south side are completed together. Through the artificial water system, urban life and natural elements will be integrated, not only purify the water, but also add the natural public space for the crowded city. The fountain before the SONY center building is the most popular place. The triangle artificial lake is the center of the square. And “ladder water” in front of the Berlin Film Festival Movie Palace is well-proportioned, and make people feel the nature.

3. The landscape urbanism is beneficial to the construction of urban public space

3.1. The necessity of the use of Landscape Urbanism in urban public space

Urban public space is an outdoor, open and public space for public recreational activities in cities. They are important for urban development and construction. Whether the layout of public space in the urban macroscopical scale, or the design of building on the micro scale of the site need a theoretical thought to guide the future

planning and design of the city. Since the development of landscape urbanism, so far, we have put forward our own ideas on the basis of absorbing the existing related ideas. The social background and the lack of green and public space faced by today's cities must make them strong adaptability and vitality.

3.2. Case studies-- The Millennium Park

The Millennium Park is an excellent example of the landscape urbanism in the construction of urban public space. (Fig. 3.)

Firstly, urban public space can provide citizens with a humane leisure space and

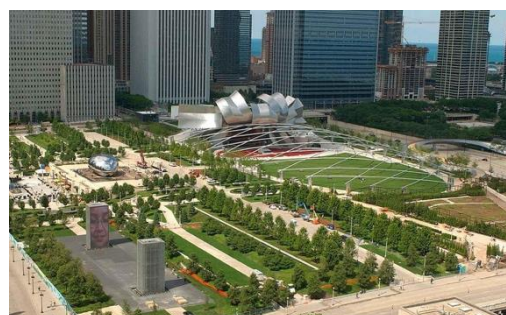


Fig. 3. A bird's eye view of the Millennium Park

high happiness index, making it an important factor to stimulate vitality of the city and ensure the vitality of the urban central area. The idea of landscape urbanism agrees with the vitality of the city, opening up many urban green spaces, and bringing the natural landscape more into the city and revitalize it.

The base of the park was originally a large underground parking lot, providing parking for the city. The original plan was to build a "green parking lot", but with the continuous implementation of the project, a large city park was formed. While realizing

the general function of urban public space, the park also provides 9000 parking spaces for the city, which greatly satisfies the parking demand of the city center. At the same time, it has also increased the vitality of the urban central area and improved the publicness of the urban public space. The park belongs to the whole city, and it belongs to all citizens, and every citizen has the power to enjoy it. The Millennium Park's planning embodies the human centered care. From the perspective of functional zoning, park planning meets the needs of different groups, whether old people, young people or children, can find suitable areas for their activities. From the park facilities, the visible barrier free facilities also allow the disabled to enjoy the construction of the urban public space. From the point of view of staffing, there are both professional staff responsible for daily maintenance and special service for tourists. From the point of view of the park's operation, the rest of the project is almost free, in addition to the parking fee and commercial operation of the commercial network. This plan will attract everyone to enter the park and enjoy the park, so that the Millennium Park can be interpreted as the publicness of the urban public space.

Secondly, the priority of the public space pattern is another important measure for the development of the city. Public space has an irreplaceable role in improving the material, ecology, recreation and landscape of the city. The priority of public space also reflects the guiding ideology of respecting nature in the process of urban construction. It is same as the landscape takes the place of the architecture and becomes the carrier of the city's function in the landscape urbanism. Therefore, the landscape urbanism has a strong connection and mutual assistance with the construction of

the urban public space on both the target and the strategy.

The Millennium Park realizes the functions of recreational entertainment and sports fitness through square, footpaths and open lawns, and realizes greening, beautifying, ecological and even popular science functions with its large area of greening and diversity plants. In addition to the park lawn and ornamental trees, there is also a botanical garden. The park covers an area of 5 acres and has 205 kinds of plants including shrubs, 21 species, 130 species perennial flowers, flower bulbs 33, other 21 kinds of plant. These varieties of plant species are planted to meet the green, beautifying and ecological functions of the park, as well as the science popularization of the botanical garden.

4. The landscape urbanism is beneficial to the revival of the natural process of the city

4.1. Landscape urbanism is the catalyst for the base

Landscape urbanism thinks about the city problem from the perspective of landscape, and the ecological strategy is the breakthrough point to solve the problem. It explores the possibility of mediating the differences between the architecture and the landscape, the site and the object, the method and the art. Therefore, in the face of increasingly complex urban environment, the landscape should be given priority. The means of ecological design should also be used as a medium to become the seed and catalyst for the rejuvenation and regeneration of the whole site.

4.2. The natural revival of the fourth middle school in Fangshan

The design of the fourth middle school in Fangshan (Fig. 4.), Beijing embodies the design form of the natural process. Also, after the city was tortured by the negative effects of environmental pollution, the designer reintroduced the positive measures of natural regulation. In the design, agriculture and landscape combine to make agriculture become a landscape, so that the landscape not only has aesthetic function, but also has production functions, and meets the functions of campus learning, culture, leisure and experience of agricultural labor.



Fig. 4. The fourth middle school of Beijing in Fangshan

The fourth middle school of Fangshan, is located in the center of a new town outside the fifth ring of Southwest Beijing. Creating more open space full of nature is the starting point of the design. This is what the Chinese urban students are in urgent need of today. The spatial constraints of the site have stimulated the design strategy to create multi layer ground in the vertical direction. The school's functional space is organized into two parts, and the garden is inserted between them. (Fig. 5.) Vertically collocated upper and lower spaces, and their contact, support or connection in different ways in the middle area, are strategies for building space, and also symbolize the relationship between formal and informal teaching space in this new school.

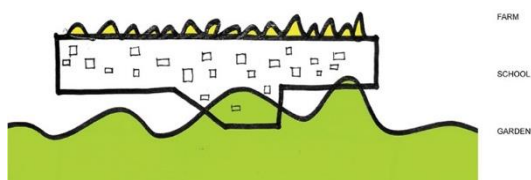


Fig. 5. The school's vertical landscape system

In this huge structure, the main traffic flow line is expanded to create an indoor place for social interaction, like a river, which also contains free-form "islands", which provides a semi private enclosure for small group activities. The roof of the teaching building is designed as an organic farm. It provides 36 experimental fields for 36 classes of students. It not only allows teachers and students to have opportunities to learn and cultivate, but also respects the past that they once used as farmland. These

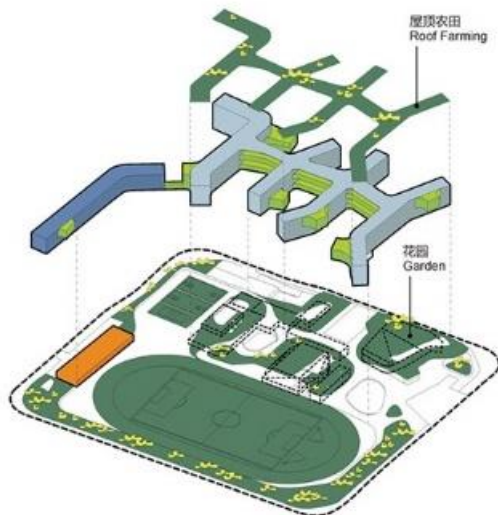


Fig. 6. Rooftop farmland becomes a dynamic landscape

changes in the landscape reflects the dynamic process of landscape. And the school teachers and students participate in the work. This scene also creates a landscape, not only to close the distance between the students and teachers, but also to the students' sense of identity, and more to reflect their participation. The whole landscape has been devoted to the cultural atmosphere of the campus. At the same time, the landscape enriches the campus environment and provides food for people. More close to the relationship between people and the landscape. (Fig. 6.)

5. Conclusion

So we can find two clues. Firstly, modern landscape science and ecological science have an increasingly deep impact on the construction of human living environment. Secondly is a landscape reading of contemporary urban phenomena. The background of these two clues is the post industrialization, the continuous spread, and the mixed city. In that era, cities showed a lot of new features: high mobility, centralization or no centralization, mixed functions, and so on. Cities can be seen as a horizontal, constantly changing landscape system, in which the concept of city and landscape has become blurred.

Landscape urbanism is under this constantly blurred boundary, which has a multifaceted impact on the urban infrastructure, public space and natural process. The mode of perfection, promotion and revival is the main mode, and the more dominant intervention in buildings and cities is more quickly solving the urban problems and affecting the urban form and experience.

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Research of Park Soundscape perception and its Impact factors Take the ecological square in Shenzhen as a case study

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Abstract

Park soundscape perception research is a research branch of park soundscape. Certain research was conducted on the relationship and effects between sound perception and gender, occupation, visual simulation, and landscape characteristic. But there was still a research gap on the relationship between soundscape inventory and its related perceptions, the influencing factors of soundscape perceptions and the relationship between people's emotions and sound perceptions. This research took soundscape in city parks as a research object. It collected a sound clip for lab study through sound-walking in ecological square in Shenzhen, then applied a dose – response lab test and survey to test the park soundscape perception. This research collected 107 effective samples for data analyzing. Results conclude as :1) All the natural sounds were acceptable sound, most anthropogenic sound were unacceptable sound. Four high listening frequencies but low acceptance sound were concluded. 2) Certain soundscape perceptions were correlated with other. 3) There was a coupling relationship between people's emotions and sound perceptions. Which showed the natural sound would aroused the pleasant emotions. 4)The noise sensitivity and water sound perception were correlated with each other. Result implied that, people who were less sensitive with noise would be more attracted by water sound. Based on the above five findings, research discussed corresponding suggestions for park soundscape management, which include soundscape inventory management, noise control methods, the landscape enhancement methods which for the park soundscape perceptions improvement.

Keywords: Soundscape preceptions; Impact factors; Management Strategies

1. Background

Take the soundscape as a research objective, the aim of this research is to reveal people's different sound perceptions and its impact factors. To identify the acceptable or unacceptable sound inventories, and its acceptance degree. Based on the sound acceptance, this

research would continue to find the potential impact factors to soundscape which might include people's noise sensitivity, park motivation and personalities, and also exam the coupling relationship between sound perception and emotions. Finally, this research will

propose suggestions and strategies for park management. Suggestions will include noise control and specific management and landscape design strategies. TWO hypothesis were proposed for future verification: Hypothesis 1: People's personality and park motivation were both apply as impact factors to people's park soundscape perceptions. Hypothesis 2: People's sound perception has coupling relationship with emotion. This research will validate these two hypotheses through the following analysis.

2. Research Methods

2.1. Data collections

Research applied the sound walking method¹ to collect the sound clip which used as the dose – response listening material. The sound walking was taken at 11:00 o' clock of April 26th, at the ecological square of OCT, Shenzhen, 2017. The weather was cloudy with slightly rain, the highest temperature for the day is 26 °C . More human activities happened at north dining area, while less human activities happened at the hard-paving area of ecological square. The sound walking route (figure 1) was started from the entrance of southwest hard paving square, walking through the square and turned to north dining area, walked along the dinning street to the jungle area of northeast part of ecological square, went through the jungle and end over at the gate zone of Jinan University Tourist college. The sound walking took six minutes. This research picked a part for the does – response clip.



Fig. 1. Sound walking routes

2.2. Questionnaire and research design

This lab questionnaire contains a dose-response listening tests were given to participants to measure their soundscape perceptions. The 18 questions in the questionnaire could be summarized as four parts. 1) Evaluating the sound clips and writing down their related feelings. 2) Testing the personality, noise sensitivity, gathering the personal information such as gender, age, park visiting frequency, living places etc. 3) Gathering information of park visiting motivations. It would take participants about 35 minutes to finish the questionnaire. The lab survey was conducted in Shenzhen Jinan university tourism college from April 26th to 29th. Participants were randomly recruited from undergraduate students in Jinan tourism college. 107 effective samples were collected during this lab study.

For the sound evaluation question, research implemented a dose-response lab test. The participants were required to wear a noise reducing headphone, and listen to a clip . After listening, participants were provided a sound checklist, and required to click the sound which they heard in the clip, and evaluated their acceptance of the sound based on a nine points Likert Scale (-4 to +4, -4 represents the very annoying, +4 represents very pleasing, see table1). Besides, they were also required to write down their feelings (words or phrases) towards the sound they heard.

The sound checklist includes natural and anthropogenic sound. The natural sound contains sound of wind, water, bird songs, animal, insects. The anthropogenic sound includes sound of aircrafts, shuttle buses, children yelling and shouting, adult yelling and shouting, group talking, eating, etc.

For the second and third part, the questions of Ten items of personality

(abbreviate as TIPI), noise sensitivity, and park motivation were setted for testing the soundscape perception factors, and the relationship among these factors. Ten items of personality scale were based on gosling’s research which has high validity for using. Four groups of laboratories (two as a group) were trained to conduct the lab questionnaire. They were ensured each participant to answer all the questions, to fill all the requirement of the sound checklist and to make sure each participant to listen sound clip carefully.

3. Results and Finding

3.1. Sound source and its acceptability

The percentage of participants in the sound clip listening that heard each of the 30 types of sound included in the sound checklist was calculated and graphed on the Y-axis. The evaluation of the sound clip listening that heard each of the 30 types of sound included in the sound checklist was calculated and graphed on the X-axis, figure 2.

Compared the natural sound types, the anthropogenic sound types were more frequently be heard. The most frequently heard types of sound were list as follows: bird song (93%), people’s voice (74%), group talking (68%), aircraft (64%), walking and running (64%), rain (63%), café (54%), Children, loud or yelling(52%),wind (48%), water(45%), loud yelling (39%), eating(38%), car driving (35%), unknown electronic devices (30%), whispering (30%). The acceptance of the according sounds was: bird song (+1.67), people’s voice (-0.41), group talking (-0.88), aircraft (-0.85), walking and running (0), rain (+0.97), café (-0.05), Children, loud or yelling (-1.32), wind (+0.76), water(+1), loud yelling (-1.55), eating(+0.15), car driving (-0.63), unknown

electronic devices (-0.41), whispering (+0.1).

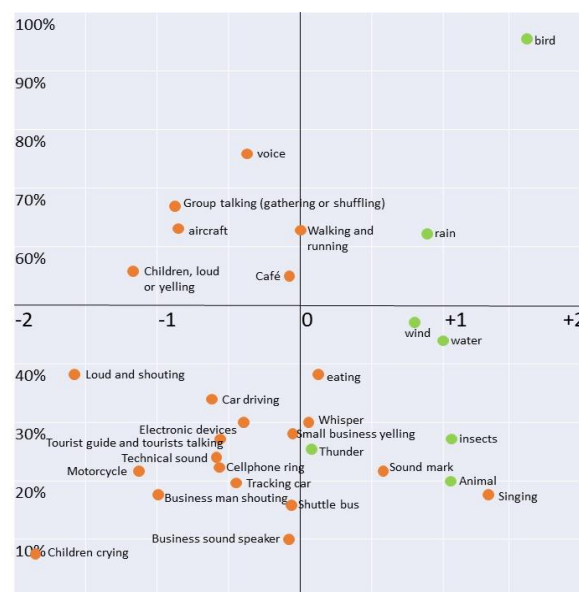


Fig. 2. Sound source hearing frequency and acceptance

From the descriptive analysis, research conclude that: 1) all the natural sound types were acceptance sound no matter the listening frequency is high or low. The bird song was the sound type with both high listening frequency and acceptance. 2) For the anthropogenic sound, the unacceptance degree of certain sound types were similar, which was between neutral to -1 unacceptance. they were walking and running sound, car driving, electronic devices, tourist guide and tourists talking, tracking car and small business yelling. 3) On the contrary, the singing, eating, whispering and sound mark as the anthropogenic sound, were the acceptable sound. The experiment showed that, most anthropogenic sounds were negative sound which would bring negative emotions to people. Hence, from the descriptive analysis, we drew conclusion that, in city park environment, the natural sound would be more acceptable than anthropogenic

sounds. But certain anthropogenic sound, such as car driving sound, electronic sound, tourist and tourist guide sound, by proper controlling strategies and management, would reduce the unacceptance to people's soundscape perceptions.

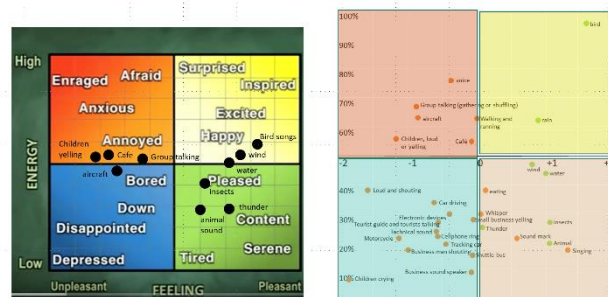
3.2. The correlative relationship between different sound types

Through the correlation analysis, research proved that the perceptions of certain sound types were correlated with each other, take significance ($P < .05$) into count, see table 2. Certain sound perceptions were correlated with each other, results showed that: The sound perceptions of wind and water ($P = .192$, $\text{Sig.} = .048$), water and insects ($P = .382$, $\text{Sig.} = .000$), thunder and insects ($P = .244$, $\text{Sig.} = .011$); animal sound and insects ($P = .341$, $\text{Sig.} = .000$) were correlated with each other. Ranking as the correlative degree of two sound types were: animal sound and insects, water sounds and insects, wind and water, wind and insects, thunder and insects, wind and water. Hence, from the combination perceptions perspective, the sound combination of thunder and rain, wind and water, animal and insects would easily rouse up people's soundscape perceptions towards the acoustic environment.

3.3. Sound perceptions and emotions

Through the grounded theory, we counted the word frequency which people used to describe their feelings towards the sound. The words used to describe the natural sound in high frequency (Figure 3) (counted by word times) were: pleasing (33 times), peace (14 times), ease (14 times), relaxation (11 times), comfort (11 times). The results showed most of participants used positive words to describe the natural sound. Wind: pleasing (4 times), peace and

comfort (3 times), relaxation and sung (2 times); Water: delight (5 times), relaxation (3 times), peace (2 times). Rain: pleasing (7 times), relaxation (4 times), comfort, peace, enjoy (2 times); Thunder: peace (2 times); Bird songs: Pleasing (14 times), relaxation (6 times), comfort (4 times), peace, delight (2 times); Insects: Pleasing (3 times), peace, comfort (2 times); Animal sound (2 times). Regarding to the four lowest acceptance anthropogenic sounds, the words which used to describe each sound were: Children yelling: irritability (3 times), annoying (3 times), noising (2 times); Café: no sense (5 times), peace (4 times), anxious (3 times); Aircraft: peace (6 times), annoying (3 times), a bit noising (2 times); Group talking: peace (5 times),



relaxation (3 times), annoying (2 times).

Fig.3. Emotional and sound quadrant diagram

By comparing the sound quadrant diagram and emotional quadrant diagram, especially anchoring the sound into the emotional quadrant diagram based on the most frequently words which participants to use to describe their feelings, this research found the coupling relationship between the sound perception and emotions. (fig.3) Results showed that the natural sound would bring pleasant, relax, and comfort emotions to people. Hence, the natural sound should be in the yellow and green quadrants of emotional quadrant diagram. On the contrary, the anthropogenic sound would bring annoying, anxious, some bit noisy emotions to people. Hence, the

anthropogenic sounds should be mostly in the red and blue quadrant of emotional quadrant diagram.

3.4. Park motivation and noise as sound perception impactors

This research proved the correlative relationship between certain park motivations and personalities, showed as table 3. This research took significance ($<.05$) as count. It found the reserved and quiet personality was correlated with the park motivation of ‘experiencing the natural quiet and peace’ ($P=.413$, $\text{Sig}=.000$), ‘experiencing the nature’ ($P=.285$, $\text{Sig}=.000$) and ‘Escaping personal/ social pressures at home’ ($P=.225$, $\text{Sig}=.021$). Also, the personality of ‘Sympathetic, warm’ was correlated with the motivation of ‘learning cultural stories of parks’ ($P=.211$, $\text{Sig}=.031$), ‘appreciating the scene’ ($P=.224$, $\text{Sig}=.022$), and ‘pursuing family leisure and recreation’ ($P=.289$, $\text{Sig}=.003$) in parks. Besides, the personality of ‘open to new experiences and complex’ was correlated with ‘inspiration of art’ ($P=.196$, $\text{Sig}=.04$) and ‘physical rest’ ($P=.212$, $\text{Sig}=.034$). Based on the analysis, we drew the conclusion that, people with special personality may have special park motivations. Overall, people with reserve and quiet personality might seek ‘quiet’ in park. People with personality of sympathetic and warm might seek dynamic activities in parks, such as ‘Learning cultural stories’ and ‘Appreciating the scenic’.

This research also examined the relationship between people’s sound noise sensitivity and perceptions. In the noise sensitivity scale, the item ‘I am sensitive to the noise’ was represented as high noise sensitivity; accordingly, ‘I find it hard to relax in places that are noisy’ represented as medium noise sensitivity; ‘I get mad at

people who make noise that keeps me from falling asleep or getting work done’ represented as slightly noise sensitivity; ‘I get annoyed when my neighbors are noisy’ represented as little noise sensitivity. ‘I get used to most noises without much difficulty’ represented as no noise sensitivity at all.

Through the correlation analysis, we got the conclusion that water sound was correlated to neutral noise sensitivity (table 7), which meant, people who liked the water soundscape might not be too sensitive to noise. Hence, water soundscape was a special sound type, which might not only affect people’s sound perception, but also people’s noise sensitivity.

4. Conclusion and suggestion

Based on the analysis above, four characteristic of sound types were summarized as following aspects:

1) The anthropogenic sounds were more easily to be heard than natural sound. The acceptance degree of certain anthropogenic sounds was similar, and the unacceptable degree was between neutral to less annoying (-1). Differ from other anthropogenic sound, the songs and soundmark were acceptable sounds.

2) The natural sounds were all acceptable sounds, even though certain of them with less hearing frequency than anthropogenic sound.

3) Certain types of soundscape perceptions were correlated with each other, such as the perception of wind and water, perceptions of animal and insects, perceptions of insects and water sound, etc..

4) Four types of anthropogenic sounds with high hearing frequency and unacceptance degree were in the upper left quadrant of soundscape quadrant map, and

needed to pay more attention in the park soundscape management plan.

Regarding to the four points above, research developed soundscape management suggestions for the improvement of park acoustic environment and park soundscape perceptions as following:

1) The park managers need to control the noise of anthropogenic sound, especially pay attention to the four types of high hearing frequency and unacceptance sound in upper left quadrant of sound chart (figure 4). Through the aircraft routes and tourists' activities management, especially the noise reducing landscape design strategies, the managers can reduce the noise impact to park acoustic environment. The noise decibel would be reduced and anthropogenic acceptance would be increased.

2) Conserve the natural sound, and explore more types of natural sounds by landscape design to enhance people's sound environment perception. Natural sound can be created through creative landscape design, such as increasing the plant coverage, landform reshaping to create more natural spaces, water landscape restoring, ecological parcels creating for bird and other habitants. and proper use the acceptable anthropogenic sound, such as song singing and sound marks.

For the correlative relationship between sound emotion and perceptions, the manager should create more natural space, such as water fountain, jungle and forest landscape to create more natural soundscape perception chance. It is important for managers to create quiet and meditate places for people with reserve and quiet personalities coming to park for natural quiet seeking. The research implied that people with less noise sensitivity may like water sound. Based on this point, we need to consider the proper usage of water

landscape, to avoid excessive noise water landscape, such as huge water fountain, large scale of waterfall and stream, the distance between residential apartment to water landscape.

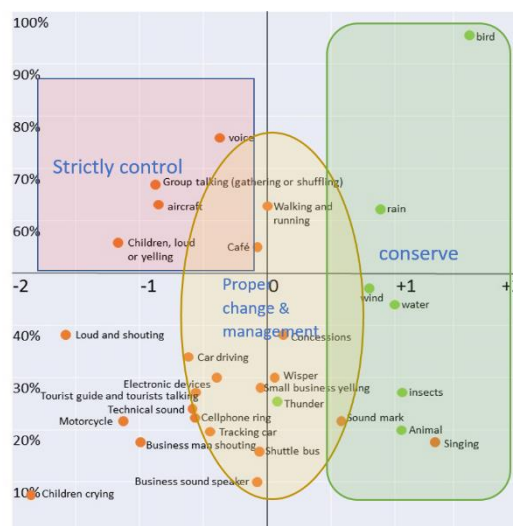


Fig.5. Soundscape management

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Table1 Sound perception checklist

Sound inventories	√	Sound acceptance										Your feelings
		Very annoying		Slightly annoying		Moderate	Slightly pleasing		Very pleasing		Please write down here	
	If heard	-4	-3	-2	-1	0	+1	+2	+3	+4		
Wind		-4	-3	-2	-1	0	+1	+2	+3	+4		
Water		-4	-3	-2	-1	0	+1	+2	+3	+4		
.....												
aircraft(airplane/helicopter etc.)		-4	-3	-2	-1	0	+1	+2	+3	+4		
Shuttle buses		-4	-3	-2	-1	0	+1	+2	+3	+4		
.....												

Table 2 The correlation among sound types

		Water	Rain	Thunder	Bird songs	Insects	Animal	Solitude	Natural sound
wind	Pearson Correlation	.192*	.059	.156	.201*	.196*	.071	-.070	-.025
	Sig. (2-tailed)	.048	.545	.109	.038	.043	.469	.475	.803
Water	Pearson Correlation	1	-.101	.104	.042	.274**	.194*	.044	-.077
	Sig. (2-tailed)		.302	.286	.666	.004	.045	.653	.438
Rain	Pearson Correlation	-.101	1	.382**	-.078	.064	-.066	-.183	-.142
	Sig. (2-tailed)	.302		.000	.423	.515	.497	.060	.150
Thunder	Pearson Correlation	.104	.382**	1	.088	.244*	.205*	-.021	.036
	Sig. (2-tailed)	.286	.000		.368	.011	.034	.830	.718
Insects	Pearson Correlation	.274**	.064	.244*	.177	1	.341**	-.048	-.132
	Sig. (2-tailed)	.004	.515	.011	.068		.000	.625	.183
Animal sound	Pearson Correlation	.194*	-.066	.205*	.045	.341**	1	.080	-.033
	Sig. (2-tailed)	.045	.497	.034	.642	.000		.413	.739
	Sig. (2-tailed)	.103	.025	.436	.478	.386	.687	.000	.001

Table 3 Correlative relationship between people's park motivation and personality

		Open to new experiences and complex	Reserve and quite	Sympathetic, Warm
Natural sound	Pearson Correlation	.010	.285**	-.072
	Sig. (2-tailed)	.917	.003	.464
Nature quiet and peace	Pearson Correlation	.038	.413**	.058
	Sig. (2-tailed)	.697	.000	.558
Escape personal/social pressures at home	Pearson Correlation	-.143	.225*	-.044
	Sig. (2-tailed)	.143	.021	.658
Learn cultural story of parks	Pearson Correlation	.102	-.042	.211*
	Sig. (2-tailed)	.297	.670	.031
Appreciating the scenic	Pearson Correlation	.055	.050	.224*
	Sig. (2-tailed)	.574	.611	.022
Inspiration of art	Pearson Correlation	.196*	.166	.123
	Sig. (2-tailed)	.044	.089	.210
For family leisure/recreation	Pearson Correlation	.219*	-.190	.289**
	Sig. (2-tailed)	.025	.052	.003
Physical rest	Pearson Correlation	.212*	.196*	.269**
	Sig. (2-tailed)	.034	.049	.007

The role of urban farms in urban renewal: a case study of urban design of the Old Fourth Ward in Atlanta

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Abstract

This paper takes Tongji University - Georgia Tech - University of North Carolina at Charlotte three towns in the United States Atlanta mm block city as the theme of urban design as an example, through the study of the US population diet structure, research on the base Analyzing and judging the possibility of urban planting industry, designing strategies to introduce urban farms into the base to meet the needs of people's healthy living, and introducing the role of urban farms in urban renewal. The article will research and develop the industrial park of production technology through the research on the design, utilize the propaganda of the original downtown area for food production and processing, and hold the strategy of food fairs and exhibitions. Residents and businesses in different communities can showcase their products. Explain the application forms of urban farms in urban public space and residential buildings.

Keywords: *Urban farm; Renewal; Downtown Atlanta; Urban design*

1. Introduction

This urban design project is located in Atlanta, Georgia. The site is in the Old Fourth Ward near the city center and not far from the Beltline. The core of the design is to improve people's health by improving the way to get fresh vegetables. From this point of view, we design a city farm to meet people's demand of healthy life and to stimulate the vitality of the site.

2. Introduction of the concept of urban farm

2.1. The food desert in Atlanta

There is a serious food desert in Atlanta. The U.S. Department of agriculture defines the food desert as a low-income community, which is more than a mile away from reliable fresh produce and other healthy foods. This map (Fig.1) shows the food desert in downtown Atlanta. The site is located in the yellow area, indicating that it is located in low income neighborhoods, and it is more than half a mile away from the nearest supermarket. In vehicle accessibility analysis (Fig.2), the base is located in the blank area, which represents that the base performed well in access to fresh food. Many residents need to shop in convenience stores, where the prices are higher than those of full-service supermarkets, and the choice is usually limited to processed foods with high-fat, high-salt and high-sugar. The difficulty in obtaining fresh vegetables leads to a high incidence of obesity, and may even lead to diabetes, cardiovascular disease and

other related diseases, which reduce the living standards of people.

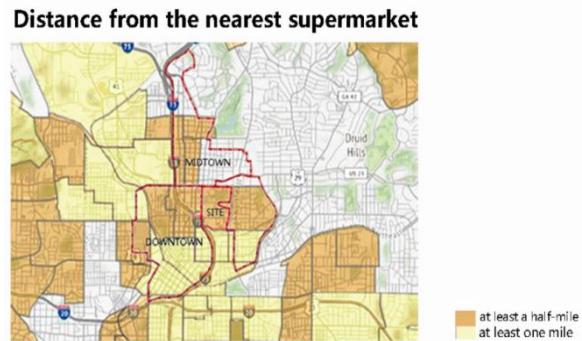


Fig. 1. Food desert situation in downtown Atlanta

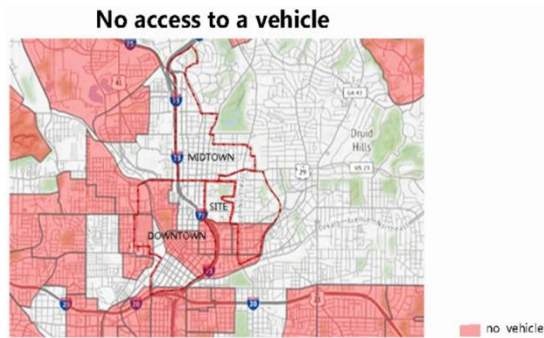


Fig. 2. Vehicle accessibility in Atlanta

As Jeffrey P. Koplan, vice president of global health at Emory University, said, "The easy availability of fresh, appetizing local food, especially fruits and vegetables, is an attractive and cost-effective contribution to improving our diet and the health of our population." This urban design aims to provide Atlanta residents with the access to safe, nutritious and cheap fresh food through the creation of a multi-functional urban farm, and to establish a sustainable local food system to enhance residents' health and environmental quality. At the same time, it promotes local economic development and establishes links between rural and urban farms.

2.2. *The advantages of urban farms*

Based on the demand for non-polluting food in Atlanta, we set up a local food production and supply system by setting up the urban farm, shortening the distance of high quality food from the farm to the table, and allowing non-insecticide, antibiotic-free and hormone-free vegetables and fruits to enter the house in a convenient way. This system can effectively improve the current situation of “food desert” in Atlanta. The establishment of the urban farm system will have a profound impact on the city: (1) A good diet structure can be formed. (2) There will be no agricultural failures due to climatic factors, such as drought, flood and pest calamity. (3) Urban stereoscopic farms grow organic crops, and there are no herbicides, pesticides and fertilizers. (4) It can reduce the cost of food transportation, save energy and reduce emission. (5) It can effectively retain the urban green space, retain the functions of the ecosystem, and improve the quality of the urban environment. (6) It can reduce unsound environmental impacts, recycle and utilize sewage, and form a new urban landscape style. (7) It establishes new production and sales system, provide new job opportunities and promote urban economic development. (8) It increases the stability of social structure by introducing agriculture into cities.

3. Design elements of urban farms

When we design urban farms in our base, we need to consider two important issues: the first is the size and location of the farms.

Urban farms can bring huge social and economic benefits. For example, one type of urban farm, vertical farm, relies on the organic farming technology of water tillage, without the need of pesticides and synthetic fertilizers, and it does not inject pollutants into the waterway. Vertical farms can efficiently produce food and vegetables. Its irrigation water comes from treated rainwater, which can alleviate the water crisis. At the same time, the vertical farm is located in the center of the city, eliminating the adverse environmental impacts of transportation and related processes. All kinds of crops can get accurate growth conditions through close monitoring, so as to increase output. Besides, indoor planting is not affected by natural disasters such as floods, droughts and hurricanes. Many sustainable technologies have been used synthetically: rainwater will be treated for irrigation, combined with water recovery systems, and unused water is collected by gas culture and hydroponics methods. The production of crops in vertical farms can be carried out all the year round. The yield of indoor acreage of 1 acres, which is equivalent to 4 to 6 acres or even more of outdoor output.

The other is what kinds of crops we need to grow and how to grow more fresh fruits and vegetables. For this reason, we calculated the area required for the farms, and set up the allocation plan of planting crop species

according to the local climate, environment and resident diet structure.

3.1. Location selection of urban farms

Question 1: the area of the farm. According to the existing population density in the base, we can predict the reasonable total population of the base will be stable at around 3,000 people. According to the proportion of 200-500g of fresh fruits and vegetables per person daily, we calculated the proportion of urban farms in the 146,073 square meters of land.

Question 2: how to grow crops better. We explored the necessary factors for the growth of crops: sunlight, soil and water. We guide the design of urban farms through the comparison of sunshine duration and crop sunshine demand in Atlanta. By using the Ecotect software to analyze the height and shelter of the existing buildings (Fig.3), we find the best sunshine area suitable for the growth of crops.

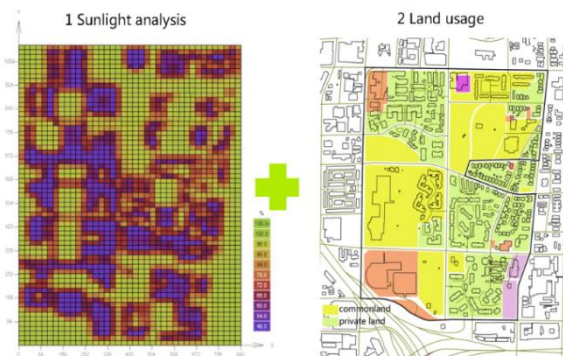


Fig. 3. Sunlight analysis and land use diagram

Through the analysis (Fig.4) of urban precipitation and other factors, we find that the annual average rainfall in Atlanta is 49.71 inches, which is 27% higher than the national average. In Atlanta, the rainfall will increase by about 10% per year in the future, and the rainstorm will increase by 50% every year. This means that there is a high possibility of flooding in the urban subsidence area, so it is very important to use the terrain to collect rainwater. We

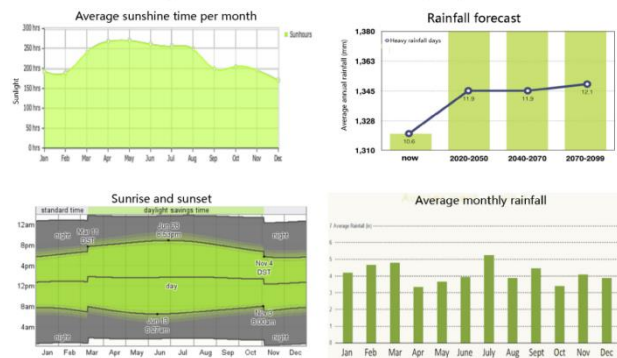


Fig. 4. Average sunshine, rainfall forecast, sunrise&sunset and the average monthly rainfall diagram

believe that this possible flooding situation can bring new opportunities for the design of urban farms.

We can combine the low-lying land with the storage irrigation system based on the elevation information (Fig.5).

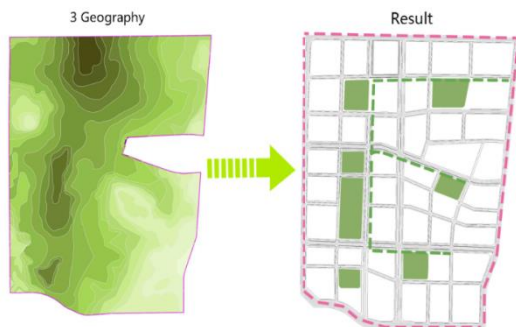


Fig. 5. The elevation information of the site

In the case of drought, the urban farm is made to be a park, and the farm is distributed along the irrigation line (Fig.6), so that the necessary irrigation requirements for the growth of the crops are satisfied. Besides, by analyzing the factors such as the original land use and elevation, we finally determined the location of the concept area of the urban farm.



Fig. 6. Water tank and stormwater park

3.2. Analysis on the function of urban farms

As for the function of the urban farm, we do not want it to be a "rural in the city", and we want to give it a variety of functions to meet the needs of modern life and increase the value of land use. We think that urban farms are more arranged in urban public space, so that farms can be used as public places for people to enjoy activities. Urban farms bring people not only food but also a

healthy concept of life. This mode can be applied to other parts of Atlanta City, so as to improve the quality of life of the whole city citizens.

Taking the two nodes in the base as an example, we discussed the positive effects of urban farms on urban renewal. The "community farm" is located in the area of the retaining church. The church can gather people for worship, and the "community farm" attracts people to grow vegetables there. In the central square, people can display their own vegetables, and they can also eat foods made from green vegetables in the surrounding restaurants. This harmonious community atmosphere can make people living in fast-paced cities feel the comfort of rural pastoral life. The experimental area we design is 12,100 square meters, covering 60 families, providing 65 urban farm areas, which can generate 5,000 dollars in income. In this "community farm", we set up a green restaurant, a picnic area and a vegetable display area, which are used to taste green food, have outdoor picnic and show planting results, etc.

For "community farms", we grow corn, onions and potatoes from April to June, and grow carrots, lettuce and broccoli from July to September, according to plant habits. In addition, the interaction of auxin among plants also promotes the growth of crops. For example, tomatoes, lettuce, and garlic grow better when they are together. The synergistic effect between plants and

animals will also affect crop growth, such as the pollination by bees.

In addition to the “community farm”, in this design project, the reservation of the original Civic Center in the base also provided a good opportunity. We transformed it into a convention and exhibition place. The latest agricultural production technology and achievements are presented here, and some food-related exhibitions will be held. The studio of Civic Center will also broadcasts the knowledge of food production technology and healthy life concept.

3.3. The combination of urban farms and buildings

For the relationship between urban farms and building groups, we have conceived that for large urban public spaces, urban farms could be embedded in the following three forms: (1) Uss public building sites to embed. (2) Transform the layout of existing public buildings, and gradate the layout of cultivation space. (3) Make full use of the large area of roofs of public buildings and arrange crop planting space. For high-rise towers and residential buildings, urban farms can also be involved in it: (1) Embed the site, taking the urban farm as a part of landscape. (2) embed the buildings, introducing the concept of vertical farm, and let crops grow in the buildings (Fig.7).

4. Conclusion

As a way of introducing agriculture into modern urban space, urban farm is mainly to put agricultural links such as agricultural products and livestock breeding into urban public space and buildings which can simulate the growing environment of crops. It can also realize the self-sufficiency of agricultural products through production and processing.

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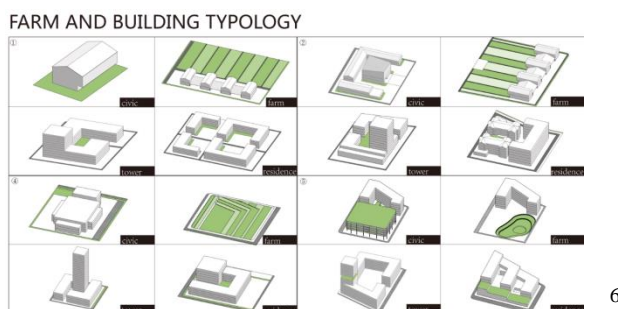


Fig. 7. The typology of combination between urban farms and buildings

Waterfront industry heritage regeneration for bridging the urban space -- a case study of the London Canary Wharf and the Shanghai Xuhui Riverside

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Abstract

The potential value of the Waterfront Industrial Heritage (WIH) in urban renewal is well recognized. This research emphasizes the renewal process required carefully design in order to increase the value of renewal WIH in bridging the urban space. Comparative analysis has been adopted as the research method to evaluate the two waterfront industrial heritage renewal cases which including the Canary Wharf in London and the Xuhui Riverside in Shanghai. Through this analysis three disadvantages of Xuhui Riverside have been revealed as oversized scale, discontinuous interface and lack of service facilities. In addition, this research concluded that the spatial integration of waterfront industrial heritage can be divided into three levels: urban area function co-ordination, urban spatial interface continuity, and urban life events reappearance. The three levels of space considering in the process of urban renewal can deal with the problems existing in the renewed waterfront industrial heritage. (This paper is subsidized by NSFC project (No. 51678412) which is named as <Research on Technical System of "Downtown Factory" Community-oriented Regeneration in Yangtze River Delta Region>.)

Keywords: waterfront industrial heritage; urban renewal; bridging; scale; spatial interface

1. Introduction

After entering the post-industrial era, the industrial heritage in the original urban central gradually became the main region for urban renewal. The waterfront industrial heritage, as the production of the development process within the old industrial city, play an important role as the intermediary in the process of bridging urban space. In the beginning of the modern

industrialization period, due to the demanding of the shipping goods, the industrial areas usually located near the riverside. Additionally, the industrial areas gradually encircled by the city in the process of urbanization (Tian and Huang, 2008) [1]. Thus the majority formal industrial facilities had becoming the industrial heritages which could be seen as the crucial elements in the urban renewal process.

In recent years, the urban renewal carried out by Shanghai has gradually transformed

the waterfront industrial heritage into a public space. There are several pilot project along the Huangpu river such as the renovation and construction of the Expo area, Xuhui Riverside and the recent Yangpu Riverside demonstration section. Although the industrial heritage on both sides of the Huangpu River have undergone a transformation, there are still many aspects for improvement. Furthermore, it is critical to improve the quality of the existing riverside public space which is reconstruction from the waterfront industrial heritage. This paper starts from the analysis of the Canary Wharf in London, and make a comparison with the waterfront space in Shanghai. In addition, proposes three levels of urban space bridging for waterfront industrial heritage.

2. Waterfront Industrial Heritage and Urban Renewal

In the late nineteenth century, Camillo Sitte (1889) emphasized the integrity of urban spatial development in his “City Planning According to Artistic Principles”, and provided a theoretical basis for urban spatial cognitive methods [2]. Kevin Lynch (2001) emphasized the individual's perception and experience of urban space, and made urban users an important part of urban space design [3]. Sun (2012) discusses the dynamic development of public space in the process of urban development from the theory of the coupling of urban public space and architecture, and puts forward five strategies for realizing the integration of urban public space and architecture, and emphasizes activities in the walking space [4]. The research on urban space has

implications for the renewal of the waterfront industrial heritage.

The research on the theory of urban renewal has a long history. Yan (2013) pointed out that the narrow sense of urban renewal theory is coping strategies facing the urban recession [5], which proposed from the stander point at the urban level. In the recent theoretical development, Robert and Sykes (2000) also elaborated on the general urban renewal approach, and defined it as a compound and overall development method [6]. Lu and Wang (2016) summarizing the concept of urban renewal in Europe and the United States [7]. Additionally, they put forward the strategy of building pilot characteristic vital areas. Zhu et al. (2015) conducted an in-depth summary of the research methods for urban renewal, pointing out that the current research focused on the renewal of material space while paid insufficient attention to institutional design [8]. This trend emphasis the impotency of carefully designed process.

Among the recent studies industrial heritage has been the hot spot for both urban planning and landscape architecture. In 2001, scholars such as Wang Jianguo and Yu Kongjian conducted research on landscape and urban design in response to regional renovations. For instance, for the study of industrial heritage, Wang (2008), Yu and Pang (2002), and Liu (2012) conducted in-depth research on protective reutilization, repair protection, and evaluation systems, focusing on the discussion and practice of protection strategies [9,10,11]. In contrast, Hospers (2002) pointed out that the tourism value of industrial heritage and the promotion of the regional environment is vital in the industrial heritage renewal [12]. Zuo (2008)

conducted a detailed study on the status quo of the protection and development of Berlin's industrial heritage and summed up a valuable protection and renewal strategy [13]. However, its actual adaptability in China remains to be verified. Liu and Li (2012) introduced the industrial heritage of Shougang as a concrete case and illustrated them from the perspective of conservation planning and renovation design [14]. Li and Sun (2017) put forward a strategy for transformation and renewal in their research on the community-oriented regeneration of "Downtown factory" [15]. Philip Feifan Xie (2015) discusses the rational use of industrial heritage from the perspective of the entire life cycle [16].

In general, the research on industrial heritage has paid more attention to the construction monomer itself, and there is lack of attention to the current situation of the industrial bridging situation after the renewal of the industrial heritage. The role of the renewal of the waterfront industrial heritage in the promotion of urban space has attracted widespread attention in the academic community.

3. The practice of waterfront industrial heritage renewal

This article selected the practice of the renewal of the waterfront industry heritage of two cosmopolitan cities, London and Shanghai, as research cases. The two cities have similar international status. They have irreplaceable status in their respective countries and are recognized internationally as the most competitive cities. Due to their important historical status, the two cities experienced the process of industrialization and several transformations in the modern

era, becoming a model city for industrial upgrading.

Additionally, London and Shanghai were crossed by the Thames River and the Huangpu River respectively, and provided the waterway traffic for their industrial buildings at early period. Therefore, it is of great significance to study the transformation of the waterfront industry heritage in these cities.

Among the two cities, the most significant waterfront industrial heritage transformation is Canary Wharf in London and Xuhui Riverside in Shanghai (Fig. 1). From the three aspects which including the historical background, the extension of urban streets and the level of urban space, it is possible to clearly display the renewal spatial relationship between the waterfront and the city.

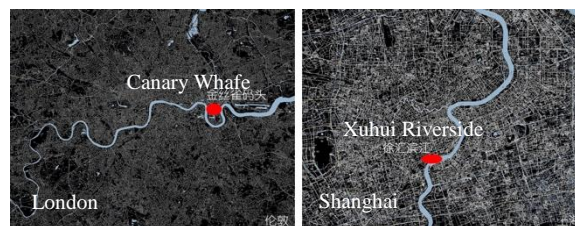


Fig. 1 Urban textures and case locations in London and Shanghai (Source: Adapt from Mapbox)

3.1. London Canary Wharf

Canary Wharf is located in the Dockland area, east of central London and is the largest urban renewal project in London in the late 20th century. The old industrial area on the banks of the River Thames had a glorious past. Along with the Industrial Revolution, the area was known as the most important

port in London at that time, but it gradually became an abandoned industrial area covering 71 hectares (Yang, 2005) [17]. Furthermore, Gordon (2001) pointed out that at the end of the 19th century, the Dockland changed from unplanned development to market-led free development zone [18]. Its renewed initiate by British Conservative government, which began in 1881, which is looking forward to regional integration and overall development through the London Docklands Development Corporation (LDDC).

Although there are general guidelines for urban design in this stage of development, without the spatial master plan, space has been fragmented and disordered (Edward, 1992) [19]. From 1991 to 2001, the Dockland region experienced a second development and renovation, which gradually made Canary Wharf a new financial center in London (Fig. 2).

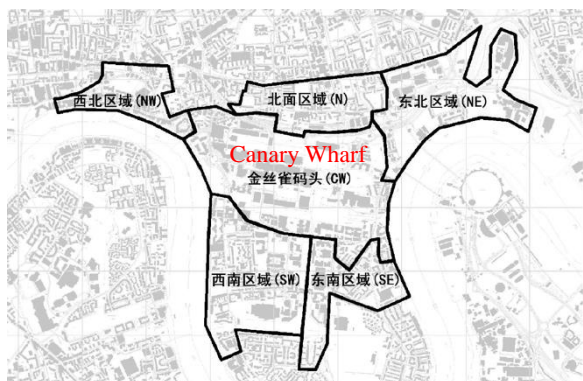


Fig. 2 Canary Wharf Scope (Source: Yang Shuo. Social Integration of Urban Space Network and Large-scale Urban Renewal: Inspiration from London Canary Wharf[J]. World Architecture, 2005(11):79-83 .)

The overall site of Canary Wharf is more regular, employing square grid roads.

Moreover, Canary Wharf using structural open space to connect the whole block. The east-west axis penetrates the site while linked open space patch. There are two more axes in the north and south.

The overall plan reflects a combination of geometry and axis. In the three-dimensional space, it presents a complex way of three-dimensional stratification with multiple functions and multiple elevations, providing the city with a rich and pleasant urban space (Fig. 3). The small-scale landscape nodes on the site also become places for traditional activities such as Christmas skating.



Fig. 3 Open space at Canary Wharf (Source: Author)

3.2. Shanghai Xuhui Riverside

The formation of Xuhui Riverside is very Different from Canary Wharf. Xuhui Riverside has always been a concentrated area of urban industry in the middle and late 20th century. The major cement factories, paper mills, ceramics and other factories and enterprises used to locate in that area. The

environmental pollution at that time also reached an unprecedented level (Lu and Zhang 2011) [20]. Afterwards, Shanghai's Xuhui Riverside was an ideal site for the 2010 World Expo. In the contrast, it is a great opportunity for Xuhui Riverside to regeneration. This huge project become an important issue for urban development. Its construction goal was to develop as an ancillary project for the Shanghai World Expo and eventually completed the transformation from an industrial land to a citizen garden (Fig. 4).



Fig. 4 Xuhui Riverside Landscape Belt
 (Source: Author)

Xuhui Riverside is the earliest development area in Shanghai with waterfront landscape oriented as a development concept. Its main area is from Rihui Port to Xupu Bridge. After planning and designing, Xuhui Riverside has three areas: Fenglin Life Science Park, Riverside District, Riverside Business District and Riverside Residential District. In this area, the Xuhui Riverside's landscape belt from Nanpu Station to Dong'an Road plays an

important connection function, and the advantages of its waterfront have been fully expressed. In the design of Xuhui Riverside, the theme and event functions were given to each venue. From the northernmost Beipiao terminal tower crane plaza to the dragon art museum to Nanpu station gantry hanging square, the historical memory of the waterfront industrial heritage was anchored in the venue. However, there are also several problems. First, the riverside landscape belt, as a linear park, measures 8.4 kilometers, but the service facilities on both sides are far away. Second, it is separated by a wide road between the waterfront landscape and its business district on the north side, and it did not connect with any subway line which causes the weakness of public accessibility. Third, the spatial interface in the waterfront area is discontinuous and the landscape greening level is relatively simple.

From the above two cases, it can be seen that the waterfront industrial heritage plays an important role in bridging the space during the process of urban renewal. In the case of Canary Wharf in London, the abandoned industrial terminal became a new financial center, and the old waterfront industrial area in Shanghai turned into a supporting area for the Expo and further became a public landscape park. From the cases of these two cities, it can be concluding that the pleasant scales, the vivid interface of street, and the nodes for recreation play an important role in the transformation of the waterfront industrial heritage. Additionally, the renewal waterfront industrial heritage can serve as a medium to bridge the urban space.

4. Three approaches of bridging

In the case of Canary Wharf, it illustrated that there is no overall planning for the early rise, and the development based solely on the economic market will eventually lead to spatial chaos. In the case of Xuhui Riverside in Shanghai, the problem of excessive scale and poor public accessibility led to the fact that the role of the waterfront industrial heritage as a mediator was not fully exploited. In order to deal with these issues, comprehensive considerations can be taken from three levels.

4.1. Functional coordination in urban areas

1. Functional positioning

In order to deal with the problem of space fragmentation in the renewal of the waterfront industrial heritage, we must first think from overall planning of urban areas. From the case of Canary Wharf, the transformation of the abandoned industrial area aims at the old features of the financial facilities in the Old City, positioning the new area in the city's emerging central business district (CBD), which corresponds to the city's overall development. (Fig. 5).

In contrast, Shanghai's Xuhui Riverside, initiate as a supporting area of the World Expo, following as a commercial area for comprehensive development, and mix functions such as comprehensive residential



Fig. 6 Functional Area Map of Canary Wharf (Source: Author)

research and development have also been well adapted to the development of the city. The Xuhui Riverside landscape belt actually lacks the corresponding functional supporting facilities and is only constructed through the construction of the basic landscape.

2. Public transportation

The construction of public transportation reflects the accessibility for the citizens.



Fig. 5 Canary Wharf Complex Transportation System (Source: Author)

Compare to London Canary Wharf the Xuhui Riverside has relatively poor accessibility due to the lack of transport facilities. In contrast, and Canary Wharf is directly connected to the city center via the subway and is organized in a complex, multi-layered approach to transportation, with multiple spatial experience (Fig. 6).

The Xuhui Riverside currently requires a 20-minute walk to reach the nearest subway station. Therefore, Xuhui Riverside District's service targets are mostly concentrated with residents in the surrounding areas, or people visiting the nearby Long Museum. It can be seen that there still could be improvement in Shanghai Xuhui Riverside area with in the overall development. It is worth considering how to solve the problem of accessibility between mixed functional areas separated from fast roads.

4.2. Urban space interface

1. Pleasant scale

In addition to the overall functional orientation, close-up scales need to be taken into account in the renovation of the

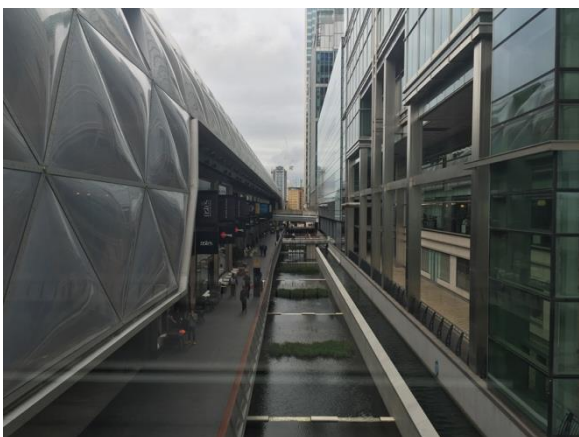


Fig. 8 Canary Wharf Waterfront Structure and Street (Source: Author)

waterfront industrial heritage. As the traditional industrial zone is a production-oriented design method, the space created is also for industrial production. In the process of urban renewal, it requires a change of thinking, and the design of the scale is based on the scope of appropriate activities. consider. In the case of Canary Wharf, a scale close to the human body was created by the structures that stretched out over the water and the enclosed space of the building (Fig. 7).

In the case of Xuhui Riverside, the scale of the landscape belt along the river has not been well controlled (Fig. 8). The riverside space usually lacks a small scale space with a sense of enclose. The space only uses water and greenery as the interface which lacks public service facilities such as public toilet, coffee shop and info station.



Fig. 7 Oversized scale at Xuhui Riverside (Source: Author)

2. Space for Recreation

According to Kevin Lynch’s theory, in the shaping of space, the nodes of space which is the one of the five essential elements have a very important role. In the case of Canary Wharf, the scene shown in Figure 9 is a scene of the public space in Canary Wharf around Christmas.

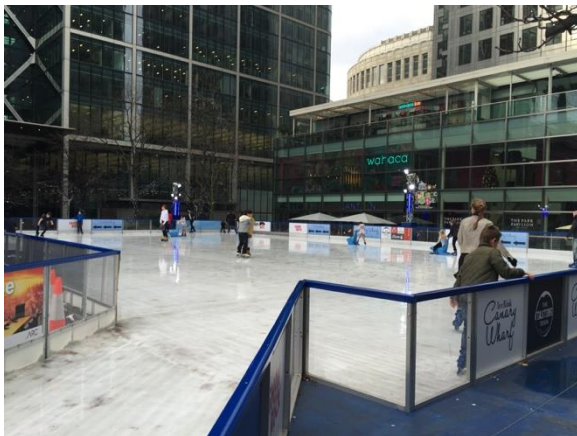


Fig. 9 Temporary skating rink in Canary Wharf open space (Source: Author)

The original green space was turned into a temporary skating rink and became a venue for Christmas traditions. In Xuhui Riverside, it is more reflected in the shaping of industrial related landscape sketches (Fig. 10). Landscape structures with traditional industrial heritage elements become attractive recreational nodes on the site of Xuhui Riverside. However, the distribution is linear and the distance between nodes is more than 1.5 kilometer. Additionally, there is a lack of necessary urban furniture in the site.



Fig. 11 Landscape features at Xuhui Riverside (Source: Author)

4.3. *Reproduction of Urban Life Events*

In discussing the subjectivity of the venues, urban life events are the best basis for testing the space. According to Jan Gehl's theory of interaction, buildings with functions play an important role in shaping the communication space. It is necessary to create spaces that have the possibility of



Fig. 10 Empty landscape features at Xuhui Riverside (Source: Author)

events through the enhancement of enclosing

of space and the implantation of functions. In the Xuhui Riverside area, landscape sketches do not have substantial commercial functions (Figure 11). The activists cannot obtain the necessary services within the venue.

Xuhui Riverside landscape belts should introduce more interfaces for living, such as cafes, sales, bars, and bookstores, or new business models based on experience. In short, relying on simple green area to open space does not create a good waterfront space for the city's riverside. In the summer and winter when the climate is relatively unfavorable, the open riverside space is inactive. In contrast, for the London's Canary Wharf, shopping malls, restaurants, and exhibitions do not appear as a series of individual buildings. Instead, they present a variety of forms that together create a place full of possibilities for life events (Figure 12)



Fig. 12 Public Space enclosed by Canary Wharf (Source: Author)

separation, the lack of supporting facilities led to a gap between the quality of space and the use of efficiency.

In order to cope with this problem, the three approach of bridging the urban space should be incorporated into the consideration of urban renewal, and further increase the continuity of the waterfront on the two sides of the Huangpu River. Eventually the urban green space can be shaped into a truly place designed for human through the construction of a human scale and further promote the regional development.

5. Conclusion

Shanghai's waterfront industrial heritage is intensively distributed on both sides of the Huangpu River. The waterfront industrial heritage, as a heterogeneity in the urban space, used to separates the uniform and coherent texture of the traditional city. Its great potential for shaping urban space in the post-industrial era has been emphasized. In the existing transformation process, there are still problems such as the lack of regional coordination, discontinuous interface, and excessive scale. Particularly prominent in the case of Xuhui Riverside, the functional

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Landscape Mediation in Leftover Spaces of Cities

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Abstract

During the rapid urbanization process, urban problems are exposed and city's rich context is reduced and interfered. Dilapidation, abandonment, and ruins in built environment initiate leftover and residual spaces which are changing the fundamental meaning of urban space. The leftover space, left behind by socio-historical processes and practices, includes back lanes and alleys, yards of dilapidated building, voids between edifices, unbuilt space for lack of finances, and space under the flyover, etc.

To respond to these changes, concepts and theories of urban repair utilizing landscape mediation is put forward, aiming to make the city more flexible, resilient and biophilic from microcosmic angles of landscape urbanism and green infrastructure theories. Instead of other approaches, landscape intervention and mediation is more appropriate and powerful to make full use of leftover spaces and make cities and communities safer and better for living. The idea of landscape mediation is not only to fill the space gap but to unify the entire heterogeneous elements.

With the purpose of looking into different strategies and methods of activating negative space, several special cases in Japan, China, Italy and U.S. are showed and made comparison to illustrate specific methods, which are introduced to make leftover spaces reclaimed, revitalized, and repurposed into urban parks and even urban agriculture. From the case studies and comparison studies, linear parks, pocket parks, micro facilities, mobile green space, urban farms, water sensitive gardens are imbedded into landscape mediation system, as shown in the examples of 606 Park in Chicago, Austin's downtown alleys, Zighizaghi garden in Italy, and Lafayette Greens in Detroit, etc. Also, specific cases in this study are illustrated where issues of urban organization are very complicated, and comprehensive ways of arranging green elements are needed, such as Bethlehem SteelStacks Arts and Cultural Campus in Pennsylvania, etc. Accordingly, Poché as joint or transition which is referred to as an "in between" to the adjoining spaces is reconsidered, showing how landscape in urban fabric connects and meshes urban tissues and meanings. By documenting activities such as leisure, urban agriculture, informal communication, and social encounters, this research also addresses landscape micro-tactics for social effects and cognitive benefits besides human sensory connection to nature and physical well-being.

By examining different types and specific tactics of reviving leftover spaces, The framework and toolbox of landscape mediation for leftover and residual spaces in cities are established. It demonstrates how inclusive and biophilic design are applied in reviving negative spaces and transforming the city's artificial environments by unifying separated parts with green elements, and how important roles landscape plays as catalysts, connections and mediations in post-modern cities.

Keywords: Leftover Space, Landscape Mediation, Biophilic Design, Poché, Cognitive Benefits

1. Urban space fragmentation and leftover spaces

In the process of urbanization, the city is constantly being injected with new relationships, values, and users. In the process of diversification of values and differences, there are some trimmed scraps. Such urban problems include the fragmentation of rapid transit networks, the derelict streets, irregular plots, abandoned land due to topography, and even the edges of roofs and buildings. At present, the urban traffic land generally accounts for 10% of the urban area and forms some fragmented conditions. At the same time, in the urban development renewal, the waste of space resources and the inefficient use of certain periods are inevitable. This situation exists not only in the horizontal space but also in vertical space. The exposure of urban problems and the influence and reduction of the rich cultural context of the city have brought a lot of leftover space. Generally these remaining spaces are defined by other heterogeneous spatial elements and are constantly influenced by various spatial elements. The transformation of this kind of passive space has a fundamental improvement in the quality of urban space.

At the same time, China's urbanization construction has gone from large-scale growth to more emphasis on the revival of space quality, such as the "Implementation Measures for Shanghai Urban Renewal" in 2015, calling for planning and design

personnel to adjust and design at the micro-space level. These changes have shown a tendency of "tactical urbanism." The transformation of the leftover space, through focusing on the existing quantity rather than the increment, integrates the relations between heterogeneous elements, so as to obtain a better quality urban space. This is precisely the perspective of creative thinking and collage oriented by transparency. Tactical urbanism makes use of a bottom-up approach, including consideration of temporary actions or low-cost measures, to achieve a full range of interventions.

From a global perspective, from the urban spatial scale, Lavilet Park indicates that landscape can become the medium of post-modern urbanism, including complex urban life, and becoming a "category of social tools". On a small scale, Mike Lydon and Anthony Garcia wrote about the relevant practice and action manual [1] by creating The Street Plans Collaborative [2]. Sue Anne Ware proposes a mobile garden in tactical urbanism, focusing on the quality and efficient use of space, and small-scale interventions by individual communities and local groups to improve an existing perspective of the city, affecting the long-term growth and image of the city. The Belgian designer Marcel Smets has also elevated the landscape to a place of great influence on contemporary urban design. He formulated a classification of contemporary urban space design concepts that respond to future developments. The network of indeterminacy (providing infrastructure),

carriers (containers, reactive organization forms), open spaces (ensure freedom of entry of new elements), and montage (great overlap of layers of different content and organization) as four design methods.

2. Integration of different functions and site activation

In city, there are bound to be spaces where forms and functions are mixed. The transformation of the remaining space mainly lies in the bottom-up collage thinking, and this approach must pay attention to the influence of the overall environment, especially the preconditions of the texture and boundary of the environment. At the same time, in the process of urban development, public space plays an important role in urban regeneration. On the platform of landscape urbanism, the role of landscape integration plays a pioneering role in urban renewal. The part of the city where the degree of openness, the higher the degree of publicity, and the intersection of the two parts of the space exist should be the space for priority transformation and the most vital space.

In the tactical measures to deal with the remaining space, related scholars have summarized different types and examples, including community-based public facilities, exhibitions and market spaces combined with plants, gardening and urban agricultural space, mobile greening devices, visual catalysis and art. Inkjets are used to stimulate public events and mixed functions of public spaces and parks [3]. The growth of urban density and the demand for space are the inevitable contradictions of contemporary cities. Due to the over-development and the emergence of meaningless negative space, people's sense of experience in urban space is degraded.

The living environment of citizens can be changed from the environmental quality and even from the green space system [4]. All these have proven that the landscape has an important, efficient and irreplaceable role in the intervention and improvement of the urban leftover space.

Through the intervention of the landscape, it is possible to form an inclusive and integrated space contradiction, and the specific methods differ according to the site scale. However, in general, the remaining space itself uses the structural elements of the surrounding environment as the interface. Therefore, the creation of space must deal with the multiple relationships between the environment and the boundary and characteristics of the site. The activation and reconstruction of the remaining space is a continuous increase in the heterogeneous diversification and dynamic of the environmental space. It is not only beneficial to social public life, but also a new sense of belonging to the resident culture and ritual space from the perspective of cultural revival [5].

At present, there are many successful cases in the world. In Venezuela, communities derived from the problems of abandoned land, scrap yards, and urban villages have created five public community spaces by improving the remaining space. PICO estudio joins local and multinational organizations, volunteers, and community members to put in brightly coloured and heterogeneous environments to allow people to regain the sense of community, activity, safety, and solidarity. These include open-air basketball courts built on roofs, juxtaposing existing buildings, and transforming the roof to make the new stadium more functional and safe; turning the dump into a terrace and open-air barbecue. Piled with stones collected from nearby rivers to form enclosed stone walls;

design a multi-dimensional space with a spacious roof, etc. In order to maximize the benefits of the new space for the community, the design first considers enough flexibility to meet the needs of each detail at the moment by associating with the periphery and saving it. At the same time, it considers how to adapt to the future of the community. In design, the use of the structural capacity of the house provided the necessary support for the green steel frame structure and the glass window wall. Through the cover pattern, it added a lot of vitality to the entire street. Other cases include the overlapping of traffic settings and landscapes, enabling people to get a double reorganization of space experience and venue function [6].



Figure 1 Venezuela problem community public space transformation (PICO estudio:2014)

In the small town of Koog aan de Zaan in Amsterdam, the highway divides urban space into two parts. The city hall and the church belong to two sides, and the administrative and church centers are physically separated. In order to connect these two important areas, the designers have reconstructed the space under the blind spot area and its extended space. This positive intervention includes the

establishment of green land hills, the introduction of rivers to create a hydrophilic space, setting up retail stores, flower shops, supermarkets, fish markets, football stadiums, basketball courts, skateboard parks, fountains and water features, sculptures, and so on. The internal excavation of small wharves, combined with the new bridge pier facade enclosing, formed a juxtaposition of different structures. Using the bridge's pillar interface and the top surface, many mixed and multi-dimensional spatial structural elements are formed to better connect the river and connect the life on both sides of the bridge.

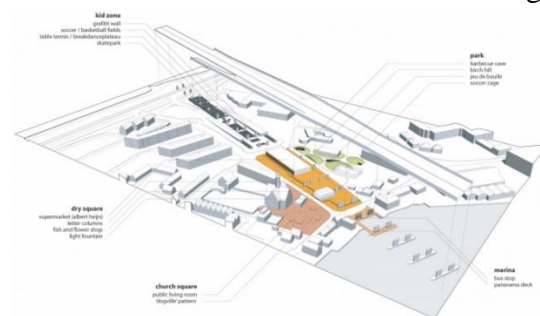


Fig 2 Space reconstruction under Koog aan de Zaan Bridge

(<https://www.architonic.com/en/project/nl-architects-a8erna/5100103>)

Similar cases also include the wave theatre in Chile, designed to use mobile facilities to integrate the interface of the remaining space, and the construction materials are from all local waste materials. Among them, Sitio Eriazo, a transformation team, specifically practices for the abandoned negative space. This project makes direct use of the boundary characteristics of the empty field and combines structural materials with site material for the activation of structural

integration and filling. Other cases include the construction of the new Bastille Opera House after the demolition of the Promenade Plantée on the Vatican Boulevard in Paris; the maintenance of the original viaduct structure at Cheonggyecheon Park in Seoul; and the urban forestry in the Seattle Highway Park. The public green space, which links with the fragmented city parts, constructs a landscape of a stream canyon. The discarded parking space on the roadside of Rue Duperre in Paris uses rubber to lay the ground of the basketball court. The wall is painted with bright paint and patterns to make a comparison with the nearby buildings.



Fig. 3 Wave Theatre (Sitio Eriazo: 2015)

3. Conclusion

In recent years, the urban leftover space transformation has drawn constant attention and exploration by scholars. Under the impact of the international case, in view of the current domestic situation, relevant scholars have proposed a strategy for renewal of transport infrastructure that promotes urban space reshaping [8], where the landscape intervention method includes the construction of stratified integrated development green based on abandoned railways. Roads, jogging trails, bicycle lanes, parks, community public spaces. Others include the superposition of avenues, the retention and linking of natural wilderness, the introduction of natural communities, the integration of chronic systems with public spaces, the installation of art facilities and movable gardens, the

introduction of children's activity facilities, and the connection of waterfront spaces. It can be argued that landscapeizing the leftover space is the most direct way of improving the urban environment, reorganizing the social order, and maximizing the public interest. At the same time, this has, to a certain degree, focused on the inheritance of urban contexts and the use of landscape environments for differences. The inclusion of traits further activates space. The pocket park in Wangfujing Street used the concept of "marks on the wall and shading under the trees". Zhu Xiaodi, the architect, extracted the ideographic fragments of the brick walls, introduced and superimposed the footprints of the courtyard houses and the existing space, and expressed Attention to the traditional courtyard houses' space and life culture has triggered further public activities. This is a useful attempt to renovate the remaining space in Beijing's Old City streets.

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A Scenario Analysis of Establishment of Mt. Wuyishan National Park Based on Value Estimation

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Abstract

The establishment of national park system is a new fundamental national-level strategy proposed by central government of China related to the ecological security of the nation, welfare of the whole people and the achievement of the national rejuvenation. The national park strategy aim to solve the key problems of the protected areas which are separated protection forces, overlapped spatial scopes, lack of scientific guidance in management. The natural resources are abundant and the scenery is beautiful in the city area of Wuyishan. There are 8 types of protected areas covering an area of 1,800 km² with a population of 238,800. It is the epitome of the protection and management situation of natural resources of the densely populated area in southern China.

The study sets up the value analysis framework of city area of Wuyishan. The value is fell into two categories, which area intrinsic value including geological and geomorphological value, ecological system value, biodiversity value, cultural diversity value and aesthetic, and utilization value including recreation and tourism, scientific research and interpretation, settlement value. The intrinsic value is the reflection of the natural resource itself, while the utilization value reflects the degree of human utilization of natural resources, and the utilization value depends on the intrinsic value.

The factors related to the planning of Mount Wuyishan National Park are complicated. Since it is made of variety of systems--natural ecology, urban economy and social culture are linked with each other, with a lot of recessive factors are not easily to be noticed, the uncertainty of the future of the city area of Wuyishan is becoming bigger and bigger. To make sure the flexibility and integrity of this research and to take various factors and different stakeholders' benefits into consideration, so that the future planners and decision makers can take balance as the situation changes. This research use scenario analysis to compare the national park scope.

Three scenarios are designed with the differences in size, natural resources and population. To make the decision of the three scenarios, 26 key indicators are selected for intrinsic and utilization value benefit estimation and direct and indirect protection costs evaluation. The intrinsic value index includes the area and quality of the value carriers, and the

ecosystem function. The utilization value index can be fell into 6 categories: the number of visitors, satisfaction, the integrity of interpretation, the perfection of the system, the industrial benefit and social benefit. The direct cost of the scenarios include land use compensation, infrastructure construction for protection, the cost of redemption of existing concession, while indirect cost consist of the input of the research and interpretation, the cost of management reform, a fund to encourage community development, etc. Based on the quantitative calculation of each index, the advantages and disadvantages of the three scenarios are examined. The scenario B is the recommendation plan by the planner.

Keywords: National Park, Protected area, Scenario Analysis, Value estimation

1. Introduction

The establishment of national park system is a new fundamental national-level strategy proposed by central government of China related to the ecological security of the nation, welfare of the whole people and the achievement of the national rejuvenation. The national park strategy aim to solve the key problems of the protected areas which are separated protection forces, overlapped spatial scopes, lack of scientific guidance in management.

Wuyishan area is in Fujian Province of China, in which the natural resources are abundant and the scenery is beautiful. It is the epitome of the protection and management situation of natural resources of the densely populated area in southern China.

There are 8 types of protected areas. The detail information of all the protected areas are listed below (see Table 1 and Figure 1). The two national nature reserves are adjacent to each other, namely Fujian Wuyishan National Nature Reserve and Jiangxi Wuyishan National Nature Reserve. Jiangxi National Nature Reserve is located in the Jiangxi Province, which is not in the City of Wuyishan. It is included in this study, because it is very similar to the nature reserve in Fujian Province in terms of its importance and characteristics. The protected areas in Wuyishan area is covering an area of 1,800 km².

Wuyishan City now has jurisdiction over 3 towns, 4 villages, 3 blocks, 4 farmlands or tea plantations, 115 administrative villages. Its total household population is 238,800 . The industrial structure of Wuyi City is mainly tertiary industry. Tourism economy has been developing at a stable speed, and transportation industry continues to develop.

2. Value framework

The study sets up the value analysis framework of city area of Wuyishan. The value is fell into two categories, which area intrinsic value including geological and geomorphological value, ecological system value, biodiversity value, cultural diversity value and aesthetic, and utilization value including tourism and interpretation, scientific research and interpretation, settlement value.

The intrinsic value is the reflection of the natural resource itself, while the utilization value reflects the degree of human utilization of natural resources, and the utilization value depends on the intrinsic value.

□ a.Geological and Geomorphological Value

Wuyishan has complex geological structure and typical geomorphological features. It is an essential part of southeastern distribution where largely exists Danxia Landform. With the altitude of 2,158 meters, Huanggang Mountain, also

known as “Southeastern China Ridge”, is located at the top of Southeastern Mainland of China and is the highest mountain in southeastern China (apart from Taiwan). It belongs to Wuyishan, a watershed between Min(Fujian), Gan(Jiangxi) and Minjiang River and Yangzte River, and also one of the cradle of Minjiang River in Fujian and Xinjiang River in Jiangxi. With rich fossils of animals and plants, Wuyishan is a typical profile in the research of strata and chronological division of Jurassic and Cretaceous in eastern part of China.

□ b. Ecological System Value

Mid-tropical forest ecological system in Fujian Wuyishan National Nature Reserve is the largest and the most well-preserved compared with those in China’s same latitude. It is typical, diverse and systematic, which are also features of vegetation in mid-tropical area. (Which contains 11 types of vegetation in total).

□ c. Biodiversity Value

With favorable natural conditions and abundant vegetation species, Fujian Wuyishan National Nature Reserve provides an ideal habitat for rare wild animals, and it is also a place where lives the most species of insects in mid-tropical ecological system in China. It is rewarded as “Kingdom of snakes”, “World of insects”, “Paradise of birds”, “The key to analyzing Asian amphibians and reptiles”.

□ d. Zhuxi’s Neo-confucianism Value

Zhu Xi is the greatest thinker, philosopher and educator after Confucius in Chinese history. Wuyishan, as a cradle of Zhuxi’s Neo-confucianism, is inseparable from it.

□ e. Tea Culture Value

With a long history of tea culture, Mount Wuyi is the birthplace of the producing

method of Chinese black tea and Fujian oolong tea. The historical sites such as ancient tea gardens, ancient tea factories and ancient tea roads witness the development history of Mount Wuyi’s tea industry. Mount Wuyi is the start of ten thousand-li Tea Road. As the collecting and distributing centre of tea, Xingcun Town, Xiamei Village, Red Stone Village and so on witness the development history of foreign trade of Chinese tea and the communication history of tea culture.

□ f. Aesthetic Value

With the colorful view of the combination of unique and beautiful mountains, luxuriant forests, devious serpentine streams, fresh and quiet tea gardens and a long profound cultural landscape, Mount Wuyi shows a fantastic beauty of harmony between man and nature.

3. Scenarios of the national park area

3.1. Method

This study divides area in National park into 4 levels of different utilization: A, B, C, and D. The basic requirements for the resource utilization for each level are listed in Table 2. It means in each level there are basic regulations on the intensity of the utilization. Three scenarios of national park area and initialization zoning are proposed using the same utilization density level control. Then it will be easy to compare the cost and the benefit of each scenario. Then it will be easier to compare the cost and benefit of each scenario.

Through the comparative study of the cost-benefit of each scenario, the suggestion will

be make for proposed national park area and the utilization intensity zoning,

3.2. Scenarios of Wuyishan National Park boundary and zoning of utilization Intensity

3.2.1 Scenario I

Scenario I covers an area of 1809.8 km², includes 4 utilization intensity levels. Utilization Intensity Level A: 402.16 km², includes core zones of Fujian Wuyishan National Nature Reserve and Jiangxi Wuyishan National Nature Reserve, special protection zones of Wuyishan National Scenic Area, core zoned of Huang Long Yan Provincial Nature Reserve. Utilization Intensity Level B: 348.67 km², includes buffer zones of Fujian Wuyishan National Nature Reserve and Jiangxi Wuyishan National Nature Reserve, class 1 protection zones of Wuyishan National Scenic Area, Nine-belt Stream National Aquatic Germplasm Protected Area, buffer zones of Huang Long Yan Provincial Nature Reserve, Wuyishan National Forest Park. Utilization Intensity Level C: 1015.99 km², includes experimental zones of Fujian Wuyishan National Nature Reserve and Jiangxi Wuyishan National Nature Reserve, class 2 and class 3 protection zones of Wuyishan National Scenic Area, experimental zones of Huang Long Yan Provincial Nature Reserve, and part of "Important Water Conservation Area, Special Species Protection Area, Important Water and Soil Conservation Area". Utilization Intensity Level D: 42.98 km², includes part of areas in Mount Wuyi World Heritage Site and part of alongside areas of Hengnan Railway. See Figure 2.

3.2.2 Scenario II

Scenario II covers an area of 979.31 km², includes 4 utilization intensity levels.

Utilization Intensity Level A: 335.95 km², includes core zones of Mount-Wuyi National Nature Reserves in Fujian Province, special protection areas of Mount-Wuyi National Scenic Area; Utilization Intensity Level B: 175.06 km², includes buffer zones of Mount-Wuyi National Nature Reserves in Fujian Province, Grade 1 protection areas of Mount-Wuyi National Scenic Area; Utilization Intensity Level C: 447.60 km², includes experimental zones of Mount-Wuyi National Nature Reserves in Fujian, Grade 2 and Grade 3 protection areas of Mount-Wuyi National Scenic Area, and upstream protection areas of Jiuqu River (except for 8 administrative village areas , which are: Chengdun, Hongxing, Zhoutou, Caodun, Chaoyang, Huangcun, Tongmu and Xingmu.); Utilization Intensity Level D: 20.70 km², includes the villages' construction area in the upstream protection areas of Jiuqu River. See Figure 3.

3.2.3 Scenario III

Scenario II covers an area of 706.60 km², includes 4 utilization intensity levels.

Utilization Intensity Level A: 335.95 km², includes core zones of Fujian Wuyishan National Nature Reserve, special protection zones of Wuyishan National Scenic Area. Utilization Intensity Level B: 175.06 km², includes buffer zones of Fujian Wuyishan National Nature Reserve, class 1 protection zones of Wuyishan National Scenic Area. Utilization Intensity Level C: 195.05 km², includes experimental zones of

Fujian Wuyishan National Nature Reserve, class 2 and class 3 protection zones of Wuyishan National Scenic Area, and areas along Nine-belt Stream. There are no utilization intensity level D in Scenarion III. See Figure 4.

In Scenario III, the protected area is comparatively small, and species resources protection zones are easily to be eroded. However, the change to current protected areas is relatively small and the difficulty of reforming management system is correspondingly low.

3.3. Cost-benefit Analysis of the Scenarios

3.3.1 Benefit Analysis

Cost-benefit analysis is a method of assessing the value of a project by comparing the full costs and benefits of the project.

Values can be converted into corresponding key indicators through actual market price assessments, simulated market assessments, and alternative market assessment methods.

16 key indicators are selected for intrinsic and utilization value benefit estimation. They are listed in Table 4.

3.3.2 Cost Analysis

10 key indicators are chosen to calculate the cost of the three scenarios. The cost are fell into two categories, which are direct costs of value protection, and the indirect costs of value protection. The detailed information of each indicator and the result of the calculation are listed in Table 5.

3.3.3 Conclusion

Based on the comparison of the benefits and costs of the above three scenarios, the summary is shown in Table 6 The values “1”, “2”, and “3” in the table indicate “optimal,” “moderate,” and “poor.” .

It is known from the comprehensive comparison that the intrinsic and utilization value of the scenario I is the highest, but the cost is the highest. In the second scenario, the value protection is good and the cost is moderate; Scenario III has the lowest value and lowest cost. In combination with the current situation of protection and the implementation of management policy, Scenario II is chosen as national park.

4. Discussion

This study provides a feasible technical method for delineating the boundaries of national parks. Through determining the value framework, conducting value analysis, designing national park plans of different sizes, and determining their basic utilization zones, the cost of multi-projects can be calculated quantitatively. In comparison with the benefits and the cost of each scenario, the most suitable national park plan was compared.

However, there are still many issues that need to be discussed, such as specific algorithms for cost and benefit. Each indicator has to be considered. Limited by the availability of data, many indicators can only be measured in terms of size.

It should be noted that the determination of the boundaries of a national park is a complex decision-making process and the factors involved are very diverse. This study

only provides a method for aiding decisions, which helps to improve the scientific decision-making.

Table 1 List of Protected Areas in Wuyishan Area

Name of Protected Area	Type of Protected Area	Level	Area (ha)	Whether in the scope of world heritage site or not	Whether in the scope of "forbidden area" or not	Time of establishment
Fujian Wuyishan National Nature Reserve	Nature reserve	State level	56527.3	yes	yes	Built in 1979, state-level
Jiangxi Wuyishan National Nature Reserve	Nature reserve	State level	16,007	Part of it is in World Heritage Buffer Area	no	Built in 1981 ,
Wuyishan National Scenic Area	Scenic area	State level	6,850	yes	yes	Built in 1982
Wuyishan National Forest Park	Forest park	State level	7,418	yes, it is in Nine-bent Stream ecological protection area	yes	Built in 2002 , provincial level Built in 2004 , tate-level
Mount Wuyi World Heritage site	Mixed World Heritage Site	World level	99,975	-	Part of it is in "forbidden area"	Built in 1999
Nine-bent Stream Spinibarbus hollandi National Aquatic Germplasm Resources Conservation Area	National Aquatic Germplasm protection area	State level	1200	Yes, it is in Nine-bent Stream Ecological protection area of the site.	Part of it is in "forbidden area,	Built in 2012
Wuyishan Dongxi reservoir National Water Scenic Area	Water Scenic Area	State level	1,830	no	yes	Built in 2013
Wuyishan Huanglong Yan Provincial Nature Reserve	Nature Reserve	Provincial level	4765.16	no	no	Built in 2015
First and second grade protected zones of drinking water resource in Xingcun village	First and second grade protected zones of drinking water resource	-	-	yes , it is in Nine-bent Stream Ecological protection area of the site.	no	Built in 2009

Table 2 Basic Requirements for the Resource Utilization for Every Protection Class

Classification	Basic Requirements for Resource Utilization For Every Protection Class	
	LEVEL A	Facilities Establishment
	Producing and Living	Prohibit producing and living activities
	Tourist Activity	Prohibit tourists to enter
	Management Activity	Allow approved scientific research activity of observation type
LEVEL B	Facilities Establishment	Prohibit permanent facilities
	Producing and Life	Prohibit producing and living activities
	Tourist Activity	Prohibit large-scale tourists to enter and move
	Management Activity	Allow approved scientific research activity
LEVEL C	Facilities Establishment	Allow necessary tour facilities which brings small changes to nature environment such as walking paths and caption boards
	Producing and Life	Allow habitants' producing and living activities which do not affect protecting objects and nature environment
	Tourist Activity	Allow large-scale tourists to enter and move with proper utilization method of recreation and rest
	Management Activity	Allow scientific research activities and facilities which do not affect protecting objects and

		nature environment
LEVEL D	Facilities Establishment	Allow recreational facilities, management facilities, culture facilities, authorized facilities, interpreting facilities, infrastructure, environmental renovation facilities
	Producing and Life	Allow habitants' producing and living activities which do not affect protecting objects and nature environment
	Tourist Activity	Allow large-scale tourists to enter and move with proper utilization method of recreation and rest
	Management Activity	Allow scientific research activities and facilities which do not affect protecting objects and nature environment

Table 3 Comparison of the Primary Data of Mount Wuyi National Park Scenarios (km²)

Zoning	Scenario I	Scenario II	Scenario III
Utilization Intensity Level A	402.16	335.95	335.95
Utilization Intensity Level B	348.67	175.06	175.06
Utilization Intensity Level C	1015.99	447.60	195.05
Utilization Intensity Level D	42.98	20.70	-
Total Area	1809.80	979.31	706.06

Table 4 A list of benefit assessment indicators based on value analysis

Value	Items	Key indicator	No	Scenario I	Scenario II	Scenario III	Unit	
Intrinsic Value	Geological and Geomorphological Value	Ontology value	Area of Danxia landform	IB1	43.87	43.87	43.87	km ²
			Amount of rare, typical Danxia landform	IB2	31	31	31	site
			The area of jiuqu river basin.	IB3	540.71	466.60	246.60	km ²
	Ecological System Value	water conservation	Quantity of water conservation	IB4	47290.9	25812.1	18930.4	Ten thousand yuan/year
		Soil conservation	Area of forest ecosystem	IB5	220.6	120.4	88.3	Ten thousand yuan/year
		Soil fertility value	Quantity of soil sequestration	IB6	224409	122486	89831	Ten thousand yuan/year
		Reduced sediment deposition	Quantity of soil sequestration	IB6	532.0	290.4	213.0	Ten thousand yuan/year
		Purify air	Area of forest ecosystem	IB5	62391.3	34054.1	24975.1	Ten thousand yuan/year
		carbon sequestration	Area of forest ecosystem	IB5	NA	NA	NA	NA
	Biodiversity Value	Ontology value	Area of forest ecosystem	IB5	1654.17	902.87	662.16	km ²
	Tea Culture Value	Area of forest ecosystem	Quantity of the tea culture value carriers	IB7	11	11	11	Site
			Protection area of the tea culture value carriers	IB8	18	16	14	km ²
	Zhuxi's Neo-confucianism Value	Ontology value	Quantity of the culture value carriers	IB9	24	24	24	site
	Aesthetic Value	Ontology value	Protection area of the aesthetic value carriers	IB10	1364.66	622.66	370.11	km ²
utilization value	tourism and interpretation	Tourism and interpretation benefit	visitor amount	EB1	322.52	296.3	291.49	number of equivalent

Value	Items	Key indicator	No	Scenario I	Scenario II	Scenario III	Unit	
	scientific research	Scientific research benefit	-	EB2 high	low	low	NA	
	settlement value	Benefits of agricultural and forestry products.	The production value of renewable resources.	EB3	1058.97	468.30	195.05	km ²
		Benefit of the ecosystem supporting service	--	EB4	28416.12	27768.96	27423.69	Ten thousand yuan/year

Table 5 The cost evaluation

Category	Items	Key indicator	Scenario I	Scenario II	Scenario III	Unit
direct costs of value protection	Ecological compensation	Area of ecological public welfare forest.	3236.51	2177.13	1836.33	Ten thousand yuan/year
	Construction input for conservation	The area of national park, planning of input for conservation construction	1750	1000	1000	Ten thousand yuan/year
	The cost of purchasing operational rights.	Category and amount of the tourism project has been sold	high	lower	lowest	
Indirect costs of value protection	Funding for research	Research funding needed	1110	200	200	Ten thousand yuan
	Input for interpretation	Planning for input for infrastructure for interpretation and the input for interpretation staff	3000	1800	1800	Ten thousand yuan
	Input for Management system reform	Management system change, communication cost and personnel cost	high	lower	lowest	NA
	Reward and compensation for community development.	--	256832	167793	132516	Ten thousand yuan
	others	The area of national park	high	lower	lowest	

Table 6 Benefit - cost comparison analysis summary

value	items	Scenario I	Scenario II	Scenario III	
Intrinsic Value	□ Geological and Geomorphological Value	Ontology value	2	2	2
		Ontology value	1	1	1
		Ontology value	1	1	3
	Ecological System Value	water conservation	1	2	3
		Soil conservation	1	2	3
		Soil fertility value	1	2	3
		Reduced sediment deposition	1	2	3
		Purify air	1	2	3
	Biodiversity Value	Ontology value	1	2	3
	Tea Culture Value	Ontology value	2	1	3
	huxi's Neo-confucianism Value	Ontology value	1	1	1
□ Aesthetic Value	Ontology value	1	2	3	
utilization value	tourism and interpretation	Tourism and interpretation benefit	1	2	3
	scientific research	Scientific research benefit	1	2	3
	settlement value	Benefits of agricultural and forestry products.	1	2	3
		Benefit of the ecosystem supporting service	1	2	3
Cost	direct costs of value protection	Ecological compensation	3	2	1

Indirect costs of value protection	Construction input for conservation	3	1	1
	The cost of purchasing operational rights.	3	1	1
	Funding for research	3	2	1
	Input for interpretation	3	1	1
	Input for Management system reform	3	2	2
	Reward and compensation for community development.	3	2	1
	others	3	2	1

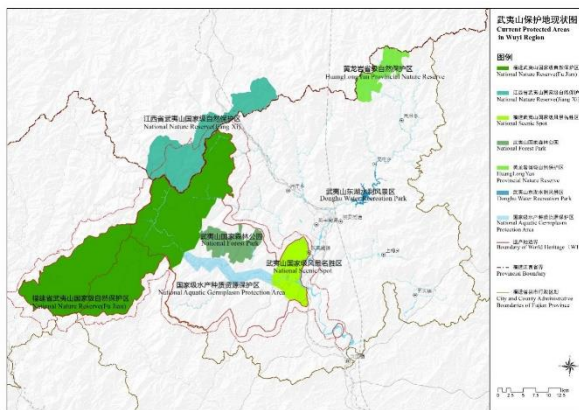


Figure 1 Current sition of Protected Areas in Wuyishan City

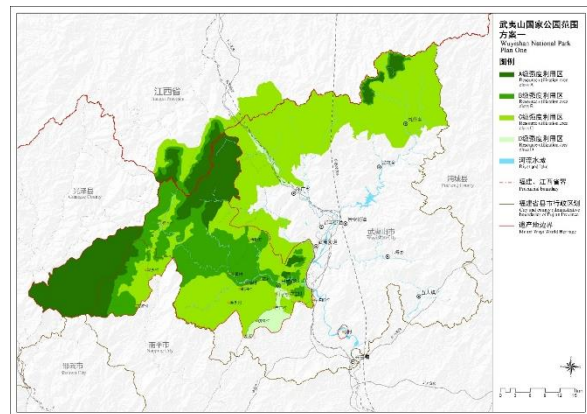


Figure 2 Scenario I

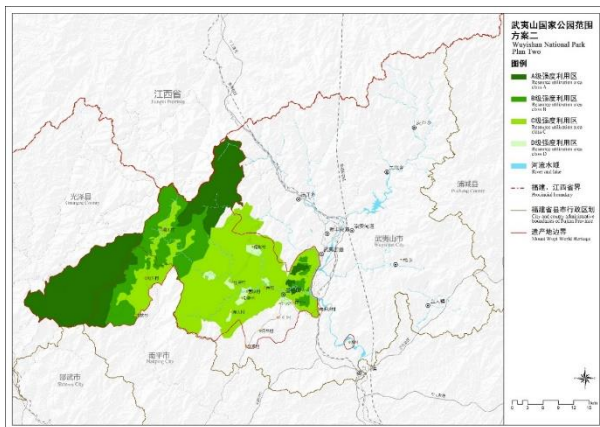


Figure 3 Scenario II

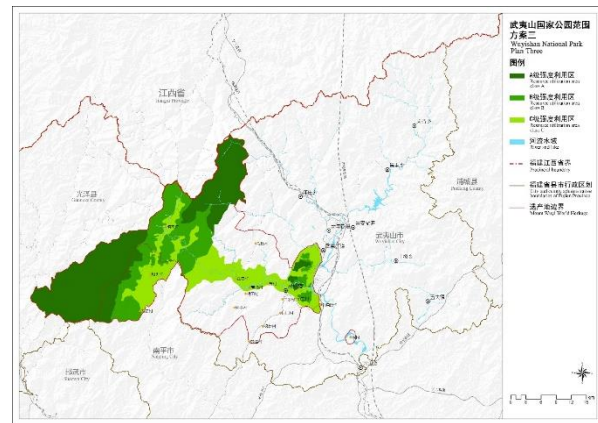


Figure 4 Scenario III

Reconnecting green: Towards a multi-dimensional biophilic city

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Abstract

Densification and greening of cities seem to exclude one another. How to deal with this? This research shows a first exploration of how city green can be optimized by integrating the facade- and rooftop green into the neighbourhood landscape. To do this, biophilic design principles were applied from a landscape architectural perspective. Due to the many green roof interventions as well as the existing big surface area of flat roofs, the city of Rotterdam in the Netherlands, was the main focus. Seven steps which can turn an unhealthy city into a biophilic one are described. Ecosystem services are related to these steps and serve as an indication for valuing ideas and design implementations for a city wide greening vision as a first step towards a multidimensional biophilic city.

Keywords: Biophilia; ecosystem services; facade green; rooftop green; landscape architecture, Rotterdam

1. Introduction

Many large cities in the world have an unhealthy stressful urban climate: air pollution, lack of water retention, lack of biodiversity, urban heat island effects, etc. There is also a lack of space in the urban environment and predictions are that urbanization and densification will increase

(DESA, 2008). This is a huge problem for cities and very difficult to plan and design for. Urban green is regarded as big part of the solution for the environmental challenges that cities are facing. Ecosystem services, the benefits human populations derive from ecosystems (Bolund & Hunhammar, 1999), in cities should be planned for. Physical needs, security of existence, social and psychological needs can all benefit from

green interventions (Hop & Hiemstra, 2013). Therefore, it is very important that local governments have ambitious green policies.

“Nature seems to bring out the best in us (Beatley, 2011). As it turns out, even small nature places can help just do that (Kaplan & Kaplan, 2005)”

A densified city lacks an abundance of open space. There is a competition for space, between different functions such as new dwellings and green developments. Since the 1980s rooftop green has been introduced on a large scale in urban areas. The motive was to bring the maximum vegetation possible into the urban setting (Kohler, 2008). Projects were developed which resulted in beautiful green roofscapes. There are some critical remarks though: First, they primarily occur in the private sector. Second, public green roofs are often unknown by citizens, as they are hardly seen from ground level and often have bad accessibility. Since mid-2000s, green façades began to emerge and green architecture became a fact. The advantages of green façades, in contrast with green roofs, is that they are visible from the street level. However, one cannot walk through a green façade. The third problem of vertical green and rooftop interventions is that they are implemented on a small scale scattered all over the city, with little to no interaction with the ground level. The effects of those green interventions are still very local, many potential synergies are unused.

Green roofs and façades are mainly architectural projects and connected in isolation of the building. There is not enough attention for this type of green interventions yet from a landscape architectural point of view. This research shows an exploration of

how city green can be optimized by integrating the facade-and rooftop green into the neighbourhood landscape. Rotterdam, the Netherlands, will be the main focus due to the many green roof interventions and number of flat roofs. The results of this research is a stepwise approach how an existing city can transform into a biophilic one.

2. Methodology

The approach consists of seven steps starting from analysing the city and its potentials. From this analysis, a vision can be made that results in a concrete plan for the development of a biophilic city. The link with existing biophilic projects is made to show what a biophilic city can look like. The analysed layers are: existing green, water and public space, existing green rooftops and potential rooftops, and the urban challenges (such as densification), and opportunities. The next step is to create a vision for the city based on the previous analysis. Spatial requirements for the development for reconnecting green are partly extracted from this vision as well as from local context. The last step is an action plan and will be illustrated with example projects.

1. Look for available spaces and analyse existing green areas
2. Map existing green roofs
3. Analyse buildings for potential green development
4. Analyse urban challenges and opportunities
5. Create a city wide greening vision
6. Reconnect green
7. Action plan

3. Towards a biophilic city

“Nature in our lives is not optional, it is essential. It is not a thing or place that we periodically visit but a surrounding condition, an ideally ubiquitous context that delights, relaxes, soothes, replenishes, inspires, and uplifts us in our daily urban lives. A biophilic city is a city that looks for opportunities to repair and restore and creatively insert nature wherever it can (Beatley, 2011).“

3.1. Look for available spaces and analyse existing green areas

To design for a biophilic city it is important to take advantage of the existing green-and public spaces, infrastructure, water ways, and other connections in a city. These green infrastructures form the backbone of the city. They can and do support a diversity of human uses as well as environmental functions, and their vitality influences quality of life as much as it does the integrity of land, air, water and forest resources (Girling & Kellett, 2005). We can look at available spaces in different scales from regional to street level. Existing green areas and available areas for green development on a regional scale are regional parks, large conservation areas, greenways and rivers. The regional parks create space, landscape and a peaceful environment and show the identity of the city and typology of soil, history and landscape type (Tillie, 2016, Municipality of Rotterdam, 2005). Rivers are the core areas for the landscape, ecology, history and recreation and create connections

on different scales; city, regional, national and international scale. City-or community parks, cemeteries, play fields, greenways and city gardens are the existing community green areas in a city and are an important connection with regional parks. On a neighbourhood scale, green sites are school yards, neighbourhood parks, playgrounds, and drainage ways (Girling & Kellett, 2005). It is of great value that the available green spaces and spaces for green are easily accessible and coherent. These are ecological and recreational routes through a city where there is a direct experience and accessibility of green. Other available spaces are (abandoned) alleys, streets, tram tracks and parking lots. Places that you don't need or want to visit but have great potential for green or biophilic development. Quays and riverside trails are perfect locations for green connections as well dike trails and road sides. On a street level scale, medians, street trees and planting strips create green corridors through a city. In Rotterdam, the river Maas is an icon of the city and the multiple canals play an import role for cultural history, usage and living quality. Three regional parks surround Rotterdam and form an important part of the urban structure: Rottemeren, Midden-Delflanden and IJsselmonde. Due to these big ecological areas and the number of smaller waterways like canals, ponds, and other greens, Rotterdam is very suitable to become a biophilic city.

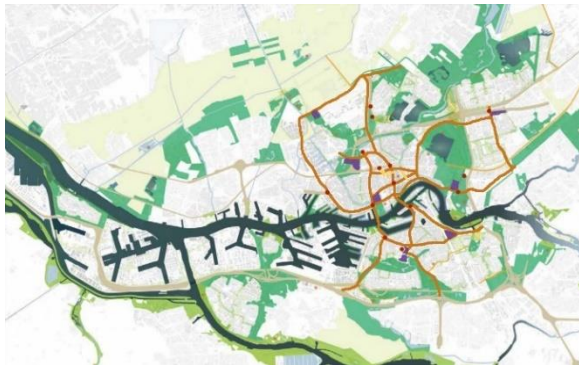


Fig. 1. Public green Rotterdam (Municipality of Rotterdam, 2012 & 2014)



Fig. 2. Current green rooftops in Rotterdam (Municipality of Rotterdam, 2007)

3.2. Map existing green rooftops

The first step to create a multi-dimensional green space is to map all the existing green roofs. Answering questions such as: Where are they located, what is the level of the intensity of green, are they accessible, do they relate, are they connected with the ground level, etc. Analysing these rooftops gives direction for planning new green rooftops. Rotterdam has the highest amount of green rooftop development in the Netherlands, with over 235.000 m² of green roofs (Municipality of Rotterdam, 2017) and the most potential to create a multi-dimensional landscape, as it has a big amount of post WWII real-estate. Only a small percentage of the existing green rooftops are always accessible.

3.3. Analyse buildings for potential green development

There are several important aspects of potential recreational green rooftops. Rooftops have to be flat for recreational green development. Due to accessibility and visibility it is wise to focus on rooftops that have a maximum of 12 meters. It is a bonus if a rooftop has the possibilities for an intensive green rooftop. Especially dense neighbourhoods with little green and little potential for ground level green development, can have enormous benefits from green rooftops. For the development of green facades another approach is made. Green facades have great visibility and work really well in dense areas. Especially small streets where there is no space for trees and other green can have great benefit from green facades and hanging green.



Fig. 3. Potential green rooftops in Rotterdam (Municipality of Rotterdam, 2007)

3.4. Analyse urban challenges and opportunities

Every city has to cope with specific challenges. Global warming and densification are key subjects of tomorrow's city planning for almost every city. Water restoration, urban heat island effects, air pollution, as well as social problems such as stress, and disconnection with nature, are huge problems. The difficulty is the lack of space in cities for creating solutions. Healthy ecosystems are the foundation for sustainable cities (TEEB, 2011). For example, trees and green rooftops serve to address the urban heat island effect and moderate and reduce urban heat and reduce air pollutants (Getter & Rowe, 2006). To connect urban challenges to green opportunities we can look at ecosystem services. Urban green and healthy ecosystems can solve many city challenges. The effects of climate change are also visible in the city of Rotterdam; sea level rise, intense rain, dynamic water levels in the rivers, and longer periods of drought and warmth (Rotterdam Climate Initiative, 2018).

The city's effort is to create and maintain a balanced green infrastructure of parks, gardens and other green areas with a high quality providing different ecosystem services ranging from recreation, ecological qualities to water storage and so on (Tillie, 2016). It is necessary that Rotterdam will adapt itself to climate change and its goal is to be climate-proof by 2025. If we look at the case of Rotterdam, another challenge is the experience of green in the city. Rotterdam has more green per dwelling than the other 3 big cities, Amsterdam, The Hague and Utrecht. However, the citizens don't experience this as such. The Reasons for this is the quality of green, monotonous (or not) and its usability (Tillie, 2016). Therefore it's not only important to create more green, it is also valuable to increase the quality of existing green in the city. The implementation of green is a step in the right direction. Which kind of problem does the service contribute to or solve? What ecosystem elements are involved in the generation of the service and where are the opportunities in the city to create this?

3.5. Create a city wide greening vision

Key is to set goals for the city. What are the most important challenges of this city? Is it the air quality, water retention or is it the mental wellbeing of its citizen, etc.? From this challenge, (or these challenges) we can create a vision for the city. The places in the city that need the most green because of its lack in green, dwelling density or other problems. For the Netherlands the green standard per dwelling is 75m² and the accessibility of green is 500m² (Bezemer et

al., 2002). Map the surface of green in the city and determine the minimum amount of green that is needed. Start at the ground level, what is already there? What is the function, and how is the quality of the green? A connection of neighbourhood green with regional green should be made in order to address weekly green and stimulate citizen to visit the nature areas outside of the city. Look for available places for green development and link this with existing green. How do they relate and, more important, how can they strengthen each other? Use the extra dimensions in the city, facades and rooftops and link these with the ground level green. Create artistic and aesthetic roof accessibilities that will attract people to the rooftops.

3.6. Reconnect green

“Reconnecting may be appropriate not only with respect to our relationship with nature, but in terms of many other reasonableness-supporting aspects of life (Kaplan & Kaplan, 2005)”

‘Daily contact with urban nature places can foster greater self-esteem, trust, and hope. It stimulates the reconnection with nature of the urbanites’ (Beatley, 2011). To create a well-connected green infrastructure which adds to daily green, it is valuable to have at least street green; trees, sidewalk gardens, courtyards, within 100m (Beatley, 2012), and larger green areas; neighbourhood parks, pocket parks, gardens, within 500m (Bezemer et al, 2002). For connecting green it is helpful to look for more solutions than only from a ground level perspective. Other dimensions are green facades and green roofs. They are the higher reaches of a city

and harbour nature. Potential benefits of green facades- and roofs include green-space amenity, habitat for wildlife, air-quality improvement, and reduction of the urban heat-island effect (Oberndorfer & et al., 2007). It is important to approach them as two different interventions as they have in common the covering of building surfaces with vegetation, but there are key differences in the application and structure of these technologies and the resulting impacts on urban ecosystems (Köhler, 2008). To make rooftops more valuable it is of great significance that they are part of a bigger green infrastructure. The difficulty of integrating green rooftops is its accessibility and the place to create accessibility. The green rooftop of the Nanyang School of Art in Singapore and the green roof of the Delft University of Technology Library in the Netherlands managed to make a whole of the rooftop and ground level to increase its accessibility. These curved and sloping roofs were part of the architecture and make a good inspiration for creating accessible rooftops on existing buildings.

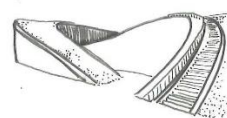


Fig. 4. Nanyang School of Art.

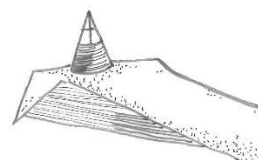


Fig. 5 Delft University of technology.

We can distinguish three types of accessibility for rooftops. The first one is based on the green slopes of architectural buildings and can be implemented at places where there is enough space. The advantages of this kind of ascent is that it is part of the green rooftop in its appearance and vegetation and functions as an extension of the roof garden. The second type is a stair which can be implemented where there is no room for a slope. This stair, depending on the size, can harbour extra commercial functions, like small shops. The last type of ascent is a tower with stairs or elevator in it. Its compact size makes it possible to reach roof gardens where there is a lack of space on the ground level. Both can be vegetated to link it with the green roof and infrastructure.



Fig. 6. Type 1: Slope



Fig. 7. Type 2: Stairs



Fig 8. Type 3: Tower.

4.7. Action plan

The goal of Rotterdam is that it will be climate-proof by 2025 (Municipality of Rotterdam, 2017). The city should function as a sponge, green should have more value and it should be social and flexible. A multi-dimensional green connection can be made which is of great value. This principle can easily be applied in the inner city of Rotterdam. For instance the Lijnbaan, which has a great amount of low (under 10m) flat rooftop buildings where a second pedestrian layer can be added to. Every 10-25 year a building has to be renovated which is a perfect timing to transform this building into a sustainable green one. When there is place for new urban development, make sure that it will be a biophilic space with enough green areas and green buildings.

Creating urban landscapes using native plants restore the ecological function and value. Native vegetation is low in maintenance and supports local ecology and evolved to live with the local climate, soil type and animals. There must be areas where

residents can see and experience native wild or semi-wild nature and native vegetation (Beatley, 2011) which links with the surrounding landscape of the city. Our urban streetscapes, city parks, regional greenways and vegetative storm water facilities are ideal spaces for incorporating native plant communities. Native plants help to capture and infiltrate storm water thus improving water quality while providing habitat and biodiversity. The biggest benefit: they complete the picture by enhancing the aesthetic values of urban neighbourhoods. A good example of a project that used mainly native species is Corktown Common in Toronto. It opened with over 700 trees and thousands of shrubs and grasses that are native to Southern Ontario's Carolinian forest ecosystem.



Fig. 9. Chaise Urbaine, Germany



Fig. 10. Biesbosch, the Netherlands.



Fig. 11. EVA Lanxmeer, The Netherlands.



Fig. 12. Corktown Common, Canada.

4. Conclusion

An attractive green city is not only beneficial for its citizens as a contribution to strengthen the economy. Green attracts firms and offices because of the pleasing setting, room for strolling and view (Tillie, 2016). Therefore it is of great value that we start now with designing our cities differently. Start by analysing the ground level for existing green and potential green. Add the second dimension analysis of (potential) green facades and rooftops. This is the base for a biophilic development. Subsequently

determine what the challenges and opportunities of the city are and link those with ecosystem services, the type of ecosystem that can treat the problems in the city. Set goals and create a vision based on the needs of a city, and the available spaces to design for. Reconnect those places with existing green and create physical, aesthetical and biological networks between the ground level and rooftop for a multi-dimensional biophilic design. At last set guidelines for architectural development. Biophilic design should at least add to air filtering, biodiversity, aesthetics and a better physical and psychological health. A biophilic city is a city where its citizens and itself can be healthy and happy. As nature in our cities and lives is not optional, it is essential.

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Rural parcel pattern as condition for future landscape urbanism in Xiongan New Town

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Abstract

This paper aims to present the study about landscape urbanism within new town context in China. Theory review will describe the historical evolution of landscape urbanism with the concepts of Wall (1999), Palmboom (1987, 2010), who emphasised the relation between landscape and urban form. Special attention will be paid to the perspective that landscape provide framework for infrastructure and urban fabric, which indicates possibility for continuity and diversity of urban form. This would be reflected with the indication of existing rural village in Xiongan new town with the help of typo-morphology analysis and mapping. Parcel pattern indicates the relation of landscape and urban form that topographic condition as priority during historical construction. The research conclusion is that flooding risk and topographic condition are critical factors to achieving landscape urbanism in Xiongan new town.

Keywords: landscape urbanism, new town, parcellation pattern, topographic condition, continuity

1. Introduction

This paper addresses study on historical construction logic and expansion phases of existing villages in Xiongan new town. Analysis based on typo-morphology and layer approach indicates that expansion phases in existing rural villages accord with concept of landscape urbanism. Therefore, this paper helps to set some conditions for future adapting of landscape urbanism in this new town. Section two will discuss the important historic and current ideas of landscape urbanism, with the urbanists Wall (1999), Palmboom (1987, 2010). Section two will indicate methodology applied in this paper, method of typo-morphology and layer approach. Section three will focus on analysis of existing rural villages in Xiongan. Section four will present conclusions. Sections five will put forward discussions in relation to future adaption of landscape urbanism in this new town.

2. Concepts on landscape urbanism

2.1. City as urban landscape

Landscape urbanism is a theory of urban planning and urban design which stated that landscape is the fundamental layer for urban development. It emphasis “the idea of city as urban landscape” (Meyer 2015). A similar view is hold by Palmboom (2010) . Palmboom (2010) describes city as “a phenomenon of landscape”. He holds the view that city can “no longer be conceived as an architectonic entity which stands apart from the landscape”, it is an “*urbanised landscape*: extensive and fluid, layered,

marked by time, unpolished, arising out of a discordant interplay of natural and cultural forces, driven forward by the pragmatism of survival, with occasional flashes of aesthetic aspirations”. Palm stressed the importance of design of landscape in urban planning and urban design that urban area could be organised through design of landscape. As stated by Meyer (2015) that landscape act as “one and only element to influence by planning and design”. It addresses the perspective that landscape act as the basic framework for large-scale urban infrastructure and building programmes. Therefore, landscape provides condition for a diversification and enrichment of urban fabric. This is supported by Girot (2006). Girot (2006) argued that landscape “become a staging ground for the unfolding of future events”, he emphasises that “what has systematically been called the impoverishment of landscape could now be understood as a form of diversification and enrichment.” Wall (1999) agrees with this view. He describes landscape as “active urban surface, structuring the conditions for new relationships and interactions among the things it supports.” Wall’s idea reveals the interaction among landscape and the other urban layers supported by landscape. Thus, in order to achieve landscape urbanism, the first step is to understand the relationship between those layers and landscape. This is in line with the view of Wall (1999). He believes that “If we accept the premise that landscape has undergone such diverse and complex alterations, we need then to decipher the implicit “genetics” of its evolution in order to explicate a vision for the future”. Process of understanding relation between landscape and other urban

layers is deciphering “the implicit genetics”. Study on “implicit generics” discusses relationship based on the dutch layer approach and method of typo-morphology.

2.2. layer approach

Layer approach is a typical dutch urban analysis method. This approach oriented from the idea of “time-oriented thinking in spatial planning and design” (Schaick and Klaasen 2011). It refers to “stratified model that distinguished spatial planning” and design tasks “on the basis of the differing spatial dynamics of substratum, networks and occupation patterns” (Schaick and Klaasen 2011). Landscape is a more “longstanding moving continuum” (Boeri and Lavarra, 2002; Girot, 2006) comparing with network and occupation layers. This approach provides handles and levers for designers to study “the implicit generics”. It helps to simplify the complex urban system into separate layers, then study on the relationship between different layers systematically. Layer approach has been extended by Plambloom (2010). Plambloom (2010) stated that “every intervention has to take its complex layering into consideration, to deal with its conflicts and use its potential of unexpected combinations and contrasts”.

2.3. Method of typo-morphology

As Moudon (1994) stated, typo- morphology view “urban form as a dynamic and continuously changing entity”, describe “urban form (morphology) based on detailed classification of building and open space by type (typology)”, which “combines the volumetric characteristics of built structures with their related open spaces to define a



built landscape type”. Typo-morphology combined urban morphology (study of urban form) and typology (study of types of urban form), creates condition for study on the relation between urban fabric and landscape. It offers an intellectually challenging framework for thinking about the built landscape within the historical context of the city. This method “stipulates that city form can only be understood as it is produced over time” (Moudon 1994). Historical perspective of typo-morphology corresponds to the idea of landscape as “longstanding moving continuum”. Thus typo-morphology combines with layer approach, providing handles and levers to understand urban fabric in relation to the specific local landscape composition layers. This helps to reveal underlying relationship, the “implicit generics”, meanwhile, contributes to “study the nature of building design, its relationship to the city, and to the society in which it takes place”.

Fig1. Dazhuanghzuang is one of the existing villages in Xiongan new town. It located beside Baiyangdian shallow lake. (Photo reference: Google.map)

3. Rural villages as landscape area

This section addresses analysis on existing rural village in Xiongan new town to draw conclusions and disciplines for future adapting of landscape urbanism. Study will be divided into the following questions to reveal local specific relationship between landscape and urban fabric: how existing fabric has changed over the course of time and what has caused these changes? The analysis process is divided to three parts: morphology analysis to understand existing village tissue; typology analysis to understand different housing types; the last but not least, discuss the relation between village tissue and topographic condition, with the rural village “dazhangzhuang” as an example.

3.1. Housing typology analysis

As Moudon (1994) stated that from the perspective of typo-morphology, buildings can be treated as “timeless, unchangeable memories of a past”. Housing types provide clue for understanding historical expansion. Three housing types will be defined in chronological order: historical small units, courtyards with thick foundation, industrial multi-layer plants. Historical small units could be recognized by extreme “small size”. These units located in historical village center on top of marsh land. Courtyards with thick foundation are larger units comparing to the first type. The courtyard is completely private that is accessible only through the gated entrance, which act as legible spatial elements for strangers. Both historical small units and courtyards with thick foundation are constructed by private owners, this resulted

these two types were both built on top of thick foundation in case of flooding risk. Differentiation among those units reflect identification of the owners, meanwhile provides visually diversity and vitality when pedestrian walking along the street. Industry plants were built in form of multi-layer related buildings.

These types indicate historical expansion process and ways that local residents react to flooding risk. Village first appeared on top of marsh land and was composed of small units. Later thicken its fringe in all directions. Areas expanded during this phase took place by larger units with courtyards and thick foundation. Then Dazhangzhuang expand itself towards Anxin. Agricultural land was replaced by multi-layer housing and industry plant.

3.2. Morphology of villages in Xiongan

Analysis process of morphology is divided to two steps. Firstly, describe the mapping result to indicate different types of urban form in those villages. This step works as reduction process to filter mass of information.



Fig2. Three existing rural villages
 (Drawing reference: Draw by author based on map from Google.map)

Secondly compare those mapping results and relate them to local topographic condition. This step works as a back and forward process to draw conclusion. These villages are in different form of parcellation pattern. Parcel in village 1&2 is much more regular than village 3. Parcel pattern in Village 3 is similar to the pattern on top of marsh land, both in form of irregular pattern. By contrast, village 1 and village 2 are more a result of artificially “planned”. We could conclude that village 3 is the first constructed village even before the dike was built. Later, since dike was built, construction logic changed from water management as priority to accessibility as priority. village 1 and village 2 appeared near the main road. Thus, we could draw the conclusion that parcellation pattern were formed due to corresponding construction logic. Construction logic changed in different historical period. The logic reflects relationship between village fabric and specific topography condition.

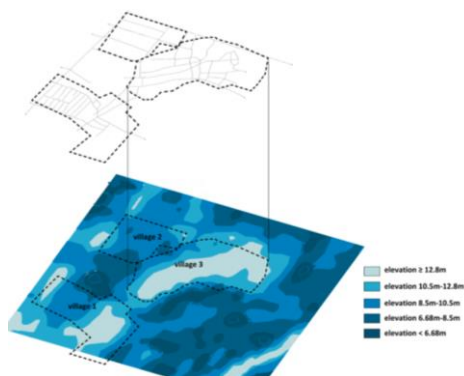


Fig3. Relation between villages and topographic condition (Drawing reference: Draw by author)

Then we compare parcel pattern in relation to topography map, it clearly indicates that irregular pattern concentrate itself on top of the area of high altitude zones. There are two types of parcellation pattern: regular and irregular. Irregular patterns resulted from original wetland topography. These villages were built on higher altitude and on thicker foundation to avoid risk of flooding. That’s why the parcellation pattern is irregular and follows the form of topographic condition precisely. By contrast, regular patterns relate to agriculture land. Villages on top of agriculture land are more a result of artificially “planned”. This is because agriculture land was formed under the precondition that dike prevents flooding. Thus, we could conclude that irregular pattern appeared early before the dike was built. Therefore, this specific irregular pattern reveals historical construction logic even before the dike was built.

In summary, parcel pattern changes corresponding to different ways of water management. Two types of parcel patterns will be defined according to water management: marsh pattern, refers to the irregular parcel pattern which is similar to reed pattern, and agriculture pattern, refers to the regular parcel pattern which is more an artificial result. The specific irregular pattern indicates that flooding risk and topographic condition are the most two important factors when we considering built area as a phenomenon of landscape in Xiongan new town.

4. Concepts on landscape urbanism

According to former analysis in section three, construction logic in existing rural villages accord with the concept of landscape urbanism. Parcel pattern and housing typology both relates to method of water management. Topography condition and flooding risk resulted historical pattern and housing typology. Thus, these rural villages could be viewed as reflection of landscaped urbanism. Besides, water and topography are the most critical layers according to historical analysis when achieving landscape urbanism in this specific location.

As stated by Burg (2015) “understanding the history of an area may enable the designer to make reasonable speculations about future developments”. Thus, analysis of existing rural villages indicates the hierarchy of landscape elements which influenced village fabric in this specific area. Landscape changes slowly Plamboom (1987), comparing to infrastructure layer and programme layer. Thus this hierarchy concluded from existing rural villages is still applicative to future urban design, as long as we aims to achieve a “landscape urbanism” new town. Therefore, this hierarchy that flooding risk and topographic condition as priority helps designer to make design as a reaction to these landscape layers logically.

5. Concepts on landscape urbanism

Flooding risk and topographic condition has potential to influence future urban design in this specific site for it effected historical parcel pattern, street pattern, and housing type. Reaction to flooding risk and

topography have potential to impact future large-scale infrastructure and small-scale spatial design in this new town. Low lying altitude topographic character brings risk of flooding. Thus, large-scale infrastructure needs to be protected from risk of flooding. Small-scale urban design programmes have potential to be designed as public space, providing place for social interaction and a liveable green living environment. These small spatial design programmes contribute to a more ecological and adaptive urban structure when reacting to water. As stated by Czerniak (2006), "conceiving of site suggests that landscape design projects can not only draw from an expanded field of information, they can impact areas larger than their own physical extent, making ecological sense”.

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Green roof technology: from singular technical solution to a key element in biophilic architecture

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Abstract

From the presentation to the IFLA Congress 2001 (Koehler et al. 2001) on the topic “Extensive green roof technology” and up today, the diverse aspects of green infrastructure (GI) technology have spread around the globe. Awareness of green roofs and their environmental functions was fostered throughout various disciplines. National green roof associations now exist in more than 30 countries. From two basic types of green roofs, “extensive” and “intensive”, the intended functionality has metamorphosed into much more detailed solutions. Local names, e.g. skygardens, living roofs, eco roofs, roof farms, etc. demonstrate the maturation of urban green roof technologies toward an increasingly multi-layered functionality. These are now central elements of the GI agenda in Cities.

Green roof professionals founded in 2007 the World Green Infrastructure Network to share knowledge and experiences and advocate the greening of buildings. More than 1000 peer reviewed articles describe the detailed research on green roof functions. Over time, focus on living walls, indoor greening, and rain gardens have supplemented the body of knowledge on GI.

At the Green Roofs for Healthy Cities Congress in 2004 in Portland, Oregon, Steven R. Kellert presented the term “Biophilia” earlier elaborated by Wilson [1]. The concept of Biophilia has since become prominent within the field, connecting human affiliation for nature with ecological functions. Cities around the globe established strategies to promote GI: incentives, guidelines, regulations, building codes, centers and demonstrations to convince stakeholders and the citizens about the multiple benefits of GI technologies.

Within a period of about two decades, the greening of buildings went from obscure to well known. Clearly exemplifying this shift is the design of the Washington DC headquarters of the American Society of Landscape Architects. In Germany the GI “white book” targets fulfillment of several of UNESCO’s SDGs.

The presentation highlights lessons learned and states the critical role of landscape architects as guides with the deepest understanding of GI’s ecological benefits and value delivery. This multi-dimensional approach includes:

- Local situations (climate, architectural history, building codes, genius loci),
- Social aspects (the wide range between elaborate private domains – and/or socially inclusive garden projects, such as urban gardens on top of buildings),

- Ecological values (multiplicity of benefits, such as: urban climate mitigation, noise reduction, water management, biodiversity etc.),
- Design questions (building as landmark or masked by vegetation).

The State of Singapore, which has realized numerous and iconic examples of GI since it last hosted the IFLA Congress, is a perfect place to discuss all of this in depth.

Keywords: Green roofs; Sky gardens; Place making; Biodiversity; Green infrastructure.

1. Introduction

Green roof technology is as old as mankind. Vegetated shelters and hanging gardens are combined technical and landscaping solutions dating back to prehistoric times [2]. Given all of the inherent benefits [3], it is difficult to understand why this technology has, until recently, been so under-utilized in urban development. Extensive green roofs and lush roof gardens are found around the globe. See Osmundson [4] for an overview of unique garden projects dating back to antiquity. While most visitors see only designed “Garden projects” on the surface, only a minority understand the engineered environmental functional details beneath this green cover. These more technical aspects are the rich environmental secrets behind, developed during the last decades. The early stage of modern green roof technology was connected with passionate architects with a favor for green flat roofs, e.g. Le Corbusier. Green roofs in Oscar Niemeyer’s projects were developed by design team member and landscape architect Roberto Burle Marx. Similar connections can be identified throughout all regions and periods. Further examples are found in the work of the German landscape architect Konrad Ben Köthner, with many hospital, city hall and head-quarter green roof projects in Europe and abroad. Köthner was additionally one of the initial practitioners facilitating

connections between the roofing industry, technical and scientific disciplines and the German professional associations FLL and FBB. With the aid of ecologists, the multiple benefits of green roofs were comprehensively presented to convince politicians and urban planners of the need for integrated environmental projects. Further ideas were supplemented via ecological research and innovation, such as light weight growth media and variations in plant selection.

This story was presented at the IFLA Congress in 2001 [5]. Questions arose concerning, among other things, the prevalent focus on extensive green roofs; why not build lush roof gardens instead? The prevalence of extensive roof types was the response to ecologists’ initiative to green all urban surfaces, also those with limited load bearing capacity.

Since then, the German green roof industry developed intensive roof garden solutions. At present about 15% of German green roofs are intensive designs. When engineering solutions support the necessary extra load bearing capacity, new roof gardens can integrate a much wider variety ecological functions, from urban food production to constructed wetlands, thus enabling a decentralization of urban green infrastructure that includes the roof (and wall) surfaces of cities.

The wide scope of opportunities for situationally responsive value creation within green infrastructure is a toolbox enabling tailored solutions for each development's unique opportunities.

In recent years the green roof industry has awoken to the values of green infrastructure. The uptake of GI solutions is growing exponentially around the globe, accompanied by a multitude of academic inquiries concerning environmental effects. Singapore is a cradle of innovation for front runner case studies. WGIN currently has affiliated national associations active in about 30 countries.

Guidelines, norms and dissemination of best practice examples makes visionary ideas tangible. Green roofs and vertical greening have become the visible symbol of sustainable architecture, of which many aspects are not apparent to the untrained eye. The discipline of landscape architecture has been significantly elevated in this exploration of increased and multifunctional greenery. The practice of integrated design is growing accordingly, where landscape architects are included from the very beginning of projects.

2. The biophilic paradigm and urban planning

Biophilia has in recent years become a key concept within holistic design and landscape architecture. The surfaces of buildings are increasingly recognized a valuable resource and opportunity for accommodating our intrinsic biophilic needs and preferences.

Psychologist and philosopher Erich From is credited with coining the term biophilia as

an “affinity for life.” Harvard biologist Edward O. Wilson further developed the concept in his seminal book *Biophilia*, published in 1984, referring to mankind's innate need to affiliate emotionally with elements of the nature we evolved in as an animal species. Together with Wilson, Stephen R. Kellert further elaborated on the concept and its implications in “The Biophilia Hypothesis” [6] in 1993.

In present days where more and more time is spent behind computer screens, and where

Biophilic design's response to well being

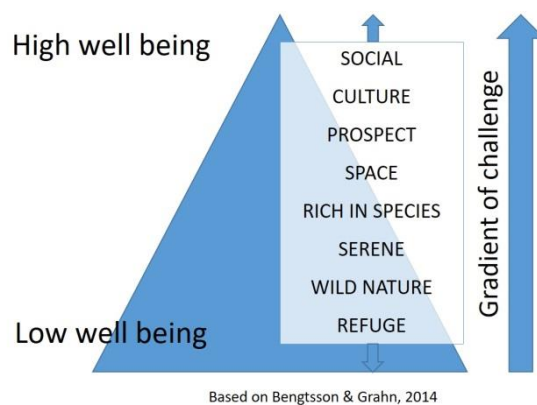


Fig. 1. Gradient of challenge figure, adapted after [8] A caption is positioned left-justified below the figure or scheme.

more than half of the global population resides in cities where natural elements are by and large removed from the immediate local habitat, the afflictions of stress and “nature deficit disorder” [7]. have become prevalent in epidemic proportions. The deprivation of biophilic satisfaction in urban areas is a compelling reason to innovate on “grey and dead” building surfaces with green infrastructure and designs incorporating both water and vegetation.

As with in all architectural and landscape design, solutions should respond to the variety of needs of those who will use the project. One simple and helpful tool used in design of healthcare landscapes, based on the Maslow hierarchy of needs, was developed by Bengtsson and Grahn [8] 2014. Figure 1, adapted from [8] suggests differentiating the

response of GI when prioritizing biophilic design according to the state of well-being of users, or patients in the cited example. There are obvious parallels here with the stated biophilic functions in the example from Terrapin, below.

Focus on biophilic design has permeated several standards for the sustainable design of buildings and neighborhoods, for example the BREEAM standards for buildings and communities and the relatively newer WELL standard launched in 2013 and administered by IWBI where biophilic quality is measured both quantitatively and qualitatively. In best case situations elevated greening can establish open space qualities and a level of biophilic satisfaction comparable with landscapes at ground level. The major difference is that elevated and building integrated solutions place much higher demands on engineering, detail planning and material choices, in addition to considerations regarding species selection.

Figure 2 shows the relation between seven main functions that can be achieved by green roofs. Since not all functions can be achieved at the place and time, projects' prioritized functions must be defined, preferably at an early planning stage of the project. In the example in figure 2 biodiversity is a main target. Certain other functions cannot be achieved on this roof at the same time.

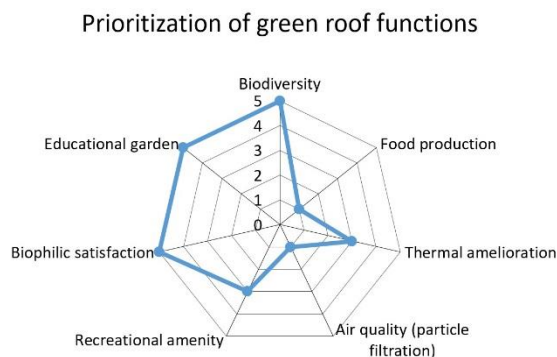


Fig. 2: Key benefits of green roofs in a decision diagram with focus on biodiversity, own survey.

3. Biodiversity solutions in green roof technology

Quantifiable ecological functionality is a research topic which has gained increased focus over the last 10 years [9]. Urban level biodiversity can be supported by the number, size and pattern of green roofs within a city. On the other hand, at a micro per-rooftop level, a heterogeneity of details of the green roof's biological support systems such as variation in growth medium, moisture content, sun/shade conditions and nutrient supply will result in increased local biodiversity. Not each big sized green roof must be number one in biodiversity [10].

4. The next level of urbanism, biophilic design meets biodiversity for increased liveability.

Biophilic structures are favored by most citizens around the globe, but few are familiar with the term biophilia [11]. In addition to the esthetic qualities, biophilic design has a huge potential for yielding a rich array of ecosystem services, or ecological function. In the body of work termed "Nature based solutions" which has rapidly gained attention recently in Europe, both biophilic design and ecology are merged resulting in the delivery of multiple co-benefits. Significant amounts of research funding are currently allocated for the study and quantification of these effects [12]. The next level of these technologies is to gain traction at the political

and planning levels. This is an area where the world can learn from the pioneering work and development of Singapore, especially the accomplishments of the present era of “City in a Garden” politics or the ABC programs dedicated to enhancement of urban water features.

In Germany the so called “Weißbuch” – Process, 2017 (“White book procedure”, see link) for greenery was recently established by the National Ministry of Construction. The preliminary phase lays out the identification of targets whereby greenery can contribute e.g. to the SDGs of the UN and contribute solutions addressing the challenge of biodiversity. The second level is the “Green book procedure” where quantification of ecological benefits will be undertaken.

Under the present policy framework all cities in Germany have defined biodiversity goals in detail, but the particular details and emphasis varies between individual cities [13].


As a further example of state level policy in Berlin: there are regulations requiring all new building developments to integrate greenery as much as feasible. In cases where integrated greenery is lacking, a justification for not integrating greenery is required.







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Appendix: Tab. 1 Biophilic design components suggested by Terrapin exemplified in green roof projects.

	Biophilic criteria	Green roof example		Example pictures
1	Visual connection to nature / surroundings	The view over a green roof or a vegetated façade hides the mass of construction and opens vistas..		Figure 3: Long view to iconic landmarks, example from Berlin.
2	Non visual connection to nature.	Material inside on walls: real nature for haptic contacts.		Figure 4: Entrance hall with indoor view to vegetation.
3	Non Rhythmic Sensory stimuli	Irregular design elements, surprises		Figure 5: Micro structures of a biodiverse green roof. (Brno,Czech)
4	Thermal and airflow variables	Differences between the expositions North-South, shade - sun ...		Figure 6: Berlin, Paul-Lincke-Ufer
5	Presence of water	Integrated ponds, fountains and other water features		Figure 7: Oh Boy! housing project, Malmö, Sweden
6	Dynamic and diffuse light	Different sun-/shade Combination-Multi-layer and accordance to typical full sun on roofs.		Figure 8: Haifa-Israel.
7	Connection with natural systems	Variation in materials, organic structures – important for biodiversity.		Figure 9: Roof garden in Osaka
8	Biomorphic forms and patterns	Organic form elements in technical construction: Clear linear forms on one hand and hidden secret path through jungle like plantings..		Figure 10: Hundertwasser House Plochingen, Germany.

9	Material connection to nature	Natural material from wood, earth and plant – life or dead decorated. Technical and organic materials in contrast /and/or in harmony.		Fig. 11: Tel Aviv, Israel,-Facebook-Hotel
10	Complexity and order	Natural structures – carpet structures Organic farming roofs, with many details and a clear structure.		Fig. 12: Kunming-Roof farm.
11	Prospect	Vistas from the roof, they are everywhere present, it is important to hide some views before some grand openings.		Fig. 13: Green roof / roof terrace in Rome with view to the Vatican.
12	Refuge	Some protected / sheltered space for sitting		Fig. 14. Roof Gardens of Kronstad Psychiatric Hospital in Bergen, Norway
13	Mystery	Something, what will not be visible at the first moment, something behind some construction.		Fig. 15: Fog system in IGA 2017 Berlin.
14	Risk/Peril	Always immanent on roofs with vistas from the top of buildings, sometimes to set in scenery with glass walls.		Fig. 16: High rise in Osaka, risk and long vista.

Investigating usability and constraints of urban green network in Klang Valley, Malaysia: Preliminary findings from a qualitative study

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Abstract

Majority Malaysian cities and towns lack of well-functioning green network such like poor accessibility considered to be an issue. Thus, this is problematic, as accessibility and connectivity are important preconditions for green space functionality. This research study determines the usability and associated constraints of urban green network in Klang Valley. Findings are based on qualitative studies undertaken in South West Bicycle Corridor, Kuala Lumpur among the user and non-user of green network (N=5) by means of semi structured in-depth interviews. The interview consists of informants from various age, gender and race. The outcomes showed all-inclusive likenesses to different societies on use of green networks. This study highlighted four major themes: Urban green network usage, constraints associated with urban green network use, attributes that influence usability and associated constraints and urban green network management and planning implication which suggested by the participants. Though the dimension of usage and associated constraints varies based on personal preferences thus this study illustrates important strategies related to urban green network planning and management to ensure better connectivity, accessibility, safety, and maintenance for promote sustainable and well being community.

Keywords: Greenways; linear trails; green infrastructure; user patterns; perceived experience.

1. Introduction

The world's cities are becoming increasingly congested and polluted (Blanco et al., 2009). Along with urbanization and urban green space loss, decreased quality of life and poorer health for city inhabitants have been reported (The World Bank, 2011;

Maller et al., 2009; Byomkesh et al., 2012). Developing countries, such as Malaysia, have been facing similar challenges of human health and well-being as their Western counterparts and most deaths in Malaysia now are from noncommunicable diseases like obesity, hypertension (Philips Index: Malaysia's Health and Well-being Report, 2010, Malaysia health system review, 2013) Additionally most Malaysian

cities and towns lack a well-functioning green infrastructure while, for example, poor accessibility can be an issue (National Urbanization Policy, 2006). Besides Kuala Lumpur does not have a proper green network that links all the existing open spaces (Sreetheran and Adnan, 2009). This is problematic, as accessibility and connectivity are important preconditions for green space functionality (Natural England, 2011). Urban green networks are important quality of life indicators in cities. However, urban green networks research mostly carried out in developed countries, which limits the knowledge about urban green network use, perceptions and preferences in urbanized metropolitan cities in developing countries.

Green networks or greenways are defined as “a linear open space established along either a natural corridor, such as a riverfront, stream, valley, or ridgeline, or overland along a railroad right-of-way converted to recreational use, a canal, scenic road, or other route” (Little, 1990). Urban green networks which are often designed with multi-use trails that provide opportunities for physical activity, recreation and transportation (Lindsey et al., 2008) are defined as places for nature in the city where people can fulfill recreational needs and achieve solitude and retreat without leaving the public realm (Luymes and Tamminga, 1995). In cities, urban green network mostly serve as recreational greenways which are featured with paths and different kinds of trails based on natural corridors as well as public rights of way, abandoned railbeds, and canals (Little, 1990). Urban green networks are considered more than just

parks or amenities (Searns, 1995). They provide a number of significant benefits and serve a number of important functions that improve the quality of life through the use of land for multiple purposes in cities (Akpinar, 2014)

Numerous studies have illustrated the ecological, environmental, social, recreational, esthetic, educational, and economic benefits and importance of urban green networks.

2. Methods

The present study investigates the experiences related usability and constraints of urban green network. The authors interested in both the information the participants can give about the research topic and how participants talk about their experiences and attitudes. In other words, the authors interested in both of the content of the interview conversation and the way informants express them-the words they use (Matthews and Ross, 2010).

A qualitative method was used to gain understanding of this issue (Boston et al, 1995). A qualitative approach was adopted because it allows a flexible exploration of attitudes and experiences of informants and produces a richness of data that allows the researcher to gain a deeper understanding of social phenomena (Creswell et al, 2012). A semi- structured face -to face interview was conducted at the study sites. The interview guide was used in this study, but not rigidly, allowing freedom to explore topics in more depth particularly for those urban green network users. The interview guide was a modified version of the interview guide

form used by Somajita and Harini in Dehli. The respondents were selected based on their availability when approached by the interviewee. Each interview lasted between 30 and 60 min and was recorded using digital audio recording devices. During the interview sessions, the interviewees briefed about aim of the study and the structure of the interview process. The interview was conducted in either English or Malay (National Language) based on the interviewee's preference. The interview was asked whether they accepted the interview to be recorded (which all did) and that he/she could just ask the interviewer to switch off at any time if not comfortable. The interview session was recorded with permission from the interviewee. The researcher also carried along a note book during the interview sessions in case if voice recording was refused by the interviewees, for example due to cultural objections to having their voice recorded something which did not occur.

1.1. Study sites

This study was conducted in South West Bicycle Corridor, Kuala Lumpur. This green network stretches 5.5 km from Dataran Merdeka runs along the Klang River for most of its length and ends near the Mid Valley Megamall. For most of its length it is a dedicated multifunctional lane; some sections (a major stretch in Brickfields) are shared with other traffic while some others shared with pedestrians. For the purpose of this study four sections which contain green elements such as trees, shrubs, hedges, and grass were identified. Among the spots are: Lebuhraya Pasar to Dayabumi, Dayabumi to Jalan Sultan Sulaiman, Jalan Sultan

Sulaiman to Tun Sambanthan Station and Tun Sambanthan Station to Mid Valley.

1.2. Data Analysis

The researcher analysed all the transcripts manually for relevant contents and themes (Burnard, 1991). Open coding was performed, and the necessary headings were generated to describe all aspects of the content excluding “dross” the headings were then grouped together under higher order headings. The new list of headings and subheadings was worked through, and repetitive or very similar headings were removed to produce a final list.

2. Results and Discussion

3.1 Characteristics of participants

This is piloted findings from five informants aged from 18 to 43 years. Recognizing that variables such as gender, age and different group of races in Malaysia to explore changes in usability of urban green network. The respondents consist of three males and two females whereby four of them are Malay and remaining one is Chinese. All the respondents were either married or single. Three of them had B.Sc. degrees, and remaining two had diploma and secondary school education. Lindsey et al. (2006) suggested people with a higher social status are more likely to be users of urban trails; they also assert that trails passing through neighborhoods with high-income, more educated residents are preferred. Purposive-sampling method was used in order to obtain a diverse sample of

respondents based on criteria drawn from the literature review, namely age, gender and race. Given the overall difficulty in accessing potential interviewees, snowball-sampling was used to supplement the purposive sampling. Demographic characteristics of the participants are shown in Table 1

Table 1

Demographic characteristics of the participants (N= 5)

Description	n
Age (yr)	
<18	1
36- 45	4
Sex	
Male	3
Female	2
Ethnicity	
Malay	4
Chinese	1
Marital status	
Single	3
Married	2
Education	
Degree	3
Diploma	1
Secondary School	1

3.1 Themes

Thematic content analysis of the interviews identified 4 major themes: Urban green network usage, constraints associated with urban green network use, attributes that influence usability and associated constraints and urban green network management and planning implication

Theme 1: Urban green network usage

The users were interviewed to obtain information about the reasons for using South West Bicycle Corridor. The greater part of the respondents related urban green network with diversion, wellness and being as one with family, primarily because of the relationship of green network as a place to enhance their wellbeing and prosperity. On top of that findings determine this green network functioning as linkage from one place to another place. Cyclist accounted as the highest proportion of users, followed by joggers, and then walkers. A man described (40, Malay, married, user) “I use this green network for cycling and I prefer to go with my friends for leisure activities. Sometimes I use this corridor to go to Midvalley shopping mall”. Interestingly a lady reported “I use this network mainly to travel from my house to my office and sometimes using this to go buy groceries. I cycle everyday but sometimes I just walk to my house from office using this route (green network). However, she added “sometimes this track is a meet up point for me with other friends”. Another male informant (37, Malay, married, user) mentioned “I use this network mainly for recreation purpose and one day I want to bring my kids to explore this lane, to enjoy the green sceneries”. One young participant (Female, 18, Malay, Single) said “even though this corridor is not located nearby to my house I use to visit this corridor with my family and friends, we love to cycle and sometimes we involve in physical activities such as jogging and walking since this corridor has good scenic view and we feel relax”

Theme 2: Constraints associated with urban green network use

Apart from the green network users, the non-green network user reported several constraints from visiting the green network in Kuala Lumpur. For example, a man (43, Malay, single, non-user) reported “I prefer to use main road compare to this green network since lack of safety like unavailability of street lights, it’s very quiet and there is a lot stranger. Once I heard from my friend who got attacked by theft”. Research over the years has aimed to understand how to have safe yet appealing green network. For example, as explained by Reynolds et al (2007), green network usage was associated positively with various determinants including proper trail condition, streetlights, cafeteria availability, and other trailside facilities. Apart from non-users there were some of the constraints reported by other users. For example (Female, Chinese) said “I have experienced crime scene whereby my gold chain was snatched by one man who came with motorbike. It was such a terrific moment, and no one came to help me even though I saw there were few people around that area. I feel it is totally unsafe. Additionally, some part of the green network not able to access since it was closed for construction of river of life project. Condition wise, drainage along the network need an attention since can cause flood during rainy seasons”. Another young female informant reported “as a cyclist my main concern is a parking

space, it’s difficult for me when I don’t see any place to park my bicycle”. Apart from the above constraints distance was noted by a respondent as a factor which discourage him from visiting this green network frequently. For example, one man (37, Malay, Married, user) “I need to drive over there and it’s difficult to find parking lot near the green network, most of the time me and my friends park our cars at Midvalley shopping Mall parking basement and we start cycle from there”. In a research by Gordon et al (2010) stated that new exercisers indicated their primary reasons for using particular trail as short travel distance and convenience.

Theme 3: Attributes that influence usability and associated constraints.

Alone/ with others

The interviews additionally uncovered that the nearness of individuals can support safe utilize. In any case, this additionally relies upon assortment of individuals exhibit, as the nearness of other individuals may either increment or abatement the use. Almost all the respondents, when they are using South West Bicycle Corridor they accompanied by their friends or sometimes family members except one lady (Chinese, Single, user) prefer to use the green network alone since she is commuting from her house to office and its very rare she go to network in a group unless she got appointment with her friends. Another similar finding by Maslow et al. (2012) discovered that more people used the trail in groups as opposed to alone.

Safety

Safety is an important dimension in the perception of urban environments and one that is sometimes perceived to be at odds with enhancing the naturalness and aesthetics of urban green network. In Kuala Lumpur people's concerns focused on two different aspects of safety: physical safety such as falling, health concerns about direct physical contact with polluted environment and personal safety whereby the green network as a hangout for gangs engaged in criminal activity, a place for drinking and drug use, and as habitat for the homeless. For instance, one informant (Male, 40, Malay, Married, user) reported "I slipped once at green network corridor since it was wet surface after the rain". Another non-user (Male, 43, Malay, Single) mentioned "I use to cycle at night for my physical therapy but I'm not really prefer to cycle along South West Bicycle Corridor since its very quiet and its very dangerous since dark and no street light along the corridor" Apart from that some of the participants did also highlight the presence of disorder people around green network, i.e those violating social norms or official laws or acting in an unpredictable and threatening manner (Ross and Mirowsky, 1999). One young girl (18, Malay, Single) have reported "I have visited green network a few times and I feel not ease when see outsiders, in some cases they do exasperate me by verbally abusing and showing vulgar signs when the corridor is empty without other users. However, findings of Bownsonr et al (2000) showed that social safety was not a restraining factor to use green network. A total of 86.9 % green network users felt very safe when

using the trail. Conversely, only very small percentage of users (1.1 %) felt unsafe when exercising on the green network.

Accessibility

Accessibility have been highlighted by most of the informants. Most of the respondents have difficulty to access along the green network since one lady (Chinese, Single, user) have reported "some part of the network not able to access since it has been closed for 'River of Live" project. So, it's very difficult for me to find alternate route and without choice I need to use main road which is not safety enough to use". Another respondent (Male, 40. Malay, Married, user) said "I need to drive to get to this green network and it's not very near of my house. This result supported by few other sdtudies whereby walking is largely influenced by the accessibility of the destinations (Chudyk et al., 2015; Van Cauwenberg et al., 2012).

Cleanliness

The cleanliness of the green network and its surrounding environment was by far the other top concern of informants. For example (Male, 40, Malay, married, user) said "I always notice a lot of trashes, dried leaves, sharp objects such as broken tree branches that could puncture bicycle tires" Moreover another Chinese lady reported the drainage along the South West Bicycle Corridor polluted with trashes and it cause flood during rainy seasons". Similarly, another study indicated that high-quality

trail design can attract more visitors compared to a poorly maintained trail environment (Reichhart & Arnberger, 2010). Apart from that, another study revealed that littering should be prohibited, and litter-free environment attracts more users to the trail (Akpinar, 2016).

Naturalness

Naturalness is a key dimension that people relate to in any ecosystem, no matter how urban it is. In the most sections of the green network corridor, people saw wild nature as a shade and mentioned nearby natural areas should be protected and well maintained. One young respondent (Female, 18, Malay, single, user) said “I like to go with my family since few sections of the corridor is dedicated with green sceneries, which provide important restorative opportunities, relaxation, and stress reduction”. Few other literatures have determined the balance between nature and the built environment was fundamental for green networks (Siu, 2001; 2007a). A research in Shenzhen demonstrated that the neighborhood green network did not manage to promote physical activities. This may be due to the absence of adequate green environment, despite it being the most accessible greenway theoretically.

Time of the day

Overall results indicated time of the day is an important dimension in the urban environments. Almost all respondents reported morning, afternoon or evening as they their preferred time to visit or use South West Bicycle Corridor excepting on Chinese lady tend to use this green network even at

night. She said, “I totally depending on this green corridor since my primary transportation is a bicycle and apart from traveling to office from home, I use this route to visit other places doesn’t matter at night even though it’s very dark”. Interestingly another informant (Male, 37, Malay, married, user) reported “I prefer to go there on weekend compare to weekdays since its very quiet with less people on weekdays”. Another study has similar finding for instance, Lindsey and Nguyen (2004) found substantial intertrail and intratril variations over various seasons, days of the week, and times of the day at five greenway trails in Indiana.

Weather

Almost most of the informants felt weather is not a disturbance. For example (Male, 37, Malay, married, user) explained “hot weather is don’t bother me unless if raining, so we need to find alternate solution like wearing rain coat”. Similarly, research in western country by Duncan et al. (2008) indicated that both adults and children showed increased step counts in summer months and decreased step counts in winter months.

Theme 4: Urban green network management and planning implication

Most of the participants suggested several strategies for Kuala Lumpur City Hall to improve the usage of South West Bicycle Corridor. Numerous informants highlighted connection is an increasingly important topic. For example, one Chinese lady said, “some of my friend told me, we rather use

main road since some sections of green network has poor connection so its demotivate us to use because somehow, we still have to get back to main road when there is no connectivity, so my opinion DBKL should consider on proper planning with proper connectivity”. Another male informant suggested safety and cleanliness as part of maintenance strategies in increasing the usage of South West Bicycle Corridor. Other suggestion included the one by young women (...): “In term of management I would like to advise the City Hall to maintain the areas...keep the corridor clean and repair the condition of pavements since some sections its not really stable with lot of cracks”. This finding confirmed the results of Gobster, (1995) explained that pathway condition may also encourage the senior citizens to walk in a green trail. Other similar studies showed that green network may promote negative perceptions among the users if they are crowded, neglected, unsafe, or poorly maintained, all of which results a decline in use or complete avoidance (Boone et al. 2009). This interviewee also suggested “apart from safety its good idea to conduct campaign to promote usage and benefits of South West Bicycle Corridor since I believe there is lack of awareness among public ... maybe” (Male, 43, Malay, Single, non-user).

3. Conclusion

This research provides one of the comprehensive assessments of how Klang valley green network users are perceived and used and what factors affect their use. The results of this study showed that

contrary to Kuala Lumpur City Council and public officials’ views, urban green networks are more than a “luxury” and could provide important health, recreational, and leisure activities for Klang Valley people. Therefore, attributes like social and physical safety, accessibility, connectivity, naturalness, cleanliness and maintenance seem to be important dimensions that effect use of urban green network in Klang Valley. Therefore, such deep interest and concern can provide a major opportunity for green networkplanners, designers, and managers as they strive to create clean, natural, aesthetically pleasing, safe, accessible, and appropriate spaces that improve the quality of life of urban dwellers.

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Sous les pavés, la forêt

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Abstract

Parking lots are probably the most anomalous kind of space in the public realm. They are daily used by all drivers; their visual impact is enormous and yet very little is invested in them. All cities have been modified to improve the massive use of the car [1]; then, why have the parking lots always looked the same? Do they just serve as mere horizontal car storage with no other possible use? If they are just unavoidable places to leave the car in our cities, unappreciated by citizens as a space with no other possible use beyond parking [2], why is so little effort invested in trying to mitigate their Impact and make them compatible with other uses that could help to improve the urban environment?

After an exhaustive analysis of several case studies, this paper proposes to transform the car parks into urban forests; forests that provide these "lost" spaces [3] with the capacity to neutralize the pollution created by the vehicles parked there, while improving the condition of this anonymous and uncharacterized lots, their negative perception by citizens and their participation on territorial green infrastructural systems passing through our cities.

If an average car travels 10,000 km a year, it means that produces 1.2 tons of CO₂. At the same time, an oak, *Quercus ilex*, neutralizes 5 tons of CO₂ a year (the average value produced by 4 cars) transforming it into oxygen [4]. It seems then that the number of cars and the number of trees in our cities should be more related, using the car parks as air purification drains. But not only: these urban forests also have a key role in improving habitats and contributing to biodiversity [5]. Tree canopies can reduce the peak of heavy rainfalls [6], while the proper use of its materials can help reduce impervious surfaces, fight heat islands, contribute to the control of water runoff and effective groundwater recharge [7] and help rebalancing the air moisture.

Sometimes the simplest actions have the greatest impact on the design of new environments. We propose to move forward new possibilities of understanding urban space and creating networks of small indigenous urban forests; permeable and dynamic spaces where you can toggle different uses depending on the occupation thereof; spaces that can neutralize, through woodland and a forest section, the CO₂ produced by a huge number of cars, plus favor and shelter biodiversity enabling a different relationship with nature, not that of confrontation but of complementarity.

The lack of literature regarding parking lots makes this research very innovative and a necessary contribution to contemporary landscape and urban studies. Through very simple

designing actions they become hybrid spaces, active areas and relievers within an urban and ecological framework.

Parking lots; Urban forests; New natures; Anomalous spaces; Urban landscape

1. Statement of intent: “let’s be realistic and ask the impossible.”

This is just one more of the unusual conditions of cities: giving preference to private traffic rather than the public one, private spaces such as parking lots against public space needs. Squares, parks and gardens, sports fields, schools and universities, would already be covered by the traditional norms, but other areas that might be also considered public, have never been considered.



Fig. 1. Graffiti from May 68’s protests

If we could look our cities from the air, we would realize that the space devoted to roads, highways and parking lots clearly stand out in our modern civilization. Since the standardization of the automobile in the early twentieth century, its use has fundamentally changed the architecture of the contemporary city, becoming one of the most important and underrated components of urban life. They have also colonized the different urban scales, from large shopping center parking lots to small interstices. Even knowing that an average car remains parked for almost 90% of its life, no one seems to pay attention to the contradiction of making places occupying a useful space in urban centers, to leave cars there almost all the time. All this means not having a clear

objective about the city we want or the environment we need.

It seems difficult to give up cars to lead an urban life. We use them to move in the city and beyond it; we see them from the window of our house in any street we walk on, in any educational or cultural centers and in the shopping malls. Any kind of intervention we can imagine for a parking lot try to pose solutions to the problem with large doses of imagination but do not directly face the problem of constantly increasing cars in our cities. The time has come in which design is not able to solve the problem: How do we eliminate the excess of traffic of private cars in our cities? Applying taxes to those circulating, which would extend inequality in use or mobility as London has done for a long time or making the possibility of using public space to park on the streets more expensive? Freeing public space to collapse all urban mobility?

As urban centers have begun a process of turning their streets to favor pedestrians, restoring the importance the pedestrian over the car, we may have to start by restoring the space occupied by urban forests and the continuity of the ecological networks; a domesticated nature only in its dimensions, but intense and dense in its realization. We have to think that part of the solution is to prevent private parking in urban centers and to convert the surplus parking spaces into places that serve to relearn how to interact with the forest, with the biodiversity that it attracts and with silence and oxygenation of urban environment that are generated by green spaces.

We propose to make a small forest in each parking lot, something that would have to do with the recovery of a memory that cities have never given priority to. Actually the

foundation of cities has been made into a sustained confrontation to turn away from nature. This fight makes no sense at all today and is a hindrance as much as could be the reptilian brain that we maintain as a legacy of our evolution.

The largest human construction and where the vast majority of people is going to live or are living now, is the city. Its growth is unstoppable and the concentration of economic power and absorption of any raw or processed material is and will be enormous. Now consider how we transport ourselves... Shall we continue driving a one-person private car loaded with refined oil and producing an enormous amount of CO₂? Shall we continue to occupy central or peripheral locations in our cities that will be turned into barren and useless spaces for any other use other than storage cars? Is the current idea of partnership between privacy, automobile and mobility the future of the city? The mobility concept still in use in our cities is almost the same as the one that followed the mass production of Ford Ts or back away in Pompeii!

The future is not the past and we urgently need to imagine it. Parking lots and other anomalous areas interests us because they occupy huge and central spaces in cities. The future of urban transportation, which is partly known, could be the use of driverless transportation that is constantly in use and whose ownership would be largely shared. From these possibilities which are already in practice in our cities, the need for parking lots is very debatable because it represents the private use of a system that apparently soon cease to exist.

The city has evolved to impose a different nature to the environment. Therefore we

need to recognize that the need for trees and not private cars would look like an inevitable recovery of our pre-urban origin, but also the loss of references that has been brought upon by a sustained confrontation with Nature. Forests instead of paved areas, permeable pavements against the spread of impervious surfaces, trees of different sizes and compatible species, shrub and therefore birds, insects and other animals better than noise and CO₂ [8].

The city of the future will have to resolve its expansion and reduce the time it takes to move through it; besides that, there have been since a while ago virtual communication systems much more efficient for air and gas emissions than physical transportation.

2. Ostiense Case Study

The area of Ostiense-Valco San Paolo is located southwest of the city, bordering with walls in its access by Porta San Paolo. Strategically located in the expansion of the city to the port of Ostia, it has always been the subject of numerous plans and projects where the main focus was to connect the city with the sea. It is the first industrial district of the city of Rome due to rich railway system but also to the navigability of the Tevere. But it is not a typical industrial area because Rome never had an industrial vocation and has never pursued a future as such.

The infrastructures and the voids related to them, the abandoned industrial mono-functional compounds, the strong naturalistic character due to the profuse vegetation in the environs of the river that crosses the whole area from North to South and the disintegrated urban tissue colonized

by numerous parking lots, together with the project of the Roma Tre University to move most of its faculties and schools to this area (a cultural infrastructure) and the project promoted by Prof. Ghio to establish a Diffused Botanical Garden in these faculties, makes of this area a perfect case to understand how a developing sector faces the voids created in their planning stage together with the existing anomalous spaces. The project of the Diffused Botanical Garden is already a very attractive attempt of intermediate scale that gives continuity and attempts to connect the different public areas, enhances the ability of this area to propose this change of the reconstruction of urban forests.

If we focus on the data of the VIII Municipality of Rome, which includes the area of Ostiense and Valco San Paolo, this is an extension of 47,29 km², of which 125.810 m² are devoted to parking, while the green space sums up to 794.045 m², plus more than 2060 m² of archaeological green space and 615.330 m² of large urban parks [9].

3. Urban forests

A forest is a radical solution in the city if we keep thinking in the lines of Thoreau, considering city and forest as opposites; however we want them to begin to understand each other and become complementary, to join the experience of being a citizen and experience the pleasure of our relationship with nature, the ancestral, the virgin (or untouched). We take as inspiration the urban forests created by Afforests and its creator Shubhendu Sharma, that managed to create in just 10 years, small but dense urban indigenous forests

with 50-100 kinds of species, stable and maintenance free (after the first three years of care using automatic irrigation) that reduce noise and dust and remove 30 times more CO₂ than a monoculture planting like the ones associated with urban parks. Our proposal with this paper is to create a city network of small forests to promote local biodiversity.

The city is an ecosystem with different environments imposed on the natural territory that can shelter new natural ecosystems. In these ecosystems, the use of species adaptable to their bioclimatic conditions can lead to the creation of a broad diffuse botanical garden that colonizes the different urban voids with a clear didactic character.

Thus, parking lots, roundabouts, plots out of regulation or abandoned, become part of an intermediate scale of landscape where to interact with species which are not chosen by belonging to the ecosystem of the city but for its environmental optimization and its pedagogical condition, contributing in an efficient way to a new urban ecology that, starting from interstices, manages to create a new system of a certain size. This new layer within the urban fabric, the system of these derelict spaces, is an opportunity to establish a new and unexpected relation between the city and its voids and between humans and nature: touring through this new system we can understand the relation that the city establishes with his limits and can colonize spaces otherwise abandoned and forgotten, giving them a new function as air purifiers and carbon sinks. This way, unused parking spots, or the combination of few of them, can be turned into microforests becoming a

new element in the imaginary of our streetscapes.

We do not want to offer anything halfway. From the analysis of projects that have worked on this issue on the design side, you can easily deduct that to involve parking spaces in public space is a necessary and vital economic investment, but also an act of voluntarism. Our plan is more drastic. As with depaving we talked about the importance of reducing the impervious surface of our cities in public spaces such as car parks and other uselessly paved surfaces, what we propose here is to return to urban forest the parking lots that are easily relocatable (buried under built surfaces or into specific buildings), bringing nature to the people, continuing the large-scale green networks and neutralizing the pollution that undermines our health and costs of public health services, supplying a pause (this time very meaningful) within the urban tissue. This is about creating a new kind of urban space where the main investment is in its correct implementation and operation, not in its formal spatial design; changing a monofunctional space dedicated to the car for another, different multifunctional one for citizens. These are forests, recreational areas different from the existing urban green spaces; large air purifiers that drain water, which can function as a new spatial category with a significant contribution to public space and urban ecology.

As an enclave it is very favorable: in Ostiense, right next to two large disused industrial areas undergoing conversion and starting from a railway line, which in its linear setbacks it is always accompanied by vegetation. We can then create a natural network based on these corridors linked to

the rail tracks to reach almost the Tevere, crossing and continuing to the Rome-Pisa railway line. In Valco San Paolo, where the various offices of the University Roma Tre will be establishing parking areas, we can create a network that goes in the opposite direction, from the river (which in this area has a larger area of influence with several sports fields) to the Via Marconi and the railway line.

Doing a quick calculation, we are proposing to convert the official 125.810m² of asphalt devoted to parking (between public and private car parks) into urban forests; transforming surfaces that disaggregate the urban tissue and impair the urban landscape, into social spaces that redefine the boundaries between built space and the environment, creating a rich and multifunctional ecotone that brings recreation to its inhabitants, a new concept of urban ecology and green continuity.

We understand the difficulty of parking in a city like Rome, where the scarcity of public funds makes it difficult to take a new action plan on these divisive spaces. But we also understand that it is in this enclave where it becomes necessary to reduce the metal invasion that is suffered by its streets. In Rome there are 2.8 million vehicles (700,000 are scooters and motorcycles) that "parked" next to each other, would occupy just over 26km². This amounts to almost twice the size of the historic center of Rome itself (15km², ranging from the Aurelian walls) or 32 times the area of the Villa Borghese. The average vehicle per thousand inhabitants (736) it is outstanding in comparison with those of other European cities such as Amsterdam (324), Barcelona (386), Lisbon (400) or Milan (513); Italy

maintains one of the highest rates of motorization in Europe with 61 cars per 100 inhabitants, surpassed only by Luxembourg with 65, it falls far short of the 41 of the Danish [10]. This data translates into a totally invaded city, where any void or road widening results in the birth of new spontaneous parking. A poor transportation system, a late system of regulation for parking (until the late 80s there was no official regulation, while in cities like London, the problem was faced in the early 70s) and difficulties for the construction of underground car parks or buildings designated for storing cars, makes the case for almost all the parking to be done on the surface, with a consequential high land use (just in the center of Rome alone 2.011.255 m² are dedicated to parking). The lack of protection by the administration makes, as in the case of Ostiense, some areas designated for parking, of questionable quality, allocating the residual areas from other actions by simply drawing stalls on the asphalt, with no trees, no green space, and no shade. The consequences of a wild, free parking on the protection of the streetscape and traffic flow are immediate [11].

But more important than these numbers is the function of cleaning the air that these spaces could provide. If an average car travels 10,000 km a year, it means that produces 1.2 tons of CO₂. At the same time, an oak, *Quercus ilex*, neutralizes 5 tons of CO₂ a year (the average value produced by 4 cars) transforming it into oxygen [13]. It seems that the number of cars and the number of trees should be more closely related in our cities, using the reconverted parking spaces into forests as centers for air purification, in order to alleviate the high

levels of pollution caused by the high motorization of our cities. But not only this: these urban forests also play a key role in improving habitats and contributing to biodiversity. Tree vegetation also helps control torrential rains during its peaks, while the use of permeable materials would help control water runoff, favor percolation of rainwater in aquifers, combat heat islands and help rebalance air moisture [14]

4. Conclusions

Sometimes the simplest actions have the greatest impact on the design of new environments. We propose to move forward new possibilities of understanding urban space and creating networks of small native or foreign urban forests; permeable and dynamic spaces where you can toggle different uses depending on the occupation thereof; spaces that can neutralize, through woodland and a forest section (large trees, medium trees, shrubs, underbrush, etc.), the CO₂ produced by a huge number of cars, plus favor and shelter biodiversity enabling a different relationship with nature, not that of confrontation but of complementarity.

We know we are bordering on a paradox, a utopia. We are launching into the immediate future a proposal that does not accept that the solution is to whitewash forgotten spaces of the city through huge investments needed for other social issues. We think that we have to undo some things before superimposing new actions and constructions. To undo few of those things that were done wrong is the goal, to discover new possibilities in the use of cities, to bring a memory lost to the urban context, to improve the quality of life in the city.

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Investigating the Usability Pattern of Pocket Parks in Kuala Lumpur

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Abstract

Research has proven that urban green spaces are beneficial to support healthy lifestyle. However densification among larger cities including Kuala Lumpur has resulted in the conversion of open spaces to pave way for development; limiting the access to green spaces for human activity, restoration and recreation. Small public urban green spaces or pocket parks have been introduced in dense city areas to contribute to the need for outdoor activities, yet research on these parks is limited. Therefore, there is a need to investigate the usability pattern of pocket parks to facilitate the park usage in Kuala Lumpur. The purpose of this study is to understanding the usability pattern (how) of pocket parks (what) to improve the park usage among urbanites in Kuala Lumpur (who). Although the nature of this research is predominantly qualitative, it is conducted through intense contact in the real urban parks in Kuala Lumpur. Observation and interview will be used to document the park visitors. Then, it uses literature review on urban green spaces in Kuala Lumpur as well as observation to provide an overview of the pocket parks and describe how the parks are used by the urbanites. Finally, it uses survey data supported by semi-structured interview to identify the usability pattern and features of pocket parks that facilitate usage among the urbanites. Results of the study would include theory of pocket park users in Kuala Lumpur and theory on the characteristics of pocket parks in Kuala Lumpur and its usage. The results are expected to lead towards recommendations of parks features that promote usage in Kuala Lumpur. This study contributes in identifying the pocket parks usability pattern and recommendation of park features that promote usage in Kuala Lumpur. It will support the requirement of more small urban green spaces in the city of Kuala Lumpur and to the inclusion of pocket parks in the urban planning and management in Malaysia.

Keywords: urban environment; small public urban green spaces; park usage; Malaysia

1. Introduction

The acceleration of developments in Kuala Lumpur has reduced the amount of total green spaces in the city (Malaysian Economic Transformation Programme—ETP Annual Report, 2014). According to the report, Kuala Lumpur recorded 8.5m² green spaces per capita in 2014 in comparison with 13m² of green space per capita in 2010.

In a study to address the importance of urban nature for citizen's well-being and for the sustainability of the city they inhabit, Cheisura, A., (2004) concluded that the experience of nature in urban environment is a source of positive feelings and beneficial services which fulfill important immaterial and non-consumptive human needs.

Small urban green spaces or pocket parks were introduced to provide facilities for recreation, reset and relaxation to all citizens in every walk of life (Seymour Jr, W. N., 1969). Recent studies have documented the benefit of pocket parks for restoration (Nordh et al., 2009; Nordh, 2011; Nordh and Ostby, 2013, Peschardt & Stigsdotter, 2013 and Peschardt K.K., 2016), physical activities (Cohen, 2014) and socialising as well as rest and restitution (Peschardt et al., 2012 and Peschardt et al., 2016). Jasmani, Ravn & van den Bosch (2016) also concluded that small urban parks characteristics have influence on bird diversity. This study highlighted the characteristics of small urban parks and their potential to support urban biodiversity and ecological function. They concluded that human activities and park surroundings have

a marginal effect on the presence of bird species in small parks. However, Zube, E.H. and Moore, G.T. (1987), concluded that over the past decade, open spaces such as public and neighborhood parks, playgrounds malls and plazas have attracted considerable research attention; with public parks as the most frequently studied open spaces with less focus on pocket parks. This is supported by Peschardt K.K., Schipperjin, J. & Stigsdotter, U.K. (2012) that research on small public urban green spaces or pocket parks are still limited.

According to Hoyle, H. et al., (2017), if public green infrastructure is to be designed and managed optimally, the complex relationship between aesthetic experience, restorative effect and well-being, and perceived and actual biodiversity in relation to varying 'natural' environments need to be understood. Ibrahim, Md Dali & Che Haron (2016) also stated the issues and problem in managing open spaces in Peninsular Malaysia. The study highlighted the problems faced by local authorities in the management of open spaces in their area of administration. It further suggests that extra attention needs to be given to the aspect of management to ensure the sustainability of open spaces. As leisure research have only been concerned with why and how people make choices regarding the free time and recreation, more research were required on the barriers to recreational participation to give insight into life and leisure satisfaction (Henderson et al, 1988). Their study to document the relationship between barriers to recreation and gender-role personality traits for women identified 10 recreational barrier factors for women which include;

time, money, facilities, family concern, unawareness, lack of interest, decision-making, body image, skills and social appropriateness. The time people need to reach a public park also influences the accessibility of the park (Breuste and Rahimi, 2015).

In the study on the components of small urban parks that can predict the possibility for restoration, Nordh et al (2009) documented percentage of ground surface cover by grass, the amount of trees and bushes visible from the given view point and park size as most preferred features of the pocket parks. Whereas, more green cover and enclosed green niches are important for rest and restitution according to Peschardt et al (2014). Her study also concluded that the presence of green features are not crucial for socialising while playground and view outside the park were identified as disturbing features. Nordh et al (2009) and Peschardt et al (2012) have outlined the following description of pocket parks which include; small green space between 3000-5000m² in size, well defined area, have its own entrance and distinguishable boundaries which separate the parks from surrounding public space, have at least some vegetation, places to sit, included public spaces but exclude all private, enclosed residential parks, playgrounds and parks that belong to café or restaurants. Pocket parks are usually only a few house lots in size or smaller and can be found scattered throughout the city to contribute effectively to city life (Blake A., 2017). She described these pocket parks as easier to create than maintained without functional design, community support, use and maintenance.

Grahn and Stigsdotter, 2010, identified the following eight park characteristics to classify nature characteristics of urban environment, including; 'serene' (e.g. silent and calm), 'space' (e.g. spacious and free), 'nature' (e.g. wild and untouched), 'rich in species' (e.g. several animals and plants), 'refuge' (e.g. safe, benches and play equipment), 'culture' (e.g. decorated with fountains and ornamental plants), 'prospect' (e.g. flat and well-cut grass surfaces and vistas) and 'social' (e.g. entertainment and restaurants). Whereas in their study to address the associations between park characteristics and perceived restorativeness of small public urban green spaces, Peschardt and Stigsdotter (2013) characterised their sample pocket parks into the following subgroups; 'Geometric design' characterised by a geometrical landscaped design; 'South European Square', characterised by a hardscape surface and a few trees; 'Multi-characteristic', an area with several functions (e.g. seating, playground, café); 'Café/history', characterised by a café area and a historical context and finally; 'Traffic', closely connected to a road with heavy traffic.

Kuala Lumpur is the major administrative centre of Malaysia. As a major urban centre in Southeast Asia, it is a perfect place to live, to conduct business and as a major tourist destination (Kozlowski M. et al., 2015). Their study on the performance of public spaces in Kuala Lumpur in terms of tropical climate concluded that a majority of public spaces in the region are not pedestrian friendly and do not reflect the tropical climate, being devoid of trees and

vegetation. According to Cheisura, A (2004), less attention is being paid to the type of nature close to where people live and work, to small-scale green areas in cities and to their benefits to the people. Her study addressed the importance of urban nature for citizens' well-being and for the sustainability of the city they inhabit through a survey conducted among visitors of an urban park in Amsterdam. While, a different research has indicated that lunchtime park walks and relaxation exercises contributes to higher levels of well-being among employees at the end of a working day (de Bloom, 2017).

The need for adequate landscape spaces for recreation and social interaction among the multi-cultural society in Malaysia has been identified as part of the focus of the National Landscape Policy in Malaysia (2011). Under the National Key Economic Areas (NKEAs), the establishment of iconic places and attractions was listed as part of the goal for Greater Kuala Lumpur/Klang Valley. This includes the preservation and redevelopment of the existing heritage sites in Kuala Lumpur and connecting the sites through heritage trails master plan. Small urban green spaces and iconic monuments in Kuala Lumpur are included as part of this trail and has been redeveloped in line with the aspiration for Kuala Lumpur as a 'Liveable City' (ETP Annual Report, 2014).

This paper explored the usability pattern of three (3) selected pocket parks in Kuala Lumpur by studying the characteristic of these pocket parks and the motivations to visit these parks. It will determine the use

and user patterns in the selected pocket parks and the factors affecting the use of these parks to enhance the use by the residents of Kuala Lumpur (e.g. Owen et al., 2004), as well as in studies on the use of urban green space (Schipperijn, 2010). This theoretical approach will be applied as a framework for analysing and understanding the behavioural use of pocket parks. Behaviour in this study is broadly defined as any sort of visit to pocket parks, mode of transport, length of stay, frequency of use and timing of visits. This study also intends to identify the constraints faced by the community in using the pocket parks.




2. Methodology

2.1. Site selection

This study was conducted at three (3) pocket parks in Kuala Lumpur selected based on the following characteristics; no more than $\frac{1}{4}$ of an acre; located in an urban area surrounded by commercial buildings or houses on small lots; few places for people to gather, relax, or to enjoy the outdoors (National Recreation and Park Association, 2017). The parks are selected from the lists of pocket parks provided by the City Hall of Kuala Lumpur (Fig. 1). The selected pocket parks are as following and presented in Table 1;

- i. 2020 Countdown Clock;
- ii. Old Market Square (Medan Pasar); and
- iii. *Laman Sultan Ismail*.

Table 1: Details of the selected pocket parks and observed features. Park categories are adapted from Peschardt and Stigsdotter (2013)

Park	Location	Category	Features	Observation
<p>2020 Countdown Clock</p> 	<p>Jalan Raja, Merdeka Square GPS: N 3.15077°, E 101.69433°</p>	<p>Geometric Design</p>	<p>Water feature Digital clock Sheltered arena Well-maintained landscape</p>	<p>Located opposite the City Hall of Kuala Lumpur and near the historic building, Sultan Abdul Samad Building Best viewed at night Provide shelter to visitors Mostly visited by foreign visitors for shelter as it does not have proper siting area The landscape is well maintained</p>
<p>Old Market Square (Medan Pasar)</p> 	<p>City Centre, behind Central Market GPS: N 3.14736, E 101.69598°</p>	<p>Café/History</p>	<p>Seating area and urban benches Historical clock tower Flowerbeds Water features Paved ground surface</p>	<p>Located behind Central Market Surrounded by tall building and refurbished shop houses Park users are mostly foreign workers or bus commuters Used for socialising and meeting friends Resting</p>
<p>Laman Sultan Ismail</p> 	<p>Jalan Sultan Ismail GPS: N 3.15985, E 101.69727°</p>	<p>Café/ Geometric design/ Traffic</p>	<p>Street-side site Well maintained Flowerbeds Urban benches Newly planted tress</p>	<p>Newly developed parks Located along Quill City Mall Facing Jalan Sultan Ismail Hardly any park visitors as it has less green cover The open space is used by the nearby café in the after office hours</p>

The 2020 Countdown Clock is the latest modern landmark in Kuala Lumpur that was officially opened to the public on 15 April 2017 (mStar Online, 2017). This landmark is located at Merdeka Square and it encompasses of a sheltered plaza area, water feature, the digital clock and well-maintained landscape.

The Old Market Square or *Medan Pasar* is one of the oldest and historically memorable locations in Kuala Lumpur. *Medan Pasar* is now one of the most important public transportation hubs in Kuala Lumpur (Star Online, 2007).

2.2. Population and sampling

The subject of the study were the park users, both male and female composed of residents, visitors or working community and non-users in the radius of <600m of the selected pocket parks (Schipperjin, J. et al., 2010). Random sampling method were used to select the survey respondents and they are not limited to the three main ethnic groups in Malaysia (Sreetheran, M., 2017). The inclusion of local and international park users will reflect the true preferences and preferred activities in the pocket parks in Kuala Lumpur. The respondents are selected between the ages of 18 to 60 (SD>30). The survey was conducted at the study sites inside and outside the selected pocket parks in Kuala Lumpur. Attempt was made to reach as many park and non-park users randomly within the designated radius.

2.3 Study method

A mixed-mode of research techniques which include observation, survey analysis or questionnaires and semi-structured face-to-face interview were conducted simultaneously to gather qualitative and quantitative responses. According to Creswell (2007), qualitative research has become more accepted as a legitimate mode of inquiry in the social behavioural and health sciences than it was in the 1990s.

1. Observation

According to Yin (2011), observation is a form of primary data to be highly cherished. It is an invaluable way of collection data because it gathers data that the researcher

sees with own eyes and perceive with own sense. During observations of the park users, most often through participant observation, the park characteristics, user behaviour, park usage and the preferred activities were observed and described. Pictures were also taken to document the observation. The description of the physical setting including the ground surface cover by grass, the amount of trees and bushes visible from the given view point, walkway, benches and park size were also be recorded. The components of the selected parks and the observations were recorded from January to March 2018 on random days during the weekdays and during the weekends (Sreetheran, M., 2017); including information such as the time, place and date of the field setting where the observation took place (Creswell, 2008).

2. Questionnaire

According to Zikmund (2003), a good questionnaire should satisfy two criteria—relevance and accuracy. Therefore, to meet the relevance and accuracy criteria, this questionnaire is divided into 4 sections; Section A: Personal Information; Section B: Behavioural use of pocket parks; Section C: The relationship between aesthetic experience, restorative effect and well-being; and Section D: Park use constraint and recommendation. The questions were modified from Nordh et al (2009), Grahn and Stigsdotter (2010) and Peschardt and Stigsdotter (2013) and developed in both English and Malay (national language). The questionnaires were distributed on-site by the researcher to obtain the first-hand experience with the park users. The

respondents were requested to complete on-site survey during the visit (Peschardt, K.K., Schipperjin, J. & Stigsdotter, U.K., 2012) or interviewer-completed survey (Sreetheran, M., 2017) at the selected site. The respondents were also required to describe how they use the park (Nordh, H. & Ostby, K., 2013) and their perception of park components that facilitate the park use. The quantitative data were analysed using SPSS Statistics Version 20. As for the questions, a pilot study was conducted to ascertain the reliability.

3. *Semi-structured interview*

To cater to the qualitative data, semi-structured face-to-face interviews that last between 20 and 30 min were conducted. The interviews were recorded in a note book for further references. Prior to the survey and interview sessions, the respondents will be briefed about the aim of the study and the structure of the survey or interview process. The interviews will be conducted in either English or Malay based on the interviewee's preference.

3. Results and Discussion

1. *Respondents profile*

A large number of the respondents are in the age group of 18-30 (48.5%) followed by the 31-45 age group (42.4%); with only 3 respondents between 46-60 years old. 60.6% of the respondents are male while 39.4% are female respondents who were mostly government and private sector employees each comprising of 27.3%, followed by

students, self-employed and retirees. The sample has a balance of Malaysian and Non-Malaysian respondents (Table 2), (57.6% to 42.4%); mostly residents in the Klang Valley and tourists visiting Kuala Lumpur for a short period. The majority of the respondents (60.6%) are single while 36.3% are married and one widower.

Table 2: Nationality

	Frequency	Percent	Valid Percent
Malaysian	19	57.6	57.6
Non-Malaysian	14	42.4	42.4
Total	33	100.0	100.0

2. *Behavioural use of Pocket Parks*

As seen in Table 3, 'to relax and reduce stress' (29%) and 'to meet others' are the majority of response received for the pocket parks usage in Kuala Lumpur among the other components. This finding supports the claim on the two health promoting uses of pocket parks by Peschardt et al (2014); i.e. 'rest and restitution' and 'socialising'. The other responses were for 'to escape from the city', 'to get artistic inspiration' and 'to take a shortcut'. Other than the given component, seven responses (11.3%) were received for the preferences on 'parks suitable for outing with family, especially children during weekend'. Three response was received each for 'easiest access to nature', to listen an observe nature' and 'for lunch break walks' while only two response was submitted for 'to contemplate and meditate'.

Table 3. Reasons for visiting pocket parks in Kuala Lumpur

Components	Frequency	Percentage (%)
To relax and reduce stress	18	29.0
To listen and observe nature	3	4.8
To escape from the city	6	9.7
To contemplate and meditate	2	3.2
To meet others	11	17.7
To take a short cut	4	6.5
To get artistic inspiration	5	8.1
Easiest access to nature	3	4.8
For lunch breaks walks	3	4.8
Others	7	11.3
Total	62	100.0

In response to the question on ‘How often do you visit the pocket parks?’, 42.4% of the respondents mentioned that they visit the parks sometimes, and 18.2% often. 39.4% of the respondents never visit the pockets parks and this may support the park usage preferences where the requirement for green space that may cater for family activities especially parks suitable for children are more prominent. A large number of respondents (42.4%) get to these parks and the surrounding area by foot; 21.2% by car; 15.2% by bus and 12.1% by bike. Only two respondents mentioned getting there by train. The respondents prefer to visit during weekends in the evening (72.8%) while 12.1% of response was received for visiting the parks in the morning and afternoon. Only one respondent preferred weekdays. 39.4% to 30.3% of the respondents answered spending ‘about an hour’ and half an hour’ in the parks. 12.1% and 9.1% of

response were received for spending ‘about 15 minutes’ and ‘less than 5 minutes’ at the park. Only two respondents selected ‘more than a couple of hours’ at the parks.

3. *The relationship between aesthetic experience, restorative effect and well-being*

According to Fig. 3, for most respondents, visiting the pockets parks generally elicited calm and happiness. Eight other claimed freedom, six respondents felt safe and four respondents agreed with ‘unity with nature’. There was one response for ‘adventure’ and two for ‘unity with myself’ and others. When asked why, among the statements that were received for the relationship between aesthetic experience and well-being, respondents claimed that ‘relaxation is very important to release tension and stress’, ‘mental health is the foundation of a happy life’ and ‘the environment makes me relax and reduce stress’ among others.

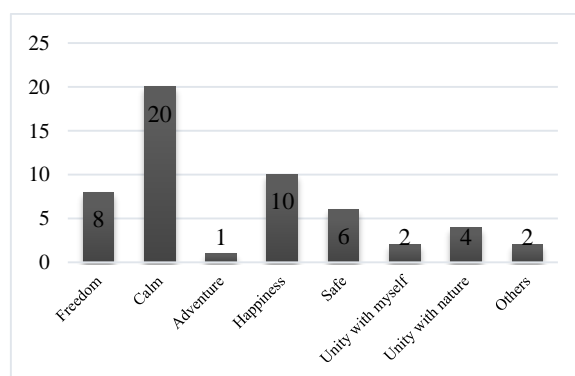


Fig. 1. The feeling evoked by visiting Pocket Parks in Kuala Lumpur

4. *Park use constraint and recommendation*

A large number of respondents (n=13) reported selecting ‘culture’ which is characterised by the presence of fountains and ornamental plants as their preferred park characteristics. ‘Serene’ characterised by silent and calm environment was the second most frequently mentioned. ‘Nature’ and ‘Refuge’ received a balanced proportion in terms of preferred park characteristics. ‘Rich in species’, ‘Social’ and ‘Space’ (10.6%, 7.6% and 4.5%) were the other selected components. ‘Prospect’ that represents flat and well-cut grass surfaces and vistas were the least preferred park characteristics (Fig. 4). ‘Nature’ represents a wild and untouched environment; ‘Refuge’ for safer parks with benches and play area; ‘Social’ for parks with entertainment and restaurants; and ‘Space’ for a spacious and free environment.

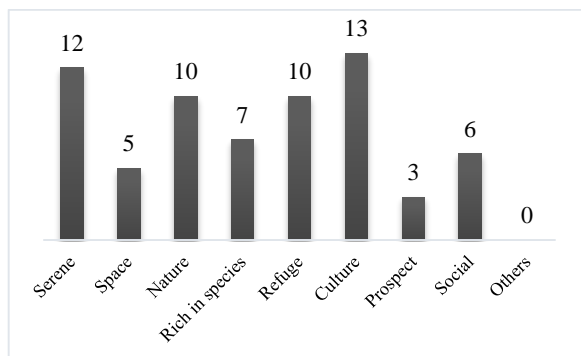


Fig. 2. Preferred characteristics of Pocket Parks

As seen in Table 4, even though 51.5% to 24.2% of respondents claimed to feel safe to very safe in the selected parks, 24.2% or eight respondents felt not very safe at the parks. When respondents were asked to describe why, they indicated the location of the parks adjacent to the main roads (2020 Countdown Clock and Laman Sultan Ismail)

to be risky to visitors especially childrens. Moreover, the presence of drug addicts and incidents of snatch theft were also indicated as their reason to be cautious at the parks..

Table 4. Do you feel safe at this park?

	Frequency	Percent	Valid Percent
Very safe	8	24.2	24.2
Safe	17	51.5	51.5
Not very safe	8	24.2	24.2
Total	33	100.0	100.0

57.6% respondents claimed to visit the parks once a month or less while the remaining 42.4% visits several times a month or more. ‘Time’ or being too busy, ‘Lack of accessibility’, ‘Heat’ and Poor hygiene of other park users’ were the most mentioned constraints in using pocket parks, while ‘No companion’, ‘Feel afraid in forest or other natural setting’ and ‘Poor park management’ were the least mentioned constraints. It is interesting to note that two respondents claimed to not know about the availability or the existence of the selected parks (Fig. 5). This finding could relate with the claim by Saw et al (2015) that the relationship between natural park usage and happiness does not hold in a tropical city-state compared to temperate countries.

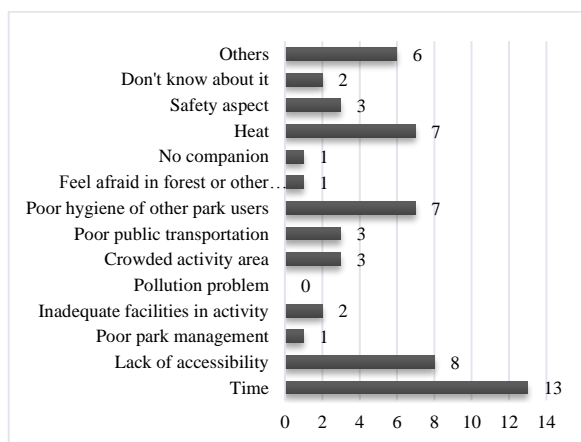


Fig. 3. Park use constraints

The sample has balance between response submitted on the availability of pocket parks in Kuala Lumpur. 54.5% to 45.5% agreed to not having enough pocket parks in Kuala Lumpur. However, there was an overwhelming preference (75.8%) for more improvement to the available parks; especially in the aspect of cleanliness; facilities such as benches, restrooms, play area and more greeneries. Several respondents suggested the need to improve the safety aspect of the park by installing surveillance camera.

The study suggests that accessibility, cleanliness and park maintenance, safety, activities in the park, and the surrounding environment influence user and non-users decisions to visit the park. There also seems to be a difference in the perception and use of pocket parks in Kuala Lumpur compared to temperate regions in terms of ‘heat’ and ‘cleanliness’.

This study also points out that respondents preferred park activities that

include passive socializing activities such as relaxing as well as socialising or meeting other. It has generated knowledge on how we can design the pocket parks in Kuala Lumpur. Parks characterised by the presence of fountains and ornamental plants as well as a silent and calm environment were the most preferred settings.

The study supports the requirement of more small urban green spaces or pocket parks in the city of Kuala Lumpur and to the inclusion of pocket parks in the urban planning and management in Malaysia. However the effectiveness of these parks is mostly dependent upon prioritised activities and the commitment to maintain the parks.

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Adapting Biophilic Design in Urban Riparian

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Abstract

The global rapid urbanization has had significant impacts on the environmental quality. As with many other countries, Malaysia has not been spared from this issue. The unprecedented urban growth has occurred at the expense of many green spaces and vegetation which promote ecosystem and human health. Urban riparian is one of the greenery commonly unaffected by the urban expansion. It has vital ecosystem functions, including maintaining the river water quality, conserving the biodiversity, and stabilizing the river banks. As such, creating a conducive urban riparian zone becomes an important strategy to promote the development of biophilic cities. This study, therefore, aimed to determine the potential functions of the urban riparian to the adjacent occupants by adopting the biophilic design approaches. To achieve the objective, two forms of river reserves were investigated by comparing a vacant riparian area in its natural condition with a riparian area that has been upgraded into a fully-utilized green space. The study observed a lack of spatial integration between the green space and the built-up area in the neglected and unmanaged riparian. On the contrary, the upgraded riparian area was more popular among the public, demonstrating a positive sense of connection between the people and the site. Moreover, the upgraded area was shown to have a lower thermal condition and a better ventilation, hence having the potential to improve the living conditions of the developed area. In conclusion, the study established that there are multiple functions of the urban riparian, especially after implementing the biophilic design approaches within the area.

Keywords: urban riparian; green infrastructure; biophilic design pattern

1. Introduction

The global rapid urbanization has had significant impacts on the environmental quality. As with many other developing countries, Malaysia has not been spared from this issue. The unprecedented urban growth has occurred at the expense of many green spaces and vegetation [1] which promote

ecosystem and human health. Urban riparian is one of the greenery that could survive in the urban areas [2]. Despite being an informal urban green space [3], the urban riparian area is an important component of the green infrastructure which maintains the ecosystem services from which humans gain benefits [4]. As such, creating a conducive urban riparian zone is important in promoting the

concept of biophilia and developing a biophilic city.

Biophilia theory has been demonstrated by previous studies whereby people remain strongly attached to the surrounding regardless of whether the environment is in its natural condition [5] or surrounded by the fabricated and urbanized area [6]. The theory also supports the notion that humans require healthy spaces to maintain their physical and mental well-being [7, 8]. A separated or disaggregated environment would cause an ineffective human functioning [9]. Therefore, it is vital to integrate the urban settings with its natural surroundings.

Application of the biophilic design offers a sustainable design strategy that seeks to reconnect people with the natural environment [10]. It has been proven by a case study in the Asian city [11] that a biophilic-inspired landscaping is feasible even in a tropical climate. Furthermore, a successful biophilic design does not only introduce vegetation to the built environment [8] but also regenerate the natural systems in the city as a whole [11]. Increasing the urban greenery coverage is, thus, an important initial step to implement the idea of biophilia in the urban development.

The urban riparian in Malaysia has been discovered to play vital roles in the ecosystem, including maintaining the river water quality, conserving the biodiversity, and stabilizing the river banks [12, 13]. Nevertheless, studies have shown that throughout the land use transformation, urban riparian has been used as the buffer strip with its restricted conditions [14] and available guidelines have been used in isolation [15, 16], both resulting in the mismanagement of this reserved greenery.

In essence, it is crucial to create and acknowledge the urban riparian as a green space [17] to achieve and maximize their potential functions [18]. It is also fundamental to explore and understand the natural ecosystem services [19] provided by the urban riparian which benefit humans and other living organisms. Instead of focusing on the in-situ and the directional relationship [20]; where the benefits are either realized in the same area or in a specific location due to the directional flow (Appendix A), it is possible to generate an omnidirectional relationship [20] which would provide advanced benefits [4] to the surrounding and the people. With this insight, this study intends to explore the potential functions of urban riparian to the adjacent occupants by adopting the biophilic design approaches.

2. Site Description

A poor planning by the government and the other authorities could result in a failure to preserve the urban riparian areas [21, 22]. To conduct the study, an overview of the



Fig. 1. The sites of study displaying the varied types of urban riparian. Site A is the Park Area, while Site B is the Vacant Area.

urban riparian condition was first acquired. Among the many rivers in Malaysia, Sungai Melana located in the Johor Bahru district was selected for this study due to its unique conditions.

Bound by the same river, the selected site has two different urban riparian settings. As illustrated in Figure 1 and Figure 2, the north-east river bank has an undeveloped river reserve with wild vegetation, while the south-west river bank has been developed into a neighborhood green area which is accessible to the locals. In this study, the urban riparian area which has been transformed into a park is labeled as Site A, whereas the undeveloped vacant urban riparian is labeled as Site B. In addition, the housing area located adjacent to the river has been properly developed without any illegal squatter. The riparian area is easily accessible, indicating its potential advanced functions for the adjacent occupants.



Fig. 2. A view of the River Melana showing the varied types of urban riparian.

3. Methods

In investigating the urban riparian and its surrounding condition, direct observations

and field measurements were employed on-site. An overview of the greenery coverage was first observed via the satellite imagery and then further evaluated on-site.

Table 1. Green Infrastructure Typologies

The site was demarcated as zones and surveyed using four techniques: (i) identification of the green infrastructure

Green Infrastructure Typologies	Diagram
Tree canopy	
Green open space a) Vegetated surface b) Bare soils c) Hard surface	
Aquatic system a) Vegetated water bodies with aquatic plant / mangrove / swamp b) Non-vegetated water bodies	
Greenery on structure a) Green roof with extensive / intensive b) Vertical greenery with living wall/green façade.	

typologies [23, 24, 25] based on the types of greenery available in each site (Table 1); (ii) observations of the map circulation patterns of the users walking at the site to show the connection between the zones [26, 27]; (iii) diurnal thermal investigation within the two

varied formations of urban riparian [28], and; (iv) identification of the 14-biophilic design patterns [29, 30] for each site (Appendix B).

The potential functions of the urban riparian for the adjacent residents vary with its physical and spatial condition. Therefore, the 14 indicators of the biophilic design patterns were used to guide the development of the urban riparian space to increase the living conditions of the nearby residential area. Furthermore, the thermal environment and accessibility were evaluated in this study due to their important role in the use of a green space [31]. All the observations and measurements were completed during good weather with the study being conducted from 8 am to 6 pm. The outcome of each technique was recorded and further analyzed accordingly.

4. Results and Discussion

Based on the overall view, the urban riparian is designated as a vegetative boundary which divides the rivers and its adjacent development. Furthermore, the green infrastructure classification for all zones is limited to only tree canopy and green open spaces. None of the buildings in the zones can be categorized as the ‘greenery on structure’. In addition, the aquatic system typologies are missing due to the excessive modification of the urban channel despite it being a river area. Such phenomenon could be due to the old housing development scheme and the properties of the channel itself, such as soil condition, water flow, and water level. To expand the green infrastructure classification, it is possible to introduce the non-invasive aquatic plants which could increase the biodiversity and

improve the water quality and the thermal condition. Additionally, promoting the use of vertical greenery among the residents could potentially improve the aesthetic appeal of their living environment.

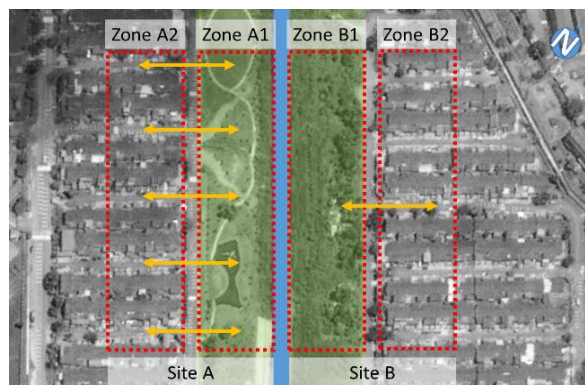


Fig. 3. A diagram showing the comparison of Site A and Site B. Site A has better connection as compared to Site B due to high accessibility and proper pedestrian ways.

Figure 3 shows that Site A has a better connection as compared to Site B. The residents in Site A could use the upgraded urban riparian because it is easily accessible and proper pedestrian ways have been designed to facilitate the connection between Zone A1 and A2. As for Site B, despite Zone B1 being a preserved environment protecting the river and the vegetation itself, the obstructing formation of the greenery has impeded any possible engagement with the adjacent occupants. In fact, the restricted public access to this reserved area has been intentional to ensure public safety and prevent any unlawful act to the river. Nevertheless, with minimal maintenance and reconstruction, the surrounding area of Site B can be improved to benefit the adjacent residents.

Table 2. Inventory of biophilic design pattern based on site

Appendix C portrays the results of the thermal investigation. The diagram illustrates

Types	Biophilic Design Pattern	Zone A1	Zone B1
Nature in Space	Visual connection with nature	✓	
	Non-visual connection with nature	✓	
	Non-rhythmic sensory stimuli	✓	✓
	Thermal and airflow variability	✓	✓
	Presence of water	✓	✓
	Dynamic and diffuse light	✓	✓
	Connection with natural systems	✓	
Natural Analogues	Biomorphic forms and patterns	✓	
	Material connection with nature	✓	
	Complexity and order	✓	
Nature of the Space	Prospect	✓	
	Refuge	✓	
	Mystery	✓	
	Risk/Peril	✓	

the proportions of greenery of both sites in

the form of tree canopy and vegetated surfaces. Site B, which is mostly covered with wild vegetation shows a higher thermal condition as compared to Site A with several designated rows of canopy trees. The location of the canopy trees allows more area to be shaded which could explain the lower temperature noted in Site A. Meanwhile, the unmaintained vegetated surfaces and tree canopy have caused less wind movement in Site B, whereas a higher wind velocity is noted in Site A.

The findings associated with the biophilic design pattern have been categorized into the nature in the space, natural analogues, and nature of the space. The results have been summarized into an inventory as shown in Table 2. Based on the inventory, the upgraded riparian (Zone A1) of Melana River has satisfied all the characteristics of the biophilic design pattern.

Firstly, in terms of the ‘visual connection with nature’, Zone A1 has fulfilled the indicators, implying that it provides views of nature which reduce stress and cultivate positive emotion. On the other hand, the vacant riparian (Zone B1) has not been well-maintained, causing the unpleasant feelings among the visitors.

Moreover, Zone A1 has satisfied the characteristics of the ‘non-visual connection with nature’ and the ‘non-rhythmic sensory stimuli’. These sensory stimuli could generate a positive effect on the physical and mental well-being of the residents. With regards to the ‘thermal and airflow variability’, the results from Appendix C show that the upgraded riparian provides a more comfortable thermal condition (30.44~31.88°C) in comparison to the vacant

riparian with a higher temperature (33.47~33.53°C).

In addition, the upgraded riparian (Zone A1) dominates in terms of the natural analogues and the nature of the space in comparison to the other zoning areas. This finding is due to the physical environment of the park, such as the playground, gazebo, and the pedestrian ways which have been designed to facilitate the recreational activities that can be done in the natural environment by the residents. Moreover, the proper management of the upgraded riparian allows the users of the park to experience freedom (prospect) and feel safe (refuge) while exploring the space within Zone A1.

In summary, each design within the upgraded riparian zone has caused a positive cognitive and psychological impact on the residents who live around the Melana River. On the other hand, the greenery area of the vacant riparian has shown less impact towards a good livability of the residence, especially in promoting the residents' health. The findings of this study have provided a new insight into the importance of proper design, planning, and management of the urban riparian in increasing the wellness of the urban residents.

5. Conclusions

Based on the findings, it can be established that the issues of isolation and mismanagement of the urban riparian can be gradually overcome by adopting the biophilic approaches. As there is an instinctive bond between human beings and other living systems, the potential functions of an urban riparian can be maximized especially after implementing the biophilic design

approaches. A locally appropriate and well-managed urban riparian along with a responsive strategy would create a better integration which benefits both the terrestrial and the aquatic living environments. Furthermore, the application of biophilic design would improve the living conditions of the residential areas surrounding the river development. It is, therefore, crucial, to comprehensively explore the relationship between urban riparian and its surrounding landscape without any directional bias.

Acknowledgments

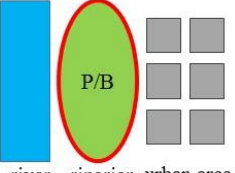
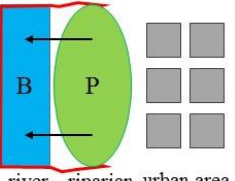
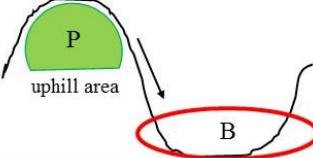
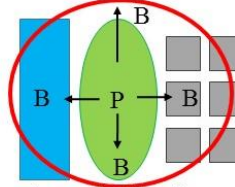
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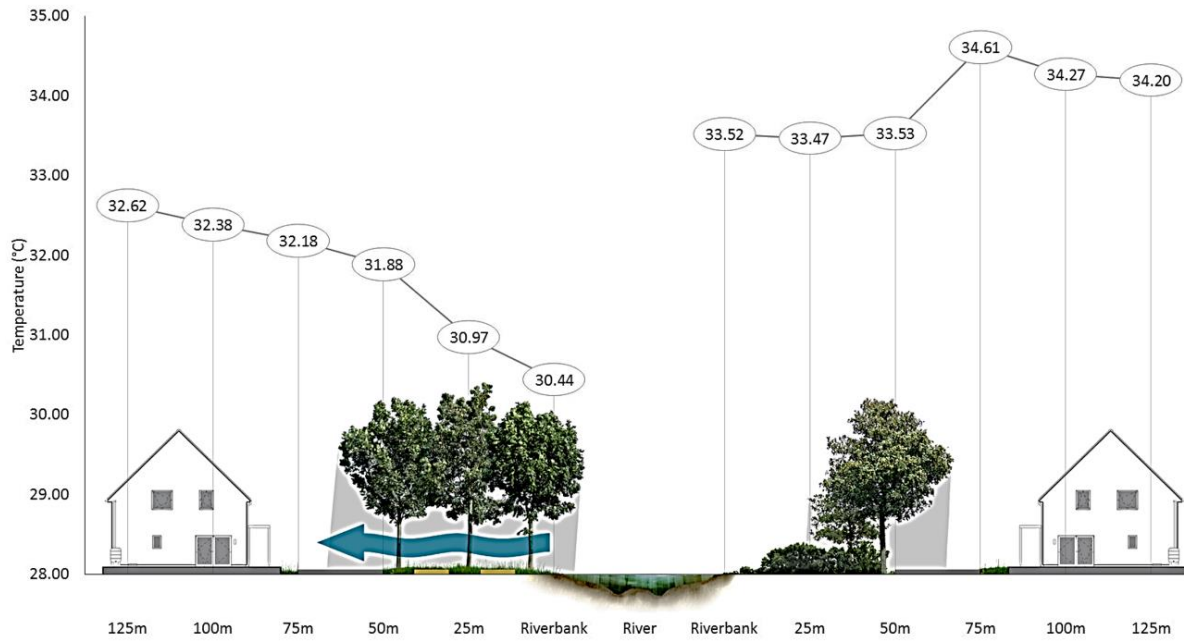
Appendix A Possible urban riparian spatial relationship between service production unit (P) and service benefit unit (B). (Source: Adapt from [20])

Types of Services and Benefits	Diagram	Benefits & Function
Services and benefits at the same location	 <p>river riparian urban area</p>	Biodiversity
Specific directional benefits	 <p>river riparian urban area</p>	Water Quality
	 <p>uphill area</p>	Bank Stabilization
Benefit the surrounding landscape, omni-directionally	 <p>river riparian urban area</p>	All including advance benefits for the adjacent occupant

Appendix B Biophilic Design Patterns and Description (Source: [29, 30])

Types	Biophilic Design Pattern	Description
Nature in Space	Visual connection with nature	Ensure visual access to the real presentations of nature.
	Non-visual connection with nature	Enhance opportunities for sensory connections (e.g. sounds, smell, texture, temperature) to nature.
	Non- rhythmic sensory stimuli	Instill patterns of nature’s movements and seasonality.
	Thermal and airflow variability	Consider sequential changes in the thermal and airflow variability to refresh spaces and enable comfortability.
	Presence of water	Use water as a static, dynamic, and/or variable design element to achieve multi-sensory experiences.
	Dynamic and diffuse light	Use mixtures of dynamic, diffuse, and changeable lighting arrangements to evoke movement, time, and seasonality.
	Connection with natural systems	Use natural systems (weather, hydrology, geology, terrestrial and aquatic wildlife, and diurnal and seasonal patterns) as the design inspirations.
Natural Analogues	Biomorphic forms and patterns	Ensure the legibility of the biomorphic patterns with a particular interest in the floor/roof/wall, places, and furniture detail.
	Material connection with nature	Consider the richness of material, color, and tactility.
	Complexity and order	Priorities the use of composition and order in the design pattern to enable stimulation, interest, and legibility.
Nature of The Space	Prospect	An unimpeded view over distance for surveillance and planning and to provide a sense of arrival.
	Refuge	A place for withdrawal in which the individual is protected from behind or overhead, provide opportunities for retreat, contemplation, waiting, meeting, and refuge.
	Mystery	Partially obscured views or another sensory that entice the individual to travel deeper and provide a sense of journey in the pedestrian environments.
	Risk/peril	An identifiable threat coupled with reliable safeguard. Lessen the personal risk in preference to safety without overriding the biophilic design opportunities.

Appendix C. The average daytime air temperature distribution in Site A and Site B. (Source: Authors)



Landscape Design As A Tool to Revitalize Biophilic Features Of A Degraded City Environment, Case Study: Old Dhaka, Bangladesh

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Abstract

Dhaka once a 'Garden City' to the British planners is now going through an irreversible transformation of landscape and mindscape. The uncontrolled urban sprawl is encroaching the greeneries in the city faster than any other time before. On the verge of this catastrophic future, Dhaka South City Corporation (DSCC) initiated to revitalize 31 parks and playgrounds to reclaim the lost public green spaces of South Dhaka, which is the older part of the city. Among these parks and playgrounds, this paper aims to represent two case studies- "Shahid Smritinagar Mini Stadium Field" and "Bakshibazar Park". Each case study has its own unique set of challenges. Careful landscape analysis was done to get a perception of inherent contextual forces: both positives and negatives. Shahid Smritinagar Field is situated in a dense shanty residential area of Old Dhaka; part of which are occupied with informal plastic factories. The plastic fumes imposes health hazard to the surrounding neighborhoods. On the other hand the undulating play field becomes a wetland during heavy downpour; as a result intended daily activities come to an abrupt halt. Proposed landscape design took an attempt to deal with these two major issues through ecosystem based solutions while providing regular civic, recreational facilities for different user groups. Heavy native plantation like bamboo (*Bambusa balcooa*) is proposed for high degree of carbon sequestration. Nageshwarchapa, Ashoka, Kadamba, Shimul and myriads other native plants has been recommended to enhance nectarivore and fructivore biodiversity like- bees, butterflies, birds and bats. The stagnant water is partially directed to recharge ground water through new soakable drainage network. The second case study "Bakshi Bazar Park" is a left over space behind Nagar Shastho Kendra in the institutional zone of Bakshibazar. An abuse of spatial use occurred due to illegal rickshaw and van parking activities. To bring positive changes, the left over space is proposed as an arboretum with lily ponds. Daily jogging trail and redesigned health complex are part of the future design. The place can become a pocket park for neighborhood recreation and relaxation. Landscape design scheme is attempted as an effective tool for humanizing urban ecology embedded in locality. In this paper it is thoroughly discussed how and what steps have been instigated to give nature back to the deserving residents of Old Dhaka.

Keywords: Ecosystem Based Design; Revitalization; Biodiversity; Urban Green Space; Biophilic

1. Introduction

The British town planners once identified the potential of Dhaka, the capital of Bangladesh as Garden City (Islam, Ahmed 2010). By the onset of new millennia, the city has lost much of its environmental legacy and has chosen the congested concrete structures over nature preservation. Nilufar (1999) in her study on open spaces of Dhaka city, shows that, the total amount of open space is about 17 - 18% of city area, which includes - roads, footpaths, parks, playgrounds, tracts, lakes, ponds etc. She also depicted that the open space to population ratio of Dhaka City Corporation, is only 0.12 acres per every thousands of inhabitants. 'Draft Dhaka Structure Plan Report 2016-2035', states current ratio of recreational area in Dhaka is 0.07 acre/1000 people.

The Local Government (City Corporation) Amendment Act (2011) divided DCC as Dhaka South City Corporation (DSCC) and Dhaka North City Corporation (DNCC) on 4 December 2011. (Ahmed, Hasan, & Maniruzzaman, 2014, c. f. Ahmed B, 2012). Upon realizing the current and future city-wide environmental crises, the current Government has taken multiple initiatives to improve the spatial quality of city life. The pro-active Mayors of Dhaka North and Dhaka South City Corporation have played pivotal roles in materializing such visions albeit struggling against different vested groups. Revitalizing the parks of Dhaka South City Corporation (DSCC) is one of such initiatives to put a stop to the encroachment and illegal activities in the parks and reclaim the public right by bring back nature to the city.

DSCC invited different consultants for the proposal. The consortium comprised of Shatotto and JPZ JV, headed by Ar. RafiqAzam, was finally chosen as the

project consultant among six short listed firms. Ar. Rafiq Azam invited two other finalists and interested young architects and landscape architects to join in this grand design process for reviving 19 parks and 12 playgrounds (Fig 1) within Dhaka South City Corporation. A thorough study was carried out to understand the associated socio-political and environmental issues at respective project sites. The city dwellers aspired the improvisation which will reform social activities in the locality along with bringing positive shifts in the three dimensional spaces.

Fig. 1

This paper aims to review the design initiatives taken by GHORAMLJON and And ORDEN under Shatotto & JPZ JV consortium with a focus on design measures adopted to enhance the environmental qualities rather than social reformations in two of the local playgrounds and parks - 'Shahid Smritinagar Mini Stadium Field` and `Bakshibazar Park`.

Footnote 1: Shatotto Architects, The awardee of the projects

2. Shahid Smritinagar Mini Stadium Field

Dhaka South City Corporation consists of 57 wards. Shahid Sritinagar Mini stadium Field is situated in ward 25, zone 3 (Fig 1), with an area of 0.99 acre. This playground is sitting in a 5 minute walking distance from the Lalbagh Fort (dated back to Mughal era) apparently connected through the labyrinth of alleys.

Fig. 2.

2.1 Existing Condition:

Situated in a characteristic dense mixed-use area of Old Dhaka, the Shahid Smriti Nagar play field was once Islambagh Eid-gah (An open-air enclosure reserved for Eid Salah or prayer offered in the morning of Eid al-Fitr and Eid al-Adha). In the existing condition there's a community hall with abandoned shops underneath at north of the field. On the southern side of the community hall there's a gallery of uneven height to facilitate the viewer during tournaments. The structure obscures the open field from the eyes of the passerby. Fig 3(site location)

Fig. 3.

Footnote 2: Website of Center for Urban Studies and Dhaka
 Footnote 3: GHORAMLIJON and AND ORDEN consortium GJAO

2.1.1 Land Use:

A large residential area predominantly resided by lower income group dwellers. The plots around the field are uneven in their profiles owing to the organic growth pattern and demonstrate mostly unauthorized proliferated multi-storied built forms. The western edge of the field is flanked by low-height makeshift structures that are illegally used as plastic factories which release detrimental fumes and odor.

2.1.2 Vegetation and Hydrology:

Though being a playfield, there is hardly any tree or plantation or even grass patch in the field (Fig 4).

Fig. 4

There are elevation changes up to as much as 1.5m (Fig 5) in the form of depressions which turn the ground into a wetland during the rainy season. It accommodates the runoffs from the surroundings and streets. The playfield lacks any decent facility for storm water drainage.

Fig. 5.

2.1.3 Geology:

The site is situated close to Buriganga River. The soil is the old natural levee deposit by Buriganga (geologically older deposits) on the old Madhupur Terrace. It is light brown and gray sand and clay silt, which slows down the infiltration of storm water runoff. The soil is 6 MSL.

2.1.4 Activities:

Despite all the stressing issues the playfield serves as a breathing place for the local users. Different user groups come and play in the field throughout the day (Fig 6). They play according to age groups and as there's no delineation they divide the field accordingly. The elders walk along the edges to keep up with physical exercise.

The community center provide place for the nuptial ceremonies within their affordability. The catering services for the events occupy the entrance of the playground.

Fig. 6.

A plethora of vendors comes around the evening and during any football matches to sell goods and foods.

Annually the field also hosts the two Eid prayer congregations. In recent years a devastating temporary cow-market takes place in the field during Eid-ul-Adha as there's scarcity of open places in the vicinity. The aftermath of the bazaar is that the field becomes lifeless.

The obscured view may have encouraged anti-social activity like drug abuse at night.

2.1.5 Accessibility:

The field is visually blocked from the main alley on the North. The gateway is very overcrowded. On the Eastern side there's a very narrow walk way which gives way to the local users. But it's inaccessible from the narrow walkway physically and visually due to 4.5 m high walls around the field.

Fig. 7.

2.2 Analysis:

After thorough survey of Shahid Smritinagar Stadium playground a SWOT analysis was done to understand the key issues and opportunities of the land.

2.2.1 Key Issues:

- The Shahid Smiriti Mini Stadium playfield is primarily unseen due to its high surrounding walls and out dated community center at the front.
- Impaired visual and physical accessibility may help thrive anti-social activities.
- The place offers no green refuge and water clogging hinder the turf growths.
- The hazardous fumes emitted by the plastic factories around the playground are contributing to the air pollution.
- Though there's a community center it hardly provides any amenities like toilets, kitchen (for food preparation of events), potable water or designated children's play area.

2.2.2 Key Opportunities:

- By removing the boundaries the field may become a special interlude in the cramped locality of old Dhaka.
- The removed boundary may aid to create a safer place for public recreational activities.
- It playground may become a green reserve in the locality by planting native trees. It will also help the fauna to flourish.
- The green reserve may help mitigate the detrimental plastic fumes and reduce the carbon footprint.
- By redesigning and relocating the community center may offer basic public amenities and scope for vendors to expand commerce.

2.2.3 Design Interventions:

In Dhaka city the concept of an ideal play field and a park is hardly applicable and out of practice. The dense urban fabric comprises these open spaces for multifunctional usages. Thus the need and application of such an open space is a hybrid of playfield and park both, necessarily an urban green space in its essences. Due to limitation of budget and time, PRA (participatory rapid appraisal) was not carried out. But informal interviews with the local people, users and Ward Counselors were taken to understand their aspirations and desires.

Fig. 8

The proposed design of the Shahidsmriti Mini Stadium playground is no exception. It's an endeavor to bring back nature to the under-developed areas of old Dhaka - a

biophilic design approach to enhance the user experience at the midst of a dense urban scenario.

In Proposed Design Futsal instead of Football, children's play area. The walking track is segregated by wire meshed screen to protect the joggers from accident. Nods for sitting, open gym, New Mimber for Eid Gah, vendor corner have been infused to fulfill the needs of the locality.

The entrance has been designed to be more inviting and open. The community center has been placed at the southern end of the field. (Figure 9)

Fig. 9.

Minimal intervention is posed to make the project durable, sustainable and buildable.

Disaster Management has been one of the major design concerns of the design initiative. It has driven the design decision of removing the boundaries and being replaced with poles/bollard to give way for people in time of emergency, so that people can access from all directions to take refuge.

The newly established connections with the place has been conceived to aid in enhanced user interaction with nature which is one of the patterns of a biophilic design. The proposed plantations covers native plants like bamboo (*Bambusa balcooa*), which sequester high degree of carbon. Nageshwarchapa (*Mesua Ferrea*), Ashoka (*Saraca indica*), Kadamba (*Neolamarckia cadamba*), Shimul (*Bombax ceiba*) and myriads other native plants has been recommended to enhance nectarivore and fructivore biodiversity like bees, butterflies, birds and bats.

Extended plinths of the *mer* in the old town were once very common. The

entrance has been designed as an extended elevated plinth to welcome day to day users to sit and relax in front of the field. Dedicated corners for adda (Bangla casual word for informal chatting) are punctuated in the green belts around the park. Benches along the periphery of the field ensure uninterrupted views of the playful atmosphere inside. The walking track has been laid behind the benches for clear demarcation between activities.

Shahid Smriti Nagar Mini Stadium is a prototype design of an urban green space, with an intention of curving a niche in the over-built context of Old Dhaka. It is expected to nurture the future generations through design and build a healthier and smarter generation.

3. Bakshi Bazar Park:

Established in 1984, the Bakshibazar Park is of 0.28 acres in size beside Girda Urdu Road. It is situated in zone 3, ward 27 of Dhaka South City Corporation. The linear chunk of land has a primary health clinic on the east, and high boundary walls surround the park in three other cardinal directions.

Fig. 10.

3.1 Existing Condition:

Bakshibazar Park faced the first wave of encroachment in 2001-2002 after the Dhaka city corporation allowed a portion of its land for a three-storied clinic under the urban healthcare project. Thus the normal functionality of the park dedicated primarily to children was gradually compromised for being hidden behind a obscuring built form.

Fig. 11

The children play area has been out of order for last 13 years. Moreover it has somewhat turned into a parking lot of rickshaws and rickshaw vans in present day scenario. A much dilapidated yet functioning one storied gymnasium stands at the back of the park.

The children play equipment are vandalized and not currently in use. (Fig 11)

Fig. 12.

3.1.1 Land Use:

Surrounded by institutional and residential areas, the park once used to function as a proper playground for children. There is a Foreign Language training center on the north and residential area on the south side. The West side end is defined by an existing outdoor cooking facility for a nearby community center. There's Bakshi Bazar playground just in the eastern corner of the plot. But due to political issues that playfield is also restricted in nature.

3.1.2 Vegetation and Hydrology:

The Bakshi Bazar Park is a barren field with only two trees in it. Due to rickshaw parking facilities, the park has mere grasses at the edges.(Fig 13) But there are mature trees in the surrounding plots of the park, especially at the northern side. These trees provide shade over the linear park and create cooler microclimate.

Fig. 13.

The park is located in a rather high land and hence there are no issues of stagnant water.

3.1.3 Geology:

The soil of Bakshibazar Park is Pleistocene Madhupur clay (geologically older deposits). Madhupur clay occurring in Dhaka Metropolitan area is also known as Dhaka clay. It is above the normal flood level of the city. It is brown to brick red and massive in nature, containing ferruginous and calcareous nodules.

3.1.4 Activities:

Unlike the Shahid Smritinagar Mini Stadium the Bakshibazar Park is in disuse to the local dwellers. The parkland is completely out of bounds of the general people due to the locally influential people. With time the identity of the park is lost and even its existence is of mere dispute.

The place partially hosts Urban Primary Health Care Services Delivery Project (UPHCSDP), an initiative of Government of Bangladesh under Local Government Division.

Other than the healthcare service, the park has currently become a parking lot of rickshaw and vans.

The gymnasium is also unfit for utilization.

3.1.5 Accessibility:

The park is visually blocked from the Girda Urdu road, the only access road to the park. To access the park, one must use the walkway beside the healthcare center.

3.2 Analysis:

SWOT analysis of the current state of Bakshi bazar helped to identify the key issues and opportunities of the site. They are as follows-

3.2.1 Key Issues:

- The Bakshibazar Park has become unknown to the local users in due course of time.
- The dual identity of the park is confusing as healthcare clinic and also as a park.
- Impaired visual and physical accessibility may help thriving anti-social activities.
- The place offers no vegetation.
- There are no public amenities like toilet or potable water facilities.
- The children playing installations are ergonomically unfit and in state of safe usage.

3.2.2 Key Opportunities:

- By redesigning the healthcare center and boundary wall the park can be revived.
- Heavy plantation of native trees and shrubs will increase the vegetative coverage of the area.
- If need be, the high boundary wall on the north, along the institute should be replaced with more perforated delineator. It will extend the visual field of the users. It may also restrain anti-social activities in the park.
- The visitors of the healthcare center can come over to the place and make the place vibrant.

3.2.3 Design Interventions:

To fit into the user's requirements and ease of construction of the parks and playgrounds have been designed in prototypical way. But Bakshibazar Park is proposed as an arboretum to supply plants to other parks and playground of DSCC.

Fig. 14.

In the proposed design the tree bed has been bifurcated by the lily pond(Fig 15). The healthcare center will remain in the same place but a new design is suggested with higher ceiling height. It will help the park to connect with the surrounding.

Fig. 15

To educate the young generation about flora and fauna, the arboretum may offer workshops.

The northern boundary wall is replaced with stainless steel cylindrical poles. It will elaborate the site visually and ensure the safety of the users at the same time.

4. Conclusion:

The design interventions for both the Shahid Smriti Nagar Playground and Bakshi Bazar Park have their interest set in timeless yet most demanding contemporary issue: the socio-environmental revival of local city community. The present century presented us the enormous environmental challenges while great achievements have been made in the field of democratic freedom. The design decisions had their foundations laid on these issues, while set a course for a meaningful future evolution. The attempt to resolve the challenging issues by employing natural elements is demonstrative of a biophilic approach. It

also gives future direction for community to take responsibility of restoring and preserving nature and their collective hopes as well.

Acknowledgments

Heartiest thanks to Ar. Rafiq Azam, heading Shatotto & JPZ JV, for giving opportunity to work in this platform and also for his consent to participate in IFLA Congress 2018 representing the Jol-Shabuje Dhaka Project.

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ART WORK APPENDIX		
No. and description	Images	Credit:
<p>Figure 1.</p> <p>List of parks and playground in the Dhaka South City Corporation.</p>		<p>Shatotto¹</p> <p>Footnote 1: Shatotto Architects, The awardee of the projects</p>
<p>Fig. 2. DSCC area allocated for playfield and parks and Ward 25.</p>		<p>Adapted from Center for Urban Studies and Dhaka².</p> <p>Footnote 2: Website of Center for Urban Studies and Dhaka</p>

ART WORK APPENDIX		
No. and description	Images	Credit:
<p>Fig. 3. Location of Shahid Smriti Nagar and morphology of the site.</p>		<p>GJAO³</p> <p>Footnote 3: GHORAMIJON and AND ORDEN consortium GJAO</p>
<p>Fig. 4. Vegetation around the site.</p> <p>Fig. 5. Hydrology of the site. Source: GJAO</p>		<p>GJAO</p>
<p>Fig. 6. Diurnal and Occasional Activities.</p>		<p>GJAO</p>




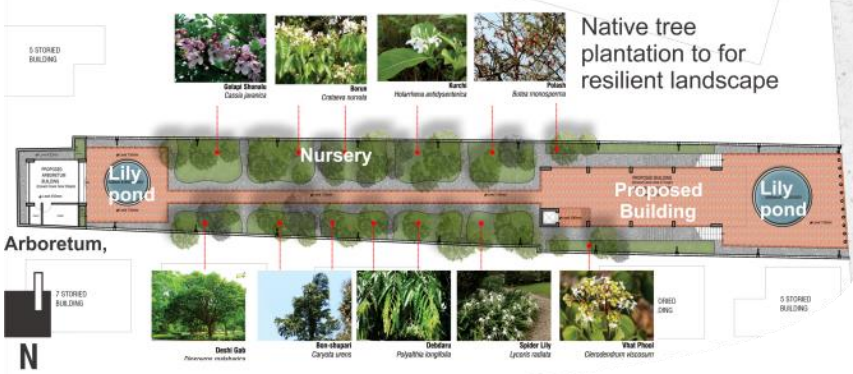
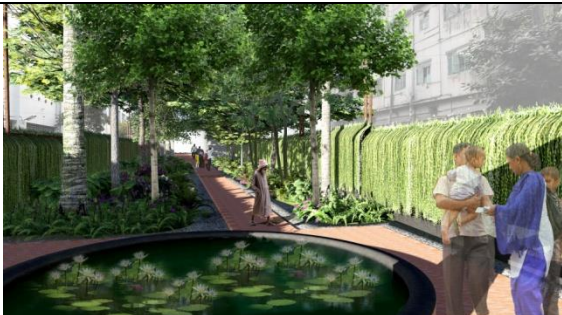
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Art work

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ART WORK APPENDIX		
No. and description	Images	Credit:
<p>Fig. 7. Entrance to the playfield. Source: JGAO</p>		GJAO
<p>Fig. 8. Proposed plan</p>		GJAO
<p>Fig. 9. Entrance to the field from road in proposed design</p>		GJAO
<p>Fig. 10. DSCC area allocated for playfield and parks and Ward 27.</p>		Adapted from Center for Urban Studies and Dhaka.

Art work

ART WORK APPENDIX		
No. and description	Images	Credit:
Fig. 11. Existing condition of Bakshibazar		GJAO
Fig. 12. Morphology and current state. Fig. 13. Vegetation surrounding the site	  <p>Secondary Road Primary Road Water Bodies Marshy land The Park Play Fields Vegetation areas</p>	GJAO
Fig. 14. Vegetation surrounding the site.	 <p>Native tree plantation to for resilient landscape</p> <p>Nursery</p> <p>Proposed Building</p> <p>Arboretum,</p> <p>5 STORED BUILDING</p> <p>7 STORED BUILDING</p> <p>5 STORED BUILDING</p> <p>N</p> <p>5-story Shambhu Cissampelos Banyan Crataeva Hesperethia Rambutan Albizia Palms Albizia Datura Cordia Delonix Spider Lily What Plant Cissampelos</p>	GJAO
Fig. 15. Vegetation surrounding the site.		GJAO

Well-being and the principles of Chinese classical gardens and contemporary landscape design

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Abstract

Background: The well-being of the urban population is becoming an ever-growing challenge for cities. The links between access to green open space and well-being activities are explicit (e.g. Ward Thompson, 2011). However, the detailed design characteristics of open green space are not well defined. This paper examines the design features of Chinese classical gardens and contemporary landscape designs that support well-being.

Methodology: The first step of the study is a theoretical analysis of the paradigms of the Chinese classical garden (CCG) and the contemporary landscape architecture (CLA) as two distinct traditions. The second part of the study uses a detailed understanding of well-being to look specifically at the design details in a case study. This study compares the well-being values of the two design traditions based on an adjusted version of Seligman's (2011) widely cited and accepted model of measuring well-being, called PERMA*:

- P (physical activity),
- E (engagement and positive emotion),
- R (positive relationship),
- M (meaning), and
- A (accomplishment).

Then we investigate how people use, experience and perceive green open space in urban case study locations. The data of the participants' behaviour is derived by combining GPS device tracking and monitoring data to identify indicators of well-being, complimented by user surveys. The detailed garden and landscape design characteristics of the sites that may impinge on well-being of the users, are recorded directly using a checklist developed by the researcher. The

behaviour patterns and the design characteristics are then analyzed using ANOVA and partial correlation.

Results: The analysis shows that the Chinese classical gardens and the contemporary landscape design have quite different well-being values. Chinese classical gardens have more spatial characteristics intended for contemplation. These correlate with Seligman's positive emotion and engagement (scoring 24 occurrences compared to 23 in contemporary design) and related to cultural meanings (scoring 11 occurrences compared to 1 in contemporary design). Furthermore, Chinese classical gardens accommodate approximately more the opportunities for achievement activities (scoring 3 versus 2), correlating to Seligman's accomplishment (A), compared to the contemporary designs. However, the contemporary landscape designs emphasize more on ecology (correlated mainly to environmental meaning) than the Chinese classical gardens, as well as opportunities physical activities (P) (scoring 13 versus 9) and positive relationships with others (R) (scoring 12 versus 6). These studies confirm the strengths of Chinese classical gardens in facilitating cultural related positive emotion (E), cultural meaning (M) and accomplishment (A). In contemporary landscape spaces opportunities for physical activities (P) and positive relationships (R) are more reinforced.

Conclusions: Based on the findings of the theoretical and case studies, we propose a design paradigm – or an assessment method – for future urban green space that combines the well-being characteristics of Chinese classical gardens and contemporary landscape architecture. In this way, new landscape design principles can explicitly contribute to supporting the well-being of an increasingly stressed and urban population.

Key words: Well-being, Design principles, Chinese Classical Garden, Landscape Design, GPS tracking.

1. Introduction

Cities have been home to an increasing number of people and this trend will continue. It is predicted that 66 % of the world population will live in cities by 2050 (United Nations, 2014). The appeals for good quality of open space is thus reasonable, since it is expected to facilitate “social inclusion and community cohesion”, and “health and well-being” (Peters et al. , 2010; CABE, 2008). However, the relevant design professions have not meet the growing needs: the popular urban design trend of ‘urban village’ in Europe and ‘new urbanism’ in the US only ends in underused spaces, though highlighting mixed-use (Shaftoe, 2012). The landscape architecture profession has been no better, seeing that in

the recent thirty years it is experiencing ‘an ecological modernity, an ecology free of romanticism and aesthetics’ (Richardson, 2011, p. 123). Designers began to realize there are more demands for user participation in creating culturally diverse and individualized space (Aslan & Robel, 2016, p. 4). Provincially in China, another design tradition of green space, Chinese classical gardening, highlights human experiences and can provide different relevancies to contemporary design mindsets. Therefore, to achieve a design paradigm for future urban green space, this study compares and synthesizes the theories and user experiences between the contemporary landscape design and Chinese classical gardens.

1.1. Well-being

In terms of the two alternatively used word, well-being and health, well-being is more relevant to everyday context of built environment than ‘health’. Health defined by (WHO, 1948) is a non-disease status physically, mentally, and socially, while Dodge et al. (2012)’s definition of well-being is more dynamic. Well-being is the balance point of between one’s power and challenge faced, or rather, to have enough physical, psychological, and social power to overcome the physical, psychological, and social challenges. The three aspects - physical, mental, and social, is to be used in this study as dimensions of well-being.

A well accepted and cited measurement of well-being is Seligman’s PERMA model (positive emotion, engagement, positive relationship, and accomplishment) in his 2011 book *Flourish* (Seligman, 2011). However, for the environment-people conversation, the model needs to be slightly adapted. Firstly, physical activity is added to Seligman’s original model for the proved significant contribution to well-being. Secondly, positive emotion and engagement are incorporated as one measure. The reason is that in terms of the environment, positive emotion empirically comes from being exposed to nature and mindfulness, which overlaps with the second measure – engagement (losing the sense of time while concentrate on doing something). Thirdly, meaning (achieved by serving something bigger than self), can be embodied as cultural meaning of being connected to history and culture, and environmental meaning endowed by ecological design.

Therefore, our PERMA* model is as follows:

- P: Physical activity is additional measure to Seligman’s original model due to the proved significant contribution to well-being.
- E: Positive emotion and engagement. In the environment, positive emotion empirically comes from being exposed to nature and mindfulness, which overlaps with the second measure – engagement (losing the sense of time while concentrate on doing something).
- R: Positive relationship.
- M: Meaning. The sense of meaning can be achieved by serving something “bigger than self”. In the green space sphere, there can be cultural meaning (MC) of being connected to history and culture, and environmental meaning (ME) endowed by ecological design.
- A: Accomplishment. In the green space, people can pursue for a skill for its own sake through studying, playing music, or climbing to the top of a pagoda.

1.2. Theoretical comparison of the two design traditions

The two design traditions have quite different main features and methodologies. To illustrate, the Chinese classical garden (CCG) is the “enchanted and tranquil gardens designed to reflect both the charm of nature and the ancient Chinese view of life” (Lou, 2011, p. abstract). The main feature is “though manmade, they (the elements of the garden) will look like something naturally created” (Ji, 1988, p. 41), which can also be put as “from nature but superior than nature” (Zhou, 2008, p. 26). The derivative four backbones are:

rockery, water, planting, and architecture (Peng, 1986, p. 41; Zhang & Xu, 2011). Plus, a fifth category called “Plaues and couplets” is also an important feature (Valder, 2002). On the other hand, the contemporary landscape architecture (CLA) is defined as “any intentional change of landscape pattern for the purpose of sustainably providing ecosystem services while recognizably meeting societal needs and respecting societal values” (Nassauer & Opdam, 2008, p. 633). There are two main principles: ecological design and design for societal needs and values. Ecological design should integrate ecological processes like “watersheds, material life cycles, habitats” (Nassauer, 2012, p. 223). Yet the “Design for societal needs and values” principle does not have synthesized structure, but still share four common resources: land and landform, water, plants, and outdoor fittings and furniture (Motloch, 2000; Simonds & Starke, 2006; Weddle, 1979).

The comparison of the design paradigm of the two traditions is based on the functions of the elements of each principle and their theoretical implications on the indicators of PERMA (Fig. 1). The analysis shows that the Chinese classical gardens and the contemporary landscape design have quite different well-being values. Chinese classical gardens have more spatial characteristics intended for contemplation. These correlate with Seligman’s positive emotion and engagement (scoring 24 occurrences compared to 23 in contemporary design) and related to cultural meanings (scoring 11 occurrences compared to 1 in contemporary design). Furthermore, Chinese classical gardens accommodate approximately more the opportunities for

achievement activities (scoring 3 versus 2), correlating to Seligman’s accomplishment (A), compared to the contemporary designs. However, the contemporary landscape designs emphasize more on ecology (correlated mainly to environmental meaning) than the Chinese classical gardens, as well as opportunities physical activities (P) (scoring 13 versus 9) and positive relationships with others (R) (scoring 12 versus 6). These studies confirm the strengths of Chinese classical gardens in facilitating cultural related positive emotion (E), cultural meaning (M) and accomplishment (A). In contemporary landscape spaces opportunities for physical activities (P) and positive relationships (R) are more reinforced.

2. Methodology

2.1. Study area

Beijing has a rich resource of green space of all kinds design features. According to the survey of (Chen et al., 2017), green spaces within the 3rd ring road and the 4th ring road in the northeastern district were high. From green spaces in these areas, we chose two parks to that had similar accessibility and representative of the two design traditions to study (Fig. 2). The two parks are both large community park. The representative of Chinese ‘Classical Garden, Lontang West Lake Park is within the second ring road in south eastern Beijing. Built in 1986, it is a 10-ha park mainly serving residents within 1000 meters’ distance. People come by walking, mostly without a need to cross the road and public transportations are all 500 meters away from the entrance of the park.

The representative of the contemporary landscape architecture is the Wanghe North Park near the 4th ring road in the north eastern Beijing. It is built in 2014 and mainly serves residents in nearby 1.5 km by walk. Nearly one thirds of the coming users need to cross a 30 m wide urban main road through the platform bridge.

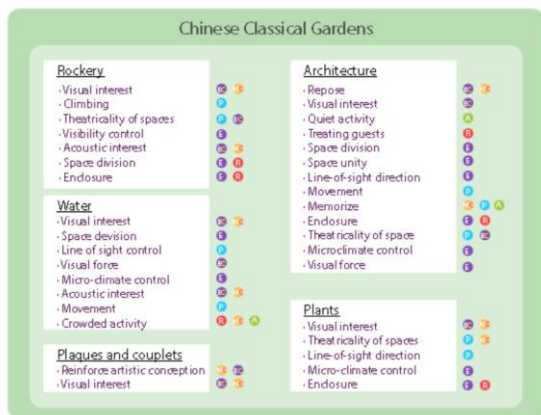


Fig. 1_a The theoretical implications of principle of Chinese Classical Garden on PERMA indicators

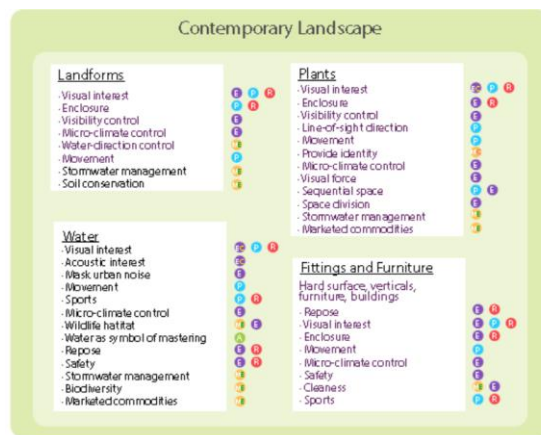


Fig. 1_b The theoretical implications of principle of Contemporary Landscape Design on PERMA indicators

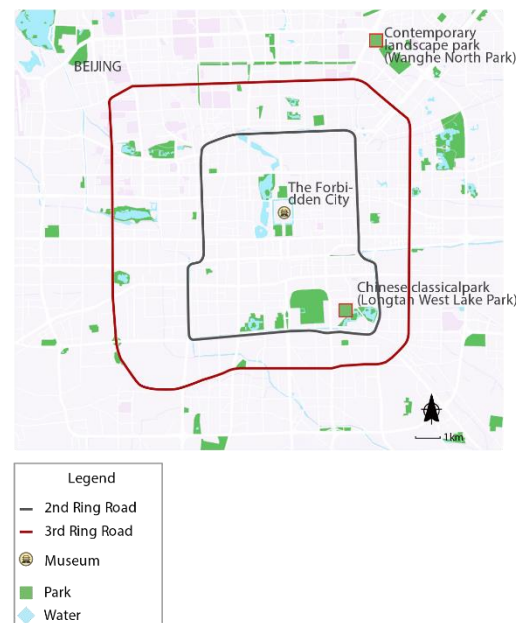


Fig. 2 The location of the two parks

2.2. Questionnaire survey

The questionnaire was a shortened version from the original PERMA questionnaire by Butler & Kern (2016). The questionnaire includes only 7 quick questions on self-reported health, PERMA indicators (Table 1) on a 11-point scale from 0 to 10. Four conductors including the author did the questionnaire on the gate way of each park on a Saturday (20th, and 28th January). The participants were invited to answer the questionnaire both before and after the using the park. This is to examine the well-being enhancement effect. After using the green space, the participants were also asked to recall their experiences in doing PERMA indicator related activities:

Did you come for physical activity? How many times did you watch an objective, talk with people, recognize cultural meanings, and feel the sense of achievement? Where these activities take place?

Table 1 The PERMA* questions on well-being

Label	Question	Response Anchor
P	How satisfied are you with your current physical health?	0 = not at all, 10 = completely
E1	In general, how often do you feel joyful?	0 = never, 10 =always
E2	How often do you lose track of time while doing something you enjoy?	0 = never, 10 =always
R	How satisfied are you with your personal relationships?	0 = not at all, 10 = completely
M	In general, to what extent do you feel that what you do in your life is valuable and worthwhile?	0 = not at all, 10 = completely
A	How much of the time do you feel you are making progress towards accomplishing your goals?	0 = never, 10 = always

E1: Positive emotion; E2: Engagement

Overall Well-being PERMA= mean (P, E1, E2, R, M A)

The answers were analyzed in IBM SPSS 22.0. The scoring of the overall is averaging all the items. The well-being before, after using the park, and the difference between them were calculated. The demographic backgrounds (gender, age, occupation, and frequency of using the park) were descriptively analyzed and run a Pearson correlation with overall well-being before and after using the park. To examine the relative importance of the factors, a confirmatory factor analysis was conducted using IBM AMOS 21.0. Finally, Pearson correlation and partial correlation analysis was done to explore the correlation between the experiences and overall well-being scores and eliminate the impact of the type of the park.

2.3. GPS behaviour tracking

10 participants were invited to wear the 10 participants the Q-Starz BT-Q1000XT GPS travel logger for ten days 10 days from Jan 22th to Feb 1st. 2018. They were all over 50 years old. The participants were asked to keep the device on through the 10 days and charge the device daily.

The GPS data was downloaded from the official website of Q-starz and imported into GIS 10.2. Trips with a speed between less than 1km/h were categorized as stay, trips with a speed between 1km/h and 9km/h were categorized as walking, and trips with a speed over 9km/h were classified as bicycle or automobile trips (Carlson et al., 2015). Kernal analysis was conducted to investigate the relative probability of the waking trip in the parks.

3. Results

3.1. Site observation

Upon observation, the Chinese classical park theoretically has more occurrence of positive emotion and engagement (scoring 11 compared to 6 in the contemporary style park), meaning related to culture (scoring 5 compared to 0 in the contemporary style park), and social interaction (scoring 6 compared to 4 in the contemporary style park). The contemporary style park has more opportunities for physical activity (scoring 5 versus 3 in the Chinese classical park) and achievement (scoring 3 versus 1 in the Chinese classical park) (Table 2).

Table 2 Characteristics of the parks and PERMA indicators

Longtanxihu Park		Wanghe North Park	
Rockery		Landforms	
Visual interest	E, MC	Space division	E
Climbing	P	Visibility control	E
Visibility control	E		
Enclosure	E, R		
Water		Water	
Visual interest	E, MC	Visual interest	E, P
Acoustic interest	E, MC	Movement	P
Movement	P	Sports	P, R, A
Crowded activity	R, MC		
Space division	E		
Architecture			
Repose	E, MC		
Visual interest	E		
Quiet activity	A		
Enclosure	E, R		
Plants		Plants	
Enclosure	E, R	Enclosure	E, R
		Visibility control	E
Fittings and furniture		Fittings and furniture	
Sports	P, R, A	Repose	E, R
Repose	E, R	Sports	P, A
		Square for multiple used crowded activity	P, R, A

3.2. Questionnaire survey

(1) Participant characteristics

64 participants completed the after-use questionnaire. Among the 64 valid answers, 31 were from male (48.4%) and 33 were from female (51.6%). Slightly more participants were elderly people over 55 years old (54.7%), unemployed (53.1%), and did not receive high education (51.6%). 73.4% of the participants came for doing physical activity, the other purposes were play (9.4%), play with children (4.7%), take a rest (3.1%) and work (3.1%). 75.0% of the participants came to the park at least once a week, which meant they are mostly frequent users of the park. While 13 participants did not come regularly, and 3 out of 64 first came to the park. There were more female

participants in the CLA than in CCG, $t(62) = 2.03, p = 0.047$. Age, occupation, education, purpose of coming and frequency of coming did not differ between the participants in the two parks ($p > 0.05$).

(2) Comparison of well-being before and after using the park

Generally, the well-being scores after using the park were higher than that before using the park (Fig. 3). The enhancement of the well-being score of all the participants is 0.31 (SD=0.876). The participants in the contemporary style park had higher well-being scores. Before using the park, the mean well-being score was 8.00 (SD=1.282) in CLA compared to 7.82 (SD=1.377) in CCG. After using the park, the mean well-being score was 8.32 (SD=1.317) in CLA versus 8.11 (SD=1.387) in CCG. The mean enhancement of well-being was also higher, scoring 0.32 (SD=0.800) in CLA compared to 0.29 (SD=0.964) in CCG. However, all these three differences were not statistically significant ($p > 0.05$). In terms of each PERMA indicator, meaning was the most enhanced indicator, and in CCG the enhancement was higher (1.52 compared to 1.09 in the CLA).

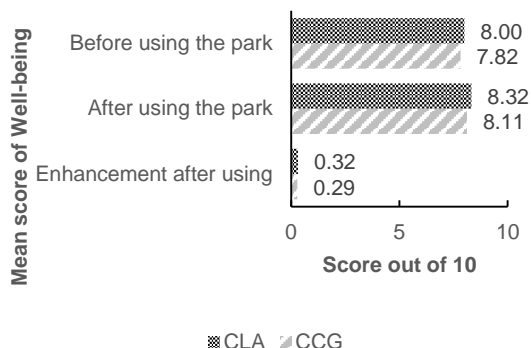


Fig. 3. Mean well-being score differences in the two parks.

The well-being enhancement was higher in the contemporary style park than in the Chinese classical park, perhaps due to the maintenance differences. The score difference is inverse to the hypothesis that the more PERMA indicator scores in a space imply more well-being enhancement. From site observation the CCG scored higher, especially on supportiveness of positive emotion and engagement. But the results showed engagement score decreased and in CCG engagement was the least important factor to overall well-being. It is perhaps because of the quality of the facilities related to engagement. The architecture, seating area, and plantings and the whole park was not as well maintained as the CLA. The CLA, in contrast, was a newly built park with brand-new facilities. This accords with previous studies that the maintenance is an important determinant of the use of the park (Dunnett et al., 2002). A telephone survey of 515 non-park users by the British Market Research Bureau revealed that more than half respondents mentioned “less dog mess, improved safety, better maintenance, and better facilities, etc.” would encourage them to use the park a lot.

(3) Confirmatory factor analysis

Confirmatory factor analysis showed that the most important factor for well-being score in CLA was engagement (standardized regression weight = 0.98), and in CCG the biggest factor was social relationship (standardized regression weight = 0.90) (Fig. 2). Good model fits of all the models were derived (Table 3).

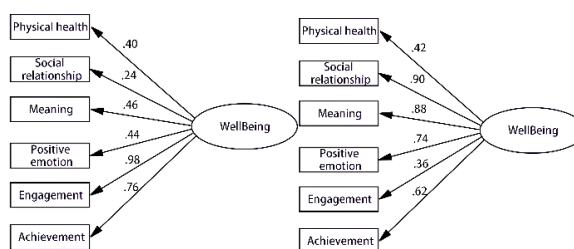


Fig. 4_a Standardized regression weights of the confirmatory factor analysis of the CLA

Fig. 4_b Standardized regression weights of the confirmatory factor analysis of the CCG

Table 3 Model fits of confirmatory factor analysis

Sample name	Chi-square (X^2)	Df	X^2 /df ratio	p	RMSEA A	CFI
Two parks	14.09	9	1.57	0.12	0.10	0.94
CLA	13.009	9	1.45	0.16	0.12	0.91
CCG	9.351	9	1.04	0.41	0.04	1.00

According to (Hu & Bentler, 1999), RMSEA (root-mean-square error of approximation) >0.06 and CFI (comparative fit index) >0.95 indicates a good model fit. A Chi-square/Degree of freedom ratio between 1~3 is recommended (Kremelberg, 2010) and p value should be larger than 0.05 (Hooper et al., 2008).

(4) The experience of related activities and well-being score

Table 4 The Pearson correlation coefficients between well-being scores

Activities	Wellbeing Before	Wellbeing After	Wellbeing Difference
Whether aimed at physical activity	-0.15	0.04	0.29*
Engagement	0.11	0.10	-0.010
Social Interaction	0.25*	0.16	-0.15
Achievement	0.32*	0.29*	-0.03
Meaning	0.41**	0.34**	-0.10

* $p < 0.05$
** $p < 0.01$

Pearson correlation showed that activities associated with well-being scores were physical activity, sense of meaning and sense of achievement (Table 4). Aiming at physical activities (1=physical activity, 2=other purposes) was positively correlated with enhancement of well-being scores. Doing other activities (play, play with children, take a rest, stroll) pertained to higher well-being scores after using the park, $r(63) = 0.29$. The more the users sensed cultural meanings, the higher well-being scores they got after using the park, $r(63) = 0.34$. Also, the more achievement-evoking activities, the higher the well-being scores after using the park, $r(63) = 0.29$.

From the partial analysis, the type of the garden differentiated the relationship between sense of meaning, sense of achievement and well-being score: The partial correlation is moderately strong and positive for the relationship between meaning and well-being after using the park, controlling for the type of park, $r(62) = 0.357$, $p = 0.001$. The result of the zero-order correlation showed that there was a moderate correlation between meaning ($M=0.51$, $SD=0.504$) and well-being after using the park ($M=8.21$, $SD=1.344$), $r(63) = 0.335$, $p = 0.020$. It indicates that type of

garden moderately influences the relationship between meaning and well-being. **The Chinese classical garden is stronger in providing cultural meaning that's helpful to well-being.**

The partial correlation is moderate and negative, controlling for the type of park, the relationship between sense of achievement ($M=0.59$, $SD=0.495$) and well-being after using the park ($M=8.21$, $SD=1.344$), $r(62) = 0.283$, $p = 0.025$. The results of the zero-order correlation show that there was also moderate correlation between sense of achievement and mean of well-being, $r(63) = 0.291$, $p = 0.020$. It indicates that type of garden slightly influences the relationship between sense of achievement and mean of well-being. **The contemporary garden is stronger in providing achievement that's contributable to well-being.**

The most important factors of the PERMA indicators in the two parks are engagement and achievement in CLA, and social interaction and meaning in CCG. For the CLA, the answers of the highest rate for engagement was watching the skiing activity (22.22%), for achievement was dancing (23.3%). In the CCG, the social interaction was the biggest factor because users there were longer-term residents and had more acquaintances than those near the CLA. The meaning mostly referred to the pavilion (the answer rate was 33.3%).

3.3. GPS tracking

(1) Speed and length of walking in the parks

Trips in the park were of from 2 out of 5 volunteers in the CLA and 4 out of 5 volunteers in the CCG. The volunteers in the CLA walked longer time and also slower in the CLA. The average walking time in the

CLA were respectively 46.54 min per day with an average speed of 2.63 (1.060) km/h. Volunteers in the CCG walked shorter time, averaging 27.96 min per day with a faster speed of 4.06 (1.167) km/h. Even controlling the size of the park, the walking time in the CLA was longer compared to that in the CCG (Table 5).

Table 5 Characteristics of the trips in the two parks

No.	Age	Days walked in the park	Time /day (min)	Time/day/area (min/d/ha)	Mean speed (km/h)	SD
CLA 1	76	6	44.36	2.77	2.53	1.038
CLA 2	55	1	59.58	3.72	3.04	1.062
Average			46.54	2.91	2.63	1.060
CCG 1	55	3	44.50	4.45	4.14	1.140
CCG 2	70	3	28.94	2.89	4.25	1.161
CCG 3	70	1	2.75	0.28	2.54	0.918
CCG 4	70	2	14.29	1.43	3.30	0.898
Average			27.96	2.80	4.06	1.167

(2) Distribution of walking in the parks

From Kernel Density analysis, the walking in the CLA is more areal while the walking in the CCG is more lineal (Fig. 5). The CLA had more open spaces for people to do activities, thus in these areas the walking can be slower (2.63km/h). The redder area in Fig. 5_a were the area walking was more probable, including the central square, the children play area, the entrance square, and the quiet relaxing area. Apart from these areas, the walking distributed along the main walking lane. The CCG had a 1 km fitness runway around the lake. Thus, the walking, mostly on the fitness runway, was faster (4.06km/h).

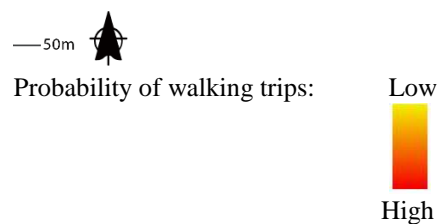


Fig. 5_a Probability of walking trips in the CLA from Kernel Density Analysis

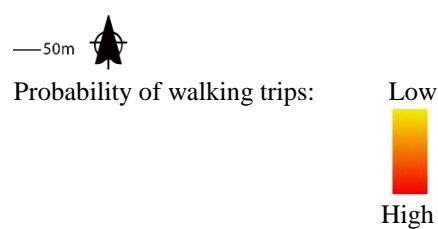


Fig. 5_b Probability of walking trips in the CCG from Kernel Density analysis

Thus, longer time and distance walking was in CLA, and was probably related to the

bigger activity area, more activities to watch.

4. Conclusion

This study explored the differences of design principles of Chinese classical gardens and Contemporary landscape architecture, and their applications on well-being based on PERMA* metrics.

- (1) Both the classical garden and the contemporary garden can enhance overall well-being. The contemporary landscape architecture is slightly stronger in supporting well-being. Parks should take more care of maintenance to better play the role of supporting well-being.

Acknowledgments

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- (2) Future design should combine the advantages of Chinese classical garden in supporting cultural meaning through historical relevant objects, and the strengths of contemporary landscape architecture in the variety of activities to better support well-being.
- (3) Future research should be more careful in choosing comparative cases. The cases should not differ significantly on confounding variables like the maintenance conditions as for comparing design paradigms.

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Spatial temporal changes of urban green spaces in relation to land surface temperature/ a case study from Beijing, China

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Abstract

Urban heat island (UHI) is a phenomenon resulting from climate change and rapid urbanization. Negative impact of UHI has been linked to heart stroke rate, morality, human comfort, energy consumption and air pollution. Fortunately, urban green spaces, besides their various ecosystem services, have been considered as an effective element to mitigate UHI through the function which is known as cooling effect. From another hand, in the recent decades, in many cities of the world, urbanization and rapid growth have put pressure on urban greeneries and caused fragmentation of green patches or replacing them with impervious surfaces which contribute to UHI. City Beijing, capital of China, is an example of such cities with an increasing trend of UHI. This study has focused on spatial-temporal changes of green space patterns in Beijing, capital of China. Also it has been tried to understand the relation between green spaces change and land surface temperature. In order to achieve the aims of research, spatial-temporal land cover map of study area was generated using Google Earth and ArcMap software packages. Changes in land cover type and portion of green spaces area in entire case study were evaluated. Connectivity as an important landscape metric was computed with FRAGSTATS. In the same time LST estimated from LANDSAT remotely sensed data. The result, in general, indicated a tight correlation between LST and land cover type. Urban waterbodies and greeneries showed the lowest LST, while Impervious surfaces such residential areas and roads showed the highest level. Furthermore it was showed that surface temperature was affected by the cooling function of greeneries and by land cover type. Further analysis showed that although recently some parks and green spaces has been constructed in some sections of study area and it has contributed to provide more cooling surface, but in general, the connectivity index of green patches has been dramatically decreased from 3.11 to 1.69 from 2000 to 2015, showing fragmentation in urban green landscape. It is suggested that green spaces and waterbodies are playing a vital role in cooling down cities and mitigating high temperature events. Urban green space planners and designer may take the advantage of this study for their further plans to increase green areas and enhance their connectivity in the cities which can provide various ecosystem services.

Keyword: Urban greenery, Ecosystem Services, Urban Heat Islands, Cooling Effect, Remote Sensing, Landscape configuration;

1. Introduction

One of the major environmental challenges humankind is facing in the 21st century is climate change [1]. In this scenario, cities and citizens are suffering from different problems such as increasing urban heat islands (UHI) [2] and increasing runoff and flood event [3] Also air pollution and low water quality decrease people well-being in the cities [4], [5].

Fortunately, trees and vegetation in an urban environment can greatly improve the microclimates, as well as mitigate UHI development by reducing summer air temperatures [6] Urban vegetation cools climates through two major processes: shading and evapotranspiration [7]. The direct effect of shading refers to the interception of solar radiation by leaves and branches of trees; this reduces the sunlight reaching the ground below the canopy of a tree or plant. An investigation in Australia demonstrated that tree shade could reduce wall surface temperatures by up to 9 °C and external air temperatures by up to 1 °C. The indirect effect of evapotranspiration is the sum of evaporation and plant transpiration, which reduces air temperatures because of the use of energy required for transpiration. A systematic study in Chania of Greece showed that urban green areas could reduce air temperature 3.1 0C, mainly through evapotranspiration [8] .

In order to protect the landscape in cities at international and continental level, and in order to preserve their biological diversity, many stakeholders have a strong interest in getting a broad view of their state, be it in terms of vegetation health, species composition or environmental conditions

such as surface temperature. In particular, it has been considered worth investigating the potential of Remote Sensing (RS) and Geographical Information System (GIS) techniques for characterizing and monitoring landscape and their stability as habitats [9].

This study has focused on spatial-temporal changes of green space patterns in Beijing, capital of China. Also it has been tried to understand the relation between green spaces change and land surface temperature

2. Methods

2.1. Study area

The research focuses on urban green landscape of city Beijing ((39°28'-41°05'N, 115°25'-117°30' E),). Beijing is capital of China and the world's third most populated city [10]. The city has a monsoon-influenced humid continental climate with an annual average temperature of 12.6 C (27C in July and -4C in January). The city has been observed the urban heat islands (UHI) phenomena since fifty years ago, and the current summertime UHI reach 4.5°C in average [2]. In this study Olympic Forest Park of Beijing was chosen as case study, The Olympic Forest Park, with the area of 10 km² has been built for 2008 World Olympic Games in the northern part of Beijing's built-up area and has become a hotspot for recreation and tourism. It is covered with deciduous and evergreen trees, grasses, shrubs and a man-made dragon-shape lake. The buffer zone of the park mainly includes green and grey spaces, and grey spaces refer to buildings, roads, etc.

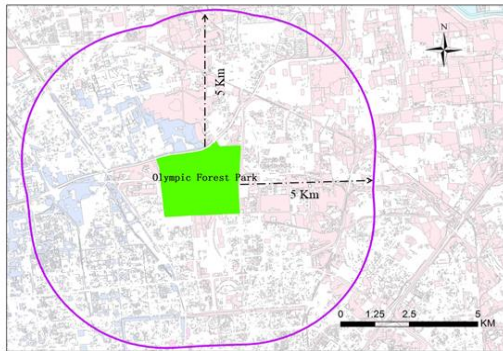


Figure 1 Area of green and grey patches in 5km buffer zone of Olympic Forest Park.

2.2. Land Surface Temperature

Surface temperatures represent heat energy given off by the land, buildings, and other surfaces. Instruments mounted on satellites and airplanes can measure temperatures of surfaces and reveal temperature differences at very fine scales (i.e. roofs, pavements and grassy areas). However, satellite data have a number of limitations, so we combined satellite data for surface temperatures and data from monitoring stations for air temperatures to offer the most complete picture of the study area's heat island. The land surface temperature data of the study area from 2000 to 2014 were derived from the thermal infrared bands (TIR) of Landsat 7(ETM+) and Landsat 8 TM with spatial resolution of 30m (resampled from 120m). Landsat 7(ETM+) images were acquired on August 2000, and August 2005. Landsat 8 TM images acquired on August 2010, and August 2014 (row32/path123).

2.3. Land Cover Pattern

The land cover of the study area was classified based on the supervised classification of remote sensing data, natural attribute of land cover and the classification system of the green space investigation data in the study area. Remote sensing data include the high-resolution images of the study area in 2000 (SPOT4, panchromatic

10m), 2005, 2010 and 2015 (SPOT5, fusion 2.5m). Six land cover categories were identified, namely green space, water-body, farmland, bare land, building and road. Urban green space, water-body, farmland were assumed as landscape components of green space, while bare land, building, and road assumed as grey space.

2.4. Calculation methods

GIS spatial analysis module was applied to understand the spatial change of green patches. Firstly, land cover vector data of different years were converted to 30m*30m (the same as the resampled pixel size of the Landsat TM and ETM thermal bands) raster data, and then overlay command of arc toolbox in ArcGIS10.0 was applied to overlay the landscape type distribution maps from 2000 to 2015, and analyze the changes in green patches over the time.

Numerous landscape metrics can be can indicate and reflect the structure and special characteristics of landscape pattern [11]. Here, we chose Connectivity as an important landscape metrics to measure connectivity (CONNECT) of green patches. It was calculated in Fragstats 4.0.

3. Result and Discussion

Among the green space types, cropland and waterbody within the study area have reduced by 1.2 km² and 5 km² from 2000 to 2005, while grass and forest (includes urban tree parks, green belts) have increased by 5.7 km² and 2 km² correspondingly. From 2005 to 2010, cropland dramatically reduced by 22.3 km² and disappeared while grass, forest, and waterbody have increased 6.7 km², 8.9 km² and 0.5 km² accordingly. From 2010 to 2015 there was no important change in the components of green spaces within the study area. Generally grass and forest have increased from 2000 to 2015 due to large-scale urban projects in this period specially construction of Olympic Forest

Park for the 2008 World Olympic Games within the study area. Meantime croplands and waterbody have been invaded by road, business and residential area, road.

Generally, the coverage area of greenery and waterbody was significantly negatively correlated with LST across each zone.

LST was negatively correlated with connectivity, (Figure 2). Also connectivity showed a decreasing trend in the time spawn, which shows the lowering connectivity of green patches because of urbanization and scarcity of green spaces.

Our result showed that both green space's composition and configuration significantly affect the magnitude and extension of LST. This research expands our scientific understanding of cooling effect of urban greenspace. These results have important plan, design and management implication. Greenspace planners, designers and managers attempting to mitigate the negative impact of urbanization and urban heat islands can gain insights into optimizing the cooling effect in cities.

The negative correlation between LST and green patches connectivity obviously reveals the impact of rapid urbanization in the study area which caused fragmentation and isolation of green space patches and contributing to landscape heterogeneity. Based on these findings, it's urgent to promote green space protecting policies by the stakeholders which benefit citizens well being through various ecosystem services they provide. According to previous researchers, the the ecological functions of urban greeneries were closely linked to the green space coverage, community structure and landscape patterns. So, construction and designing urban green space should not be confined to aesthetic values bust must highlight ecological function of greeneries network in the cites. In this regard, paying attention to vertical greening (green walls/etc) and green roofs and also optimizing the layout and pattern of

greeneries is necessary to ecological and sustainable development of cities.

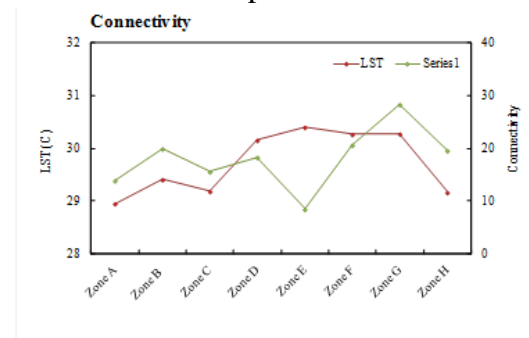


Figure 2 relations between LST and Connectivity in different zones of the study area.

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Participatory Cultural Ecosystem Service Assessment for Cultural Landscape Corridor Planning: A bridge for Public Attitude Prediction and Negotiation

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Abstract

We are witnessing the increasing strategic promotion of landscape corridors in various regions. In decades, a variety of landscape corridors have been developed by regional landscape policy-makers, especially under the promotion of Pan-European ecological network and Green Infrastructure strategy. However one problem is, in the ongoing promotion of landscape corridors, public attitude facing with the corridor planning movement are largely ignored. The public may present a resistant or supportive attitude towards the corridor proposal and various stakeholders with different demands (cultural heritage, tourism, agricultural development etc.) involved in landscape corridor planning process may have conflicting interests. Ignoring those opinions may lead to social conflicts during the promoting process. For the perspective of landscape corridor planning, it is valuable to explore the common language for negotiation with various stakeholders.

Detecting Cultural ecosystem service (CES) could be used as an instrument to predict public attitude and provide a common language between various stakeholders. As a category of ecosystem services, cultural ecosystem service (CES) are defined as all the nonmaterial benefits for people provided by the local environment on spiritual enrichment. Thus, cultural ecosystem service contains complete emotional responses to local environment (eg. attitude, feeling, memories), which could be proposed as an efficient approach to present public attitude relating to local landscape in social-ecological systems. The purpose of this study is exploring an efficient method to predict public attitude for landscape corridor planning on spatial pattern through cultural ecosystem service. The study performs spatially participatory mapping exercises and structured assessments of local cultural ecosystem services and public attitude based on tracking an ongoing cultural landscape corridor case along silk route. Our research is aiming at the following questions: (1) What is the spatial pattern of cultural ecosystem service (CES)? (2) What is the public attitude for the influences that corridor planning bring to the CES-providing region and what's the spatial pattern of local public attitude? (3) How are local public attitude and cultural ecosystem services relating to local landscape features? Through three workshops and an APP that we created for spatial public participation on smart phones, we

conduct open interview, semi-structured assessment and public participatory mapping with local responders living in the corridor planning region. The outcome reveals the spatial pattern of cultural ecosystem services, public attitude, and potential conflict area, which are related to landscape features. The cultivated land provides highest immaterial cultural ecosystem service for residents and performs high level of resist attitude to corridor planning proposal, which predicting the potential conflict area. To sum up, we conclude that cultural ecosystem service assessment provides a bridge for public attitude visualization which incorporates the potential conflict area provides a rich basis for landscape corridor decision making.

Cultural Ecosystem Service, Mapping , PPGIS, Landscape Corridor, Conflict,

1. Introduction

We are witnessing the increasing strategic promotion of landscape corridors in various regions. In decades, a variety of landscape corridors have been developed by regional landscape policy-makers, especially under the promotion of Pan-European ecological network and Green Infrastructure strategy.

However, one problem is, in the ongoing promotion of landscape corridors, public residents' idea and attitude facing the corridor planning movement are largely ignored. The public may present a resistant or supportive attitude and different interests towards the corridor proposal and various stakeholders with various demands (cultural heritage, tourism, agricultural development etc.) involved in landscape corridor planning process may have conflicting interests. Ignoring those opinions may lead to social conflicts during the promoting process. For the perspective of landscape corridor planning, it is valuable to explore the common language for negotiation with various stakeholders.

Cultural ecosystem service (CES) could be used as an instrument to predict public attitude and provide a common language between various stakeholders since ecosystem services framework have been used as a common language for people describe the value, demands and experiences for instance in landscape management [1] Thus, as a category of ecosystem services,

cultural ecosystem service (CES) are defined as all the nonmaterial benefits for people provided by the local environment on spiritual enrichment including cognitive development, recreation, and aesthetic feeling" [2]. Based on the main messages in the Millennium Ecosystem Assessment (MA) [2], people have always influenced the landscape to enhance the availability of cultural ecosystem services values. And the same time, the cultural ecosystem service including human cultures, knowledge, religions, feeling, aesthetic values always have been shaped by the landscape conditions in which culture is based and people lived. Thus, cultural ecosystem service contains complete emotional responses to local environment (e.g. attitude, feeling, memories). Assessment of cultural ecosystem service could be proposed as an efficient approach to present public attitude relating to local landscape in social-ecological systems. To implementing this approach, a deeper spatial understanding of the cultural ecosystem service and conflicts with people is required [3]. Several studies including qualitative and quantitative methods have been developed to explore such CES values and conflicts at various level, for instance, the study on CES of wind framing [4] or CES mapping and assessment in a community [5]. Mapping of cultural ecosystem service provides spatial pattern understanding of subjective knowledge and attitude of residents on the cultural landscape, which benefits for understanding the social

suitability of project and predict the potential conflict between different stakeholders for further planning and decision-making process. Public Participation Geographic Information Systems (PPGIS) have been particularly widely used as they allow putting the cultural ecosystem service values on a map [6].

The term PPGIS “public participation geographic information systems” was conceived in 1996 at the meeting of the National Center for Geographic Information and Analysis [7]. The concept describes the process of using GIS technologies to produce local knowledge with the goal of including and empowering marginalized populations. Based on [transactionalism](#) influence theory of human, landscape and cultural ecosystem service, mapping and assessment of cultural ecosystem service of local landscape express the subjective knowledge and attitude of residents and spatial pattern on the cultural landscape. Using PPGIS to its analytical category will greatly enhance its interpretation of complex social phenomena. Therefore, it is important to explore a GIS-based community subjective activity representation and analysis method to promote community participation and regional harmonious development.

In this study, we link participatory mapping with cultural ecosystem service assessment through PPGIS as an efficient method to predict public attitude and knowledge on a spatial pattern for landscape corridor planning. This study provides a bridge for public attitude prediction and negotiation with the conflicts between public stakeholders and decision makers for further landscape corridor planning. During the planning process of landscape corridor,

conflict and negotiation happened between various stakeholders, for example, the migration and land use of residents living in the region. Due to the weakness and difficulties of expressing residents’ knowledge and attitude, the establishing of working platform is required to express residents’ knowledge and record their daily life behavior technologically.

2. Objective

Our study performs spatially participatory mapping exercises and structured assessments of local cultural ecosystem services, public attitude and potential conflicts between development preferences based on tracking this ongoing corridor case. The specific research questions are (1) What is the spatial pattern of cultural ecosystem service (CES) of public residents in the corridor planning area. (2) What is the public attitude for the influences that corridor planning bring to the CES-providing region and what’s the spatial pattern of local public attitude? (3) How are local public attitude and cultural ecosystem services relating to local landscape features? (4) What’s the potential conflict between the public residents and decision makers? We discuss how our main outcome could provide a bridge for public attitude prediction and negotiation with different stakeholders for further cultural landscape corridor decision making and management.

3. Method

3.1. Study area

The case study area is performed in central towns in Dunhuang-Zhangye part of Heixi Corridor in Western China. As important historical site, this region is located in the Ancient Silk Road which connecting the western and eastern civilization world in the past 2000 years as an important cultural route. The cultural route region obtains numerous temples, trading heritage, cave sculptures and other heritages left by the historical cultural exchange. Grassland and traditional farmland transformed from wetland as oasis area along river in Gobi desert and Danxia landform area represent the most characteristic ecosystems of the area, with livestock breeding and framing having an almost 2000 year tradition. Based on the current linear heritage and landscape situation, the regional government want to connect existing greenway patches by a heritage corridor planning project for preservation of destroyed and degraded wetlands along river and the integration of local cultural and historical features. The “Silkroute Cultural Landscape Corridor ” project aim to develop a regional landscape corridor with recreational and enriching historical/cultural resource, preserving the local natural and cultural values, providing opportunities for economic development and improving existing greenery spaces, establishing new connection between them. Due to different preferences between decision makers and the public, there would be potential conflict on the developing direction between public preference and the current cultural landscape corridor proposal

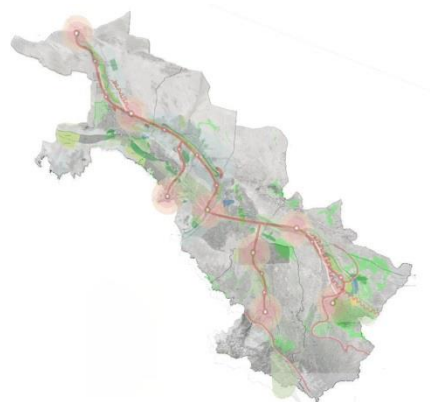


Fig1. The current proposal of cultural landscape corridor planning area

from the municipality. Thus it is important to analyze public attitude spatial pattern by mapping cultural ecosystem service practice and predict the potential conflicts area under the background of ongoing promoting for the Silk Road Heritage Corridor, which providing guideline for supporting further decision making. The cultural landscape corridor proposal coverage is 65.5 km². (Figure1).

3.2. Categories of cultural ecosystem service

Due to the contribution of The MA, 2005, ecosystem services could greatly consider as a key goal and effectively incorporated into policy-making in EU level and even the global. As the identification, cultural ecosystem service is non-material benefits provided by ecosystem and environment for people through spiritual developing, for instance, the enriching of aesthetic benefit, recreation benefit, and cognition of place. “(MA, 2003, Chapter 2,p.58). Thus, among ecosystem services, cultural ecosystem

services illustrate the close relationship with human individual feelings, attitude, preference, and cognition. In our exercise, cultural ecosystem services are selected as the carrier to express local residents' attitude and reveal their daily life and knowledge of the area.

In our study, the categorization of the cultural ecosystem services is mainly based on the Millennium Ecosystem Assessment. But we dropped items like 'knowledge system,'

3.3. Data collection

Our approach applied cultural ecosystem service as the carrier for expressing public attitude and knowledge through participatory mapping and semi-structured interviews into PPGIS system (public participatory GIS). We performed a participatory mapping survey through an online app on a smartphone with the help of a local community. The survey included 9 categories of cultural ecosystem service assessment on cultural ecosystem services that people appreciate and influence to each cultural ecosystem services by the corridor planning proposal. Respondents were asked about the spatial location of each cultural ecosystem service, development preferences and the influence of the corridor planning by face to face interviews. We chose to study local residents as responders including framers, technology staff, administrations, students, and rural tourism homestays as they are key active public stakeholders infected by in the corridor planning projects. Our survey covered full- or part-time local residents who were recruited through snowball sampling. The mapping app obtains the graphic map of the area at

'inspiration', and 'education value' which are difficult explain to residents and less relating to their daily life. Additionally, we integrated potential services relating to the landscape feature of the study area. Finally, we selected 8 types of cultural ecosystem services as following to express local residents' options and attitude as follows: 1). spiritual service, 2). educational value 3). aesthetic value 4). social relation 5). sense of belonging 6). recreation 7). economic value 8). cultural heritage

1:20,000 scale, in which pre-identified current land cover, residents settlement, and heritages for local residents building the sense of space. For the mapping of cultural ecosystem service, we formulated the questions such as "Which place do you think is the most beautiful and attractive scenery in your town (e.g. river view with ancient fire tower) ?" (for Aesthetic benefit). The responders were asked to point out one or more places as the description above. For development preferences, we used these typical indicator questions like "Please mark areas/ places where you believe that vineyard and wine cultural resort could occur". In addition, we asked the reason for choosing each place and they most enjoy the local landscapes. In the assessment part, the responders are also requested to express their main attitude and visions and concerns about the influence of the corridor planning project. A semi-structured assessment was performed to present public concerns about the corridor planning influence to landscapes with each cultural ecosystem service (CES) they mapped through the questions like "What is the influence of the corridor project do you think will affect the place for your recreational activities (for Recreation

benefit)?"'. The Likert scale was used to assign the negative or positive The Likert scale was used to assign the negative or positive influence they thought as table1.

Strongly negative influence	Negative influence	No influence	Positive influence	Strongly positive influence
-2	-1	0	+1	+2

Table1. The Likert scale of public attitude to corridor planning influence to local landscape with CES.

3.4. Spatial analyses

We analyzed the frequency and distribution of each type of cultural ecosystem service and development preferences through descriptive statistics and T-tests for significant associations. We also used significant associations in T-test finding to explore the cultural ecosystem service that people appreciate relating to their different background. The attitude and daily life places of residents recorded by the eight types of cultural ecosystem service with 8 layers for spatial analyses in Arc GIS. The spatial analysis process includes analysis steps as following:

1). Kernel Density: to analysis spatial pattern of cultural ecosystem service and development preferences. We used the places with cultural ecosystem service and development preferences mapped by the residents as the input for ArcGIS. The active variables on hotspots revealed the area attracted most attention by the Kennel Density heatmaps. Additionally, we used the result of the semi-structured assessment as the score to examine the public attitude relating to the places with different cultural

ecosystem service for the corridor planning. We assigned the scores different cultural ecosystem service layers. Finally, Kernel Density was used to generate the score regions which performed the resist and support attitude for the further corridor planning.

2). Compatibility analysis: We built the compatibility index CI system to reveal the compatibility between public attitude and current corridor proposal from the decision maker, which provide the way to analyses the pattern of public attitude and their development preference to find out the potential conflict areas between decision makers and public resident, and among residents themselves.

3) Correspondence analysis: to analysis how local public attitude and cultural ecosystem services are relating to local landscape features. It will provide the outcome of which kind of landscape features would easily have public resist/ support attitude for corridor planning due to their negative/positive influence concerned by the local public resident, and what kind of cultural ecosystem service provided by the landscape features.

4. Result

4.1 Characteristics of respondents

Our survey covered full- or part-time local residents. In total, 200 respondents participated in the survey. The responders consist of 53% male and 47% female. The majority of responders as local residents are

farmers (69%). Of the responders, most of them in our survey are landowners (36%). While there are 24% participants have no registered land ownership even though they are local residents.

4.2 Ecosystem services that people appreciate

Responses to the open question on benefits provided by local landscape were classified as ecosystem services, including freshwater and natural conservations. We asked the ecosystem services that local people appreciate. The most often mentioned concerns about appreciating cultural ecosystem service is the economic benefit (n=133). For other cultural ecosystem service selected from our study categories, recreation benefit (n=98, followed by the sense of belonging (n=97) and social benefit (n =80) are also frequently appreciated by local residents (Figure.2)

In addition, we explored how appreciated ecosystems services relating to people from different background. T-test performed that residents with different landownership will have significant difference preference on the ecosystems services that they appreciate. While there was no difference in their appreciation of people with different age, gender and education level. As shown by Figure3, landowners expressed their appreciation on freshwater (82%), economic benefit (73%), natural conservation (53%). While landowners and people without land had significant differences in sense of belonging (diff =-0.290*) and spiritual benefit (diff =0.340*) among the ecosystem service them appreciate. More than half landowner appreciates the sense of belonging

while 40% people without land appreciates it. Spiritual benefits were also more concerned by the landowner (38%) than people without

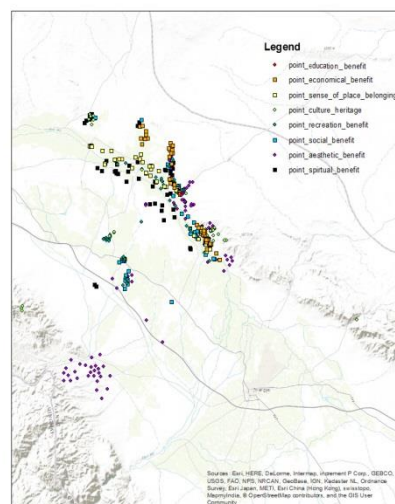


Fig3. Mapping points and the hotspot distribution of cultural ecosystem services

land (22%). To sum up, the people with landownership registered have a stronger sense of belonging and spiritual benefit feeling with people without landownership. (Figure. 2).

4.3 Spatial patterns of cultural services

4.3.1. Mapping of cultural service

In our spatial analysis, economic benefits points were by far the most frequently mapped landscape values (68%), followed by recreation benefit (57%); sense of belonging 52.%, social benefit(50%), cultural heritage (46%), spiritual benefit (38%) ,aesthetic benefit(24%)and education(16%). These cultural ecosystem services were not assigned equally across regions of the

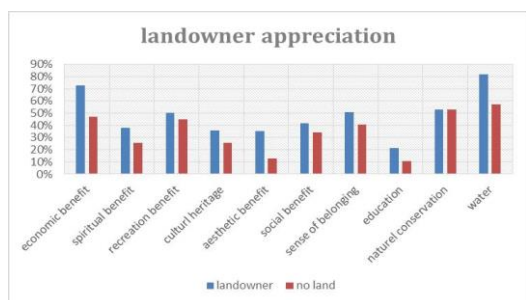


Fig2. The ecosystem services that appreciated by landowner or residents without land

planning region. The distribution of cultural ecosystem service is shown in Figure3.

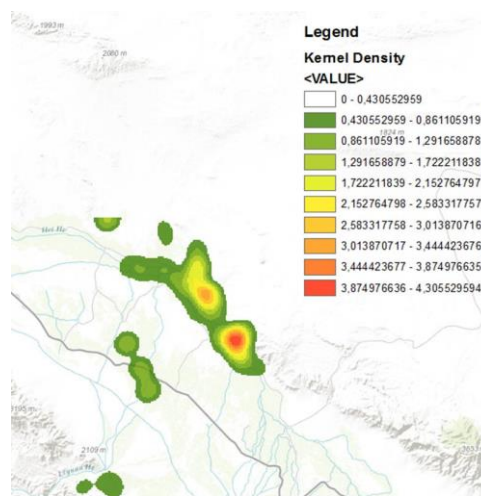


Fig4. Kernel density heatmaps of local cultural ecosystem services

4.3.2. Kernel density heatmaps of cultural services

The outcome of Kernel density heatmaps performs the spatial pattern of local cultural services to specific sites (Figure 4). The highest intensity of cultural services was observed close to the wetland, fishing pools, settlements, woodland and the cultivated land. Richness and diversity of cultural services were also highest around the riverside and cultivated land.

4.4. Public attitude patterns of corridor planning area

4.4.1. Public attitude of corridor planning influence to cultural ecosystem services

A semi-structured assessment was performed to present public concerns about the corridor planning influence to landscapes with each cultural ecosystem service(CES) they mapped through the questions like “What is the influence of the corridor project do you think will affect the place for your recreational activities(for Recreation benefit)?”.As the result, the local public

residents presented their resist attitude for the corridor planning in the sites with economic benefit spiritual benefit and social relation benefits as they thought the cultural landscape corridor may have negative influences to these sites because of the requisition of cultivated land and the land use change probably in the planning process. The trails and reception facilities for tourists across their land also have the negative influence on their sense of belonging. On the other hand, the local public residents presented their support attitude for the corridor planning in the sites with recreation benefit, cultural heritage, aesthetic and education benefits. They believed that the government will invest more to improve the sites by building up more public facilities. The result of influence score to each cultural ecosystem service under the corridor planning was showed as table 3. We assigned the influence score to different cultural service layers to explore the public attitude pattern.

Cultural ecosystem service	Influence score of corridor
Aesthetic benefit	+1.9
Recreation benefit	+1.5
Cultural heritage value	+0.7
Education benefit	+0.2
Economical	-0.5
Social relation benefit	-0.75
Spiritual benefit	-0.9
Sense of belonging	-0.8

Table 3. Influence of corridor planning to sites with each cultural ecosystem services

4.4.2. Public attitude patterns of corridor planning area

We assigned the above influence score to cultural ecosystem service layers and collected the scores in 1000*1000m mesh cell and sum the scores in each fishnet. The outcome is the generate score region by Kernel Density performing the public attitude pattern. The spatial pattern of public attitude are depicted in Figure 5. The green region with negative scores presented the resist attitude of local public residents as they thought the corridor project cause negative influence. Whereas the public residents will support attitude for the corridor planning in the red region with positive scores because of the positive influence of local sites with cultural ecosystem services. The result performed potential conflicts between public and decision makers for corridor planning.

4.5. Relationship to landscape features

The land cover types of the area (forest, cropland, grassland, water body, settlement,

and quarry) are used for different purposes

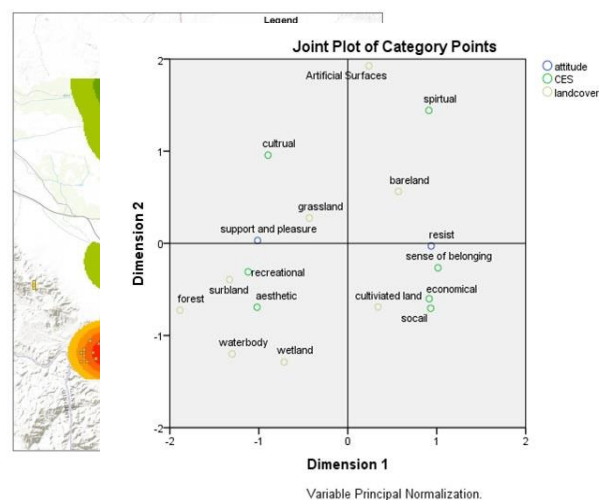


Fig5. The Fig6. Correspondence analysis of landscape attitude : features, cultural ecosystem service and public attitude

and exhibited, therefore, disparate relationships to ecosystem services perceptions. Thus, we made the correspondence analysis to explore how they relating to each other (Figure6).

The most frequently used sites, or those with the highest immaterial value for community members, were related to cultivated land. Bare land, artificial surfaces with spiritual benefit and economic benefit frequently shows the resist attitude for the corridor planning project. Grassland, shrub land, waterbody, wetland and forest: with recreational benefit, aesthetic benefit and cultural heritages shows the support attitude to the corridor planning.

5. Conclusion

The planning of landscape corridor is a complex process referring with the different stakeholders including the public and the decision makers. However, current spatial planning, integrated cultural landscape corridors management have been limited by a weak consideration of public attitude and demanded public attitude prediction and negotiation between different stakeholders to avoid potential conflicts. In this study, we suggested cultural ecosystem service mapping as the bridge to present public attitude for two reasons: First, Cultural ecological services are directly experienced and intuitively appreciated by people [8,9]. Second, cultural ecosystem service could provide a common language to describe different supply and demands [10,11]. which benefits for negotiation of various stakeholder with their own demands. As these reasons, our study used participatory Cultural Ecosystem Service mapping to explore the spatial pattern of cultural ecosystem service and public attitude for the influences that corridor planning region for better understanding potential conflicts between public residents and the decision makers. Such understanding, combining place-based narratives of local public residents and social-ecological knowledge, could provide further advanced improvement for current corridor planning proposal. Thus, we argue that participatory cultural ecosystem service mapping for cultural landscape corridor planning provides a bridge for predicting public attitude on spatial pattern and negotiating with public

residents. The consideration of cultural ecosystem service and public attitude can help avoiding social conflict, improve current planning proposal and contribute to further cultural landscape corridor spatial strategy making.

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Biophilic Approach to Landscape Restoration of the Owuru River Wetlands, Redemption City, Ogun State, Nigeria

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Abstract

The Redemption City is an emerging iconic religious tourist destination in Ogun State, Nigeria. Ten percent of its land area is made up of high bio-diverse fresh water wetlands. Recent environmental crisis facing the Holy City include flooding, deforestation, unauthorised fishing activities, high rate of sedimentation, water ways obstructions and wetlands encroachments. This paper explores biophilic restoration of Owuru River flood plain as much needed added value to the spiritual atmosphere of the Redemption City. The study is underpinned by biophilism and landscape reinterpretation. Biotope mapping of the framing four kilometres Owuru River and its four main tributaries were undertaken to comprehend inherent ecological goods and services. Further social analysis enumerates the goods and services derive from the wetlands. The biodiversity of the swamp forest is dominated by three tree associations namely *Raphia* species, *Elaeis guineensis*, or *Symphonia globulifera*. The core ecological goods include fresh water fishing, peasant farming, ethno-botanic resources; fuel wood sourcing; and palm wine making. Services include wetland water filtration, fluvial flood soft engineering natural control and religious interactions. The goal of biophilic design principles is drawing man towards a positive relationship with nature. Site programming towards Owuru River wetland biophilic restoration is conscious of pragmatic development with site's hydrological system. While allotment gardens and fish farming are introduced to meet the livelihood needs of peasant farmers, praying groves were introduced in clusters. Non-motorized transportation mode including elevated deck board, nature trails and off road bike routes drive low carbon movement within the wetlands. The spiritual landscape sacredness ambience is enhanced in each of the four alcoves, trails, rest stops by numinous, cosmic, and aesthetic principles using native plant species and park furniture. The Redemption City and its biophysically restored wetlands will help illuminate why river landscapes have inbuilt capacity to attract man.

Keywords: Biophilia; Biotope Mapping; Landscape Reinterpretation; Restoration.

1.0 Introduction

The perception of landscapes as the spatial representation of an ecosystem or overlapping ecosystems place emphasis on agglomeration of ecological goods and

services. Landscape then connotes a bank of natural assets on which the livelihood of local people depends. Livelihood is composed of assets, capabilities and activities towards a satisfying means of living. A study of

landscape to isolate ecological goods and services is an important strategy for meeting food security and redefining inherent functions. Landscapes on this platform are considered as socio-ecological systems- a manifestation of community and local ecosystems symbiotic relationship (Adejumo, 2012). It is about making available services for the wellbeing of man and reciprocal management to keep the ecosystem in good health. Provided ecological services display carbon sequestration, tourism, recreation, flood control, bioengineering, water filtration, sense of place and spiritual values.

The latter drives the religious belief system that influence the wellbeing of man as a spirit being. Typical examples are many belief systems where mountains are seen to connect the physical world to spiritual plane of existence. Cultural groups attach the significance of mountains to the sky world (Garrett and Garrett, 1996; Vastokas, 1990). So also are rivers and other water bodies. Gadon, (1991) noted that rivers are primary natural landscape features deemed as sacred and most often associated with female divinity. The confluence of two rivers is seen as very sacred place within the landscape. For Hindus in India bathing in a river and visiting a sacred place liberates one's soul from karma in this lifetime. Rivers as *Tirtha*, in Hindu worldview are believed to be portals crossing from the profane space to sacred space (Gadon, 1991). Many cultural groups from diverse religions background believe in the healing powers of hot springs, mineral springs and sacred wetlands for various ailments (Rossman, 1936; Fishwick, 1978; Cohen, 1981; Kearns and Gesler, 1998; and

Lane, 2002). The human wellbeing is rooted in religious obligations that form the rudiments for spiritual tourism.

Ecological services, including biophilic spiritual values, as link between human and natural systems resonate the fact that the two systems are in a feedback loop in which human culture changes landscapes and landscapes influence culture (Nassauer, 1995). Sustainable derivation of these values then demand ecological restoration of degraded processes to make available inherent resources. That is the scenario in Owuru River wetlands that framed the Redemption City in Obafemi-Owode Local Government Area of Ogun State. The paper explores biophilic approach to landscape restoration of Owuru River wetlands towards the improvement of ecological health of degraded riparian landscape and enhancement of spiritual value. This will certainly boost spiritual tourism perspective of the Redemption City.

2.0 Study Area

The Redemption City is an iconic Christian faith based settlement that monthly attracts hundreds of thousand faithful's in search of spiritual succour. The 4.4 kilometres long and 880 hectares Owuru River wetlands and its four main tributaries freshwater wetland should ordinarily enhance the biophilic and spiritual values of the City but recent developmental activities including illegal logging, unauthorised fishing, land reclamation and peasant farming continue to strip the landscape of its vegetative cover. This is aggravated by fluvial flooding driven by erratic rainfall pattern in intensity and duration. Habitat loss and ecological

fragmentation are major threats to ecological health of the wetlands and the City. Hence the urgency for restoration that will benefit the residents and hundreds of thousands of spiritual tourists that monthly or occasionally patronize the Redemption City.

3.0 Biophilic Spiritual Landscapes

Spirituality is a way of life, an aspect of personality, an experience or simply a way of relating to a higher being in intangible realm. Religion include these spiritual aspects in an organized manner with defined hierarchy, history, and rules. The spiritual aspects of a person, a place, or an object cannot be seen, touched, or heard in many instances but exist as a realm, primarily outside scientific knowledge. Spirituality is then impacted by how humans interact and perceive natural landscapes as well as how the biophysical environment affects human lives. Kong, (2001) example of rain worship for groups living in arid climatic belts is fascinating. The physical and drier environment contributes to the worship of rain as a phenomenon.

This same perception of awe and inspiring natural landscapes with enchanting rivers and geomorphology trigger innate relationship which science classify as ecological goods and services. As noted by Mills, (1992) early men desire to travel down to rivers and wooded pathways to experience invisible realms. Humans delight in nature's sense of beauty, felt the unseen powers and cultivated a sense of holiness. From that distant past until now, humans have found themselves existing not only in the bio-physical and social worlds, but also in the worlds of spiritual imagination. Therefore, spirituality is more about how humans as individuals and

within groups see themselves fitting into duality of realms.

The numinous, cosmic and aesthetic dimensions of spirituality are important in understanding spiritual experiences man has in biophysical world especially at certain natural places. That is probably why Mills, (1992) submitted that the numinous, cosmic, and aesthetic dimensions of spiritual experiences define a spiritual landscape. Mills, (1992) definition of a spiritual landscape is undercurrent that drives Lane, (2002) triple axioms of sacred landscapes. The first axiom is a chosen place to be revealed (numinous). The second is an ordinary place made "sacred" through ritual and efficacy of prayers (cosmic). Thirdly it is a centre that is local and yet universal (aesthetics).

The definition of spiritual landscape for this paper follows the basic ideas of a "sacred place" but focuses only on natural landscapes in combination with the human element of perceptions, experiences and feelings. Since sacred places are often connected to some historical or religious documentation by a cultural group, this paper will free itself from such entanglement bearing in mind the Christian doctrine of the Redeemed Christian Church of God (RCCG), the proponent of the Redemption City. Therefore, the paper opts for the term 'spiritual landscape'. The use of the term spiritual landscape allows for a more encompassing association of different natural landscapes that promotes intended Christian faith. Biophilic spiritual landscapes are more personal and relate to people's personal spiritual experiences at such 'places'.

Planning biophilic landscapes benefit landscape ecology conceptual framework. Landscape ecology is geared towards the identification of the various ecosystems, habitats, flora associations and species relative to the geomorphologic formations. It is also interested in how the local communities relate to the landscape as an ecological pool of goods and services. Since the objective of sustainable living is a continuous derivation of social, economic and cultural benefits from the environment, a biophilic planning that respects the biogeography must be conceived as the final restoration thinking framework for degraded ecosystem like the Owuru River.

This demands landscape re-interpretation. Landscape re-interpretation provides much needed window to understand historic antecedent especially people-nature relationship. Re-interpreting degraded local landscapes is the first step towards appropriate remediation, reclamation, rehabilitation, mitigation and restoration measures. While it is acknowledged that remediation, reclamation, rehabilitation and mitigation differ; this paper will use all-encompassing restoration as the act of bringing degraded ecosystem to its healthy and original state. Restoration of ecosystem actually referred to the restoration of fundamental processes by which ecosystems work. Ecosystem or habitat restoration is therefore restoration of its basic functions and processes that support biotic community. Three issues should be considered in the process of restoration including remodelling of the physical aspects of the habitat; remodelling of the chemical aspects especially nutrients and toxicity; and

replacing missing species or removing undesirable exotics (Bradshaw, 1996). It is apparent that successful intervention demands clear understanding of prevailing ecosystem problems.

It is a fact that services as link between human and ecological systems are opened to both internal and external influences. Hartel et al, (2014) observation of dynamism in social, tribal, cultural, institutional and economic spheres of any community is informative on what constitute agents of landscape changes. On urban scale, change in land use intensity triggered by population upsurge; informal settlements on fragile ecosystem enhanced by rural–urban migration; dumping of untreated sewage in precious wetlands; and insensitive urbanization have high capacities to redefine landscapes.

Mention should be made of unsustainable surface mining activities, poorly managed ‘slash and burn’ farming process and creation of dams with minimal consideration for socio-cultural perception of downstream rural inhabitants. So also are natural phenomena including tsunamis, volcanic activities and climatic anomalies – major force behind devastating flooding and erosion in Nigeria coastline. Since any system can be dismembered physically, mentally and graphically it is necessary to fully comprehend which unit of the ecosystem needs urgent attention. That is, which ecological functions or processes are malfunctioning? What unit or units of the functions or processes are diagnosed and needs treatment?

4.0 Study Protocol

Four stages were involved in this study. The first stage focused on delineating existing drainage network and natural vegetation areas in the Redemption City. Secondary data from topographical maps, 2017 satellite images, previous soil and hydrological studies and field work were used to document existing vegetation and drainage network of the City. The second stage involved biotope mapping to comprehend inherent ecological goods and services.

Three interrelated steps including field surveys through four transect cutting of the wetlands, categorization of plant associations and structured interview of nearby communities to document fauna and fish inventory in the wetlands. Secondary data relied on information from topographical maps, 2017 satellite images and previous ecological studies.

The third stage include synthesis of structured interviews of community opinion leaders to document Owuru River restoration expectations; and questionnaires distributed to monthly tourists focused on understanding desired conservation perspectives especially how their needs can be accommodated in the final restoration scheme. The fourth stage is the biophilic design proposal based on the synthesis of the first three stages.

4.1 Biophysical Setting

Two broad ecological zones including fresh water and degraded low land rainforest are identified. The later supports the various urban layers drained by Owuru River tributaries eastward. It was pristine vegetation with characteristic 3 level

physiognomy some 50 years ago. Intensive human activities especially urbanization and traditional shifting cultivation farming system fragmented the once luxuriant rainforest ecological zone. Patches of secondary bamboo association still remains at upper elevation along the Owuru River. Such patches may sometimes be difficult to distinguish from Owuru fresh swamp.

Degradation of the ecosystem translates to loss of habitat and extinction of typical faunas that roamed the zone some 50 years ago. Owuru swamp forest occupy the poorly drained soil areas of the flood plain. The organic matter contents of supporting soil are very high. The swamp forest is characterized by an even 6 meters' trees height on the average.



Plate 1: Map of the Redemption City Showing the 4.4Km and 880 Hectares Owuru River Wetlands (Edited from Google Earth Satellite Imagery, 2017)



Plate 2: Aerial View Showing the Owuru River Forest

At its prime state the zone is structurally composed of tall trees, open canopy and an impenetrable understory with tangles of shrubs and vines. But most of the commercial tree species within the zone have been unsustainably harvested in the last 50 years leaving thick understory and scattered tall trees with boles less than 600 millimetres at breast height. The biodiversity of the fresh water swamp forest is dominated by less than 3 species at the prominent tree layer.

The conspicuous tree associations are *Raphia hokerii*, *Elaeis guineensis* and *Symphonia globulifera*. All but the later belong to the palm family. The dominance of each of the 3 species is influenced by prevailing edaphic variation, drainage pattern and level of water table. This subdivides fresh water swamp forest into three units namely Raphia Swamp Forest, Elaeis Swamp Forest and Symphonia Swamp Forest (Plate 2).

Owuru River landscape restoration will focus on these three native species in the re-forestation program. This will be supplemented by bamboo species at the transition zone between the wetlands and the degraded secondary rain forest.



Plate 3: Pictures Showing Some of the Fishermen and Farmers Crossing the Owuru River with Local Boats

Mammals observed include *Tragelephaspekei* (Sitatunga), *Crossarchusobscurus* (Mongoose), *Cercopithecusnicitans* (white nose monkeys), *Cercopithecus mona*, *Naja melanolenca*, *Pangolin*, *Giant forest squirrel*. *Veranusnilotius* (Monitor lizard) and *Thryonomy swinderianus*. *Python sebae* are prominent reptiles.

The avifauna community is basically lower forest strata birds including; *Egrets*, *Storks*, *Ducks*, *King Fishers*, *Lily trotters*, *Pin-tailed whydah*, *Babblers*, *Bulbuls*, *Warblers*, *Sun birds*, *Eagles* and *Forest robins*. A diverse range of the butterflies inhabited the fresh water swamp forest. Depending on the season, swarms of different butterfly species are noticed within the floodplain. Fish resources in Owuru River and the four major tributaries include *Tilapia nilotica*, *Tilapia galilaea*, *Tilapia sillii*, *Claria slazera*, *Heterabran chusbidorsaili*, *Heterotis niloticus*, *Gymnarchus niloticus*, *Citrari nuscitharus* and *Lates niloticus*.

The core ecological goods include fresh water artisan fishing, peasant farming, ethnobotanic resources; fuel wood sourcing; and

palm wine making. Services include wetlands water filtration, fluvial flood soft engineering control and religious interactions. The importance of the Owuru River wetlands soft engineering and water purification services cannot be compromised with the reality of incessant flooding in recent years and uncontrollable reclamation responsible for the degradations and high turbidity (Plate 4). The success of the Owuru River restoration will be influenced by the provision of alternative livelihood for the local people.



Plate 4: Owuru River Showing the Level of Degradation and Turbidity

4.2 Socio-Religious Inputs

Restoring the biological diversity of the Owuru wetland demands inclusive planning that respects the inputs of the Redemption City residents and the monthly spiritual tourists. Analysis of questionnaire returned by the tourists show preference for highly vegetated natural parks that accommodate praying alcoves, meditation points and group picnic grooves. These participatory submissions and the biophysical findings constitute the undercurrent for biophilic planning programming of the Owuru River

restoration. Considerations are given to the following in the wetlands restoration programming; reintroduction of four native plant species in the degraded areas and setbacks of the four main tributaries; use of shade trees on the streets; alternative livelihood for local people especially small scale; nature trail, off road bike lanes, rest stops and picnic shelters; meditation gardens and picnic groves.

5.0 Owuru Wetland Biophilic Restoration Framework

Site inventory, analysis and synthesis shows the prime position of the Owuru River and its four major tributaries in the hydrological process, edaphic variation and the vegetation associations in the study area (Figures 1 & 2). Restoration framework focus on meeting the primary purpose of the settlement relative to site ecological goods, services and human needs. The primary goal of the Redemption City is spiritual upliftment of both residents and the monthly tourists. This brings into focus the numinous, cosmic, and aesthetic principles of spiritual landscape (Mills, 1992).

Conceptualizing the wetlands as Christian spiritual landscape looks into localizing biblical scenario that appreciates the hydrological description in the Garden of Eden. The Kings James Version (Tecarta Inc., 2017) account of the Bible identified four rivers that define the hydrological patterns of Eden namely; *Pishon*, *Gihon*, *Tigris* and *Euphrates*. The root meaning of these rivers relative to the names are Pishon which means 'increase'; Gihon connotes 'bursting forth'; Tigris is 'rapid'; and Euphrates means 'fruitfulness'. The four

Owuru tributaries are metaphorically viewed as the four rivers (*Pishon, Gihon, Tigris and Euphrates*) and the four confluences conceptualized as praying and meditation groves to characterize ‘*Increase*’, ‘*Bursting Forth*’, ‘*Rapid*’ and ‘*Fruitfulness*’.

5.1 Biophilic Proposal

The goal of biophilic design principles is drawing man towards a positive relationship with nature. The starting point is nature conscious site planning process. As noted by LaGro Jr. (2008) “sustainable approach to site planning pays close attention to the development intensity, location and considers the initial benefits and impacts of developments”. Ecosystem conscious site planning respects contextual environmental process, highlights protection of fragile natural and cultural resources.

The bottom line is to minimize developmental impacts by fitting human design into ecological patterns and processes. Site programming towards the Owuru River wetlands biophilic restoration is conscious of pragmatic development with site’s hydrological system since the improperly introduced land use and land use changes may negatively impact water quality and quantity.

While allotment garden and fish farming are introduced to meet the livelihood needs of peasant farmers, four praying and meditation groves were introduced in clusters according to the interpreted biblical Garden of Eden rivers cape. Non-motorized transportation mode including elevated deck board, nature’s trails and off road bike routes drive low carbon movement within the wetlands

(Figure 3). The spiritual landscape sacredness ambience is enhanced in each of the four alcoves, trails, rest stops by numinous, cosmic, and aesthetic principles using native plant species and park furniture.

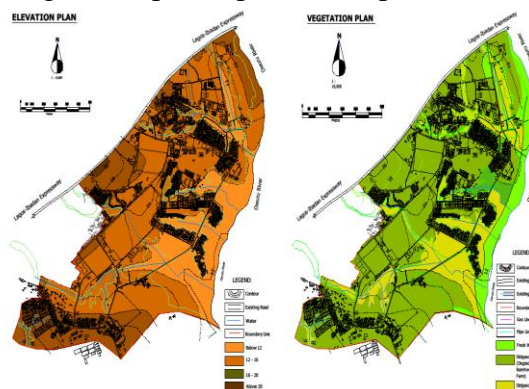


Figure 1&2: Analysis Showing the Elevation and Vegetation Plan

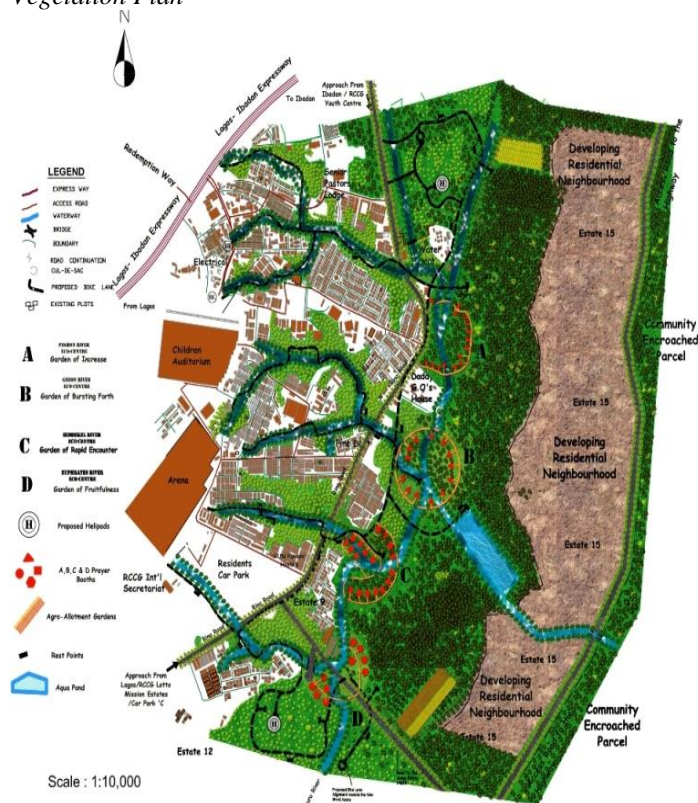


Figure 3: Proposed Site Plan

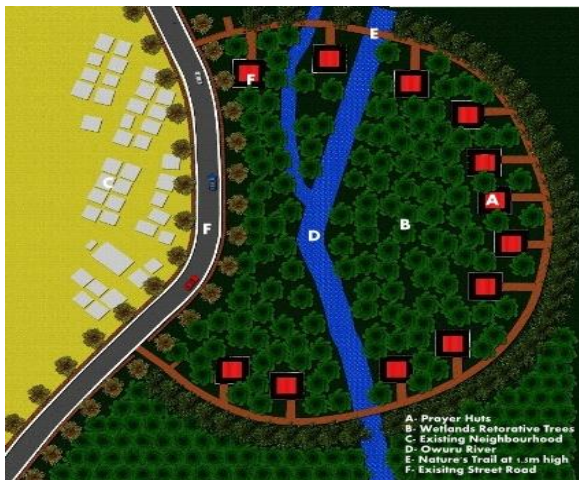


Plate 5: Proposed Prayer and Meditation Alcove (Garden of Increase)



Plate 6: Proposed Garden of Increase (Aerial View)



Plate 7: Proposed Garden of Increase (Aerial View)



Plate 8: Proposed Bicycle Lane/Nature's Trail

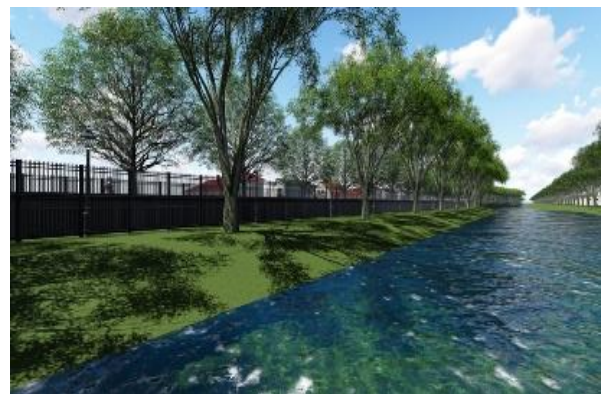


Plate 9: Proposed Owuru River View

6.0 Conclusion

Bio-centric approach to landscape restoration is at the centre of sustainable solutions to the current environmental crisis plaguing humanity. More than other nature conscious design philosophies, biophilia will go a long way in restoring symbiotic relationship between man and nature. This has been the focal point of this paper to engage biophilic perspective as a restorative approach that invokes religious values of the Owuru River freshwater landscapes. Site programming was conscious of the social use of the wetlands by the permanent residents of the Redemption City and attributes that should

enhance the place attachment for the religious tourists. Introduced clusters of small scale aquaculture centre and small scale vegetable allotment gardens provided alternative livelihood for the artisan and peasant farmers.

Raphia hokerii, *Elaeis guineensis*, *Symphonia globulifera* and bamboo species native to the wetlands were suggested as the species for reforestation of degraded patches. They will not only attract the fauna and avifauna resident to the wetlands but also increase the naturalness on which the biophilic essences depend. Then suggested nature's trails, rest stops, prayer and meditation alcoves will manifest desired numinous and cosmic ambience to create place based sacred Christian wetlands landscape.

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Impact of Elements of Rock and Water Combination on Landscape Perception ; a Visual Landscape Quality Assessment on Kaludiya Pokuna, Sri Lanka

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Abstract

Landscape architecture needs to encompass a place making process, carefully composing and manipulating landscape elements to address perceptual needs of humans, especially aesthetical, psychological and spiritual. The objective of this qualitative investigation is to enquire the impact of elements of rock and water combination on landscape perception and related feelings, emotions and behavior.

Past empirical studies have assessed the impact of landscape elements in isolation on user preference, yet the combined effect of elements have been less considered. This research was conducted with reference to the combination of qualities of water and rock through a visual landscape quality assessment focusing on landscape qualities derived from five visual concepts (coherence, historicity imageability, naturalness, and ephemera). “*Kaludiya Pokuna*” archeological site in Anuradhapura was investigated with a sample of university students (n=19, male 14, female 5, age 20-25) using a five point Likert scale via a perception based questionnaire and a visitor employed photographic survey (VEP). Two hypothetical questions were taken in to investigation concerning biophilic (naturalness) and topophilic (historicity) aspects of humans to prefer a landscape with rock and water.

The findings revealed that this combination encourages both biophilic and topophilic aspects, but in varying degrees. The identified hierarchy of visual concepts based on visitor’s preference signify coherence (93%), historicity (89%), imageability (79%), naturalness (75%) and ephemera (70%) respectively. It was further revealed that this combination creates a scenery more coherent dominating information processing aspect of humans to perceive a landscape over the biophilic and topophilic aspects. Different characteristics and secondary landscape effects created by rock and water combination have impacted in transforming a space in to place, fulfilling the aesthetic and spiritual aspects. These findings enhance a means of making places for people, resource management and historical landscape conservation. Equalization of gender based participation, taking diverse cases and increasing the sample size with more analytical photographic analysis are recommended to enhance the quality of further research.

Key words; Biophilic, Landscape perception, Visitors's preference, rock and water combination, visual concepts.

1. Introduction

Landscape architecture is one of the most important disciplines focused on the space designing process for the human, considering not only the fundamental needs but also other aspects like psychological, spiritual and aesthetic needs. Space designing is done composing landscape elements. It can be a combinations or arrangements of hard and soft elements in an artificial or a natural setup. "Human functioning depends on information, much of this information is provided by the immediate environment. There are combinations and arrangements of elements that constantly require deciphering" [1]. It is essential to investigate the most preferred landscape elements and human perception associated with that particular elements, determining the corresponding effect on change in human behaviour, feelings, emotions and expressions.

Water is one of the most important aesthetic and functional elements of the landscape. It is essential to know the visual qualities of water when planning and designing the landscape. "Water in the landscape tends to be dominant because of its visibility, movement, reflections, colour and consequent contrast to adjacent earth surfaces." [2]. Reflection of water as a continuously changing source of beauty in the landscape and reflected light from surfaces link the visual environment with human feelings [3]. But, water cannot generate such qualities being in isolation and should be fused with other elements, preferably hard elements. Human beings prefer isolated hard elements less. The 'yin yang' philosophy explains the nature of

combining opposite elements together to complement the sense of satisfaction. It further describes how apparently opposite or opposing forces may actually be complementary, interconnected, and interdependent in the natural world, and how they may give rise to each other as they correlate to one another [4]. Accordingly, it is evident that, Sri Lankan as well as other eastern landscape traditions, have repeatedly used rock as a hard material combining with water and it has been continuing for a long time in history [5].

The user preference on landscape elements, element combinations and the corresponding impacts on people's perceptions have been less considered in current landscape interventions where the quality of space has been sacrificed enormously due to the impact of economic factors, time factors and political decisions on the landscape design process.

This research focuses on user preference on combination of rock and water elements in landscape and how it impacts landscape perception. The study intends to enquire as to why water and rock material combination has been used repetitively in landscape design, with the use of supportive literature. The influence of above combination on human perception with reference to an array of qualities of water combining with rocks will be looked at focusing on human feelings, emotions, expressions, behaviours and preference to spaces.

It was limited to assess five visual concepts which are related to this combination. The architectural landscape selected included sufficient sceneries with rock and water combination and having

significant religious and historical background.

This research was conducted to fill the gap in empirical knowledge of the landscape perception paradigm. There are a number of research conducted on the landscape style, preference of landscape elements, landscape perception and the relationships of preference of water, vegetation and rock. None of them have examined the relationship of water and rock material combination and how it affects the human perception of a space.

2. Literature review

2.1 Human perception

Perception is the process of recognizing and interpreting sensory stimuli in which information is consequent through senses and a complex sensation of the inner mind, stimulated by outside encouragements. It is an active process which takes place between the organism and its environment [6]. Perception can stem from abstract notions such as memory and preference. This means that it will be affected by that person's experience and empirical knowledgebase as well as the culture in which they were brought up in.

2.2 Landscape perception

Landscape perception is considered as a function of the interaction of humans and the landscape [7]. The human component encompasses past experience, knowledge, expectations and the socio-cultural context of individuals and groups. The landscape component includes individual elements, combination of elements and landscapes as objects. The outcomes of the interaction results are affected by both the human and landscape components. Humans are biological and social beings, therefore several theories have been combined with landscape experience which differ remarkably in the way they treat biological against social determinants of landscape experience. Further it has been discussed on two notions; moods of landscape perception, namely space and place.

2.3 Space to place transformation

It is explicated that humans perceive the landscape in as space primarily in relation to their biological needs in which they focus on the subsidiary use of the landscape. It will be transformed into a place when people perceive the landscape in terms of self-reflection such as experiences, achievements and social integration like values, norms, symbols, and meanings. [8]. Thus, when individuals or groups become familiar with a particular space and link it with their cultural values, social meanings and personal experiences, it becomes a place for them [9]. In other words, personal, social and cultural processes of appropriation

superimposes a layer of meaning on space and thus transforms it into place.

2.4 Topophilic aspects of sensing a space

The word Topophilia, which literally means “love of place” is a strong sense towards place mostly mixed with the sense of sociocultural identity among certain people and a love for certain aspects of such a place. The love of or emotional connections with a place or physical environment is mainly based on visual perception. However, people perceive the environment through more than five senses (seeing, hearing, touching, tasting and smelling) [9]. Topophilia takes many frames and varies greatly in emotional range and intensity; visual pleasure, sensual delight, fondness to place etc.

2.5 Biophilic aspects of sensation

Biophilia is the innate love towards the natural world, supposed to be felt universally by mankind. It is believed to have developed through evolutionary history as a consequence of its functional significance. This hypothesis describes the human needs of intellectual, cognitive and even spiritual meaning of satisfaction, rather than the fundamental needs of physical matters. Biophilia can be further defined as the innate tendency to connect with nature and other forms of life with the aesthetic and spiritual satisfaction [10].

2.6 Information processing theory

Information is the ultimate concept of their approach. Information has been dominant to human experience and survival throughout the evolution of the human being [11]. People need to gain information to make sense out of the environment, but an individual also values environments with capable information for exploration [12]. Further, people gain information from the immediate environment through their senses, mostly through the visual sense. This theory suggests that information is derived through the contents and the organization of the environment. Organization of an environment is an important variable in perception since it affects the degree of making sense.

2.7 Landscape preference

The content and spatial arrangement of landscape attributes could be used to predict landscape preference as suggested in theories of landscape aesthetics [1]; [13]. Further, the impact of these attributes on preference can be objectively measured through preference scores by altering the biophysical attributes in the images [14]. As per the established framework by Ode et al (2006), there are nine key concepts describing visual landscape character namely, stewardship, disturbance, coherence, historicity, imageability, scale, complexity, naturalness and ephemera [15]. Furthermore, reviewing landscape preference research may provide a better understanding on the notion of place

attachment. In the field of environmental psychology, research on visual preference has been developed in such a way to identify and understand the values that people place on different landscapes [16].

Out of the nine parameters which explain concepts describing landscape character [15] the current investigation will look in to the five aspects namely coherence, imageability, naturalness, historicity and ephemera. The justification behind this

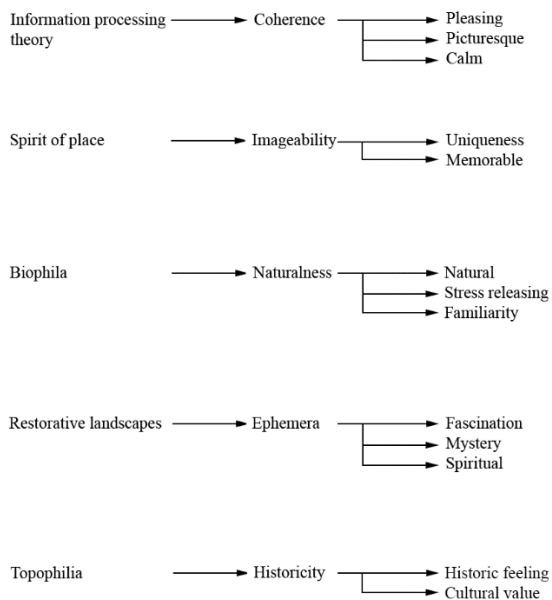


Fig. 1. Preference model, compiled by Author.

selection is that each of these concepts focus on different aspects that contribute to the visual quality of the landscape, where visual quality is a holistic experience of them all. The visual concepts presented are used to describe different characteristics of visual landscapes, rather than presenting a normative value for visual quality.

figure 9 summarizes the relationship between the five selected landscape qualities and corresponding visual concepts described under the landscape perception theories.

2.8 Human perception on rock and water

Meanings and values related to water and rock in the landscape, varies diversely in the sources of literature on human perception, ranging from ancient religious, spiritual and even mythical references to modern technical and scientific studies.

Viewing water in the landscape has been found to have beneficial psychophysiological effects, potentially serving important restorative health needs [17]. Reflection of water as a continuously changing source of beauty in the landscape and reflected light from surfaces links the visual environment with the human feelings [3]. Thus, water plays a vital role directly affecting the overall landscape perception resulting in corresponding feelings and expressions. On the other hand people are found to have a tendency of being closer, attached or being in love with rocks/stones present in landscapes. Accordingly rocks/stones are found to play a main role in appreciation of a landscape connected with an array of meanings, feelings, emotional and behavioral connotations. For instance the deep and intense love or passion of

Chinese culture for rock or stones identified as “Lithophilia”, has encouraged people even to venerate rocks [18].

3. Research Methodology

The method of study was based on a public perception based approach. A visual landscape quality assessment was conducted to understand the landscape attributes, their spatial patterns and their importance to people with reference to thirteen identified landscape qualities that contribute in creating the five visual concepts; coherence, imageability, naturalness, historicity and ephemera. It was attempted to identify the most influential factors on landscape preference associated with rock and water combination present in a landscape.

Two hypotheses were tested via a combination of qualitative and quantitative data collection, namely photo projective method (PPM) [17] and questionnaire survey. The assessment context and the instructions were provided to the observers who were asked to rate landscape quality to express preferences among landscape scenes in a selected location. A sample of University students (n: 19, age: 20 – 25, female: 5 and Male: 14) of the same ethnic group and same region were engaged as respondents for the final data collection. Visitor employed photograph (VEP) method was adopted in capturing the sceneries with a moderation to ensure the quality of the photographs. Two hypothetical questions

were derived by reviewing the theories on the landscape perception as applicable to the subjects of Sri Lankan context. (For the summary of research design see appendix A)

Hypothetical question 1,

Do people prefer spaces with rock and water because of the inherent tendency of humans to connect with nature? This refers to the influence of the notion of biophilia (naturalness) on landscape preference.

Hypothetical question 2,

Are there any influences for the people to prefer a landscape because of the historical influence and cultural identity of rock and water? This refers to the influence of the notion of topophilia (historicity) on landscape preference.

3.1 Case study

Among an array of Sri Lankan historical landscapes where different rock and water combinations can be found, Kaludiya Pokuna was selected as the case to investigate the biophilic and topophilic aspects. It has both natural and historical value without any domination and reputed for its qualities emerged by the said



Fig. 4 – Contextual map - kaludiya pokuna monastery landscape, Source: Google earth

combination.

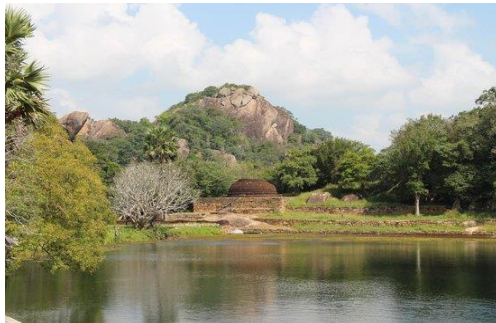


Fig. 2. Reflective dark water pond, kaludiya pokuna.

4. Findings and analysis



Fig. 3 -Rock, water and trees as a combination

Further, the study focuses on a religious landscape because this combination has played a significant role in religious landscapes in the eastern world. It is also one of the monastic landscapes with adequate sceneries with rock and water which is proven to be a designed landscape [5].

As the first step, diverse landscape qualities perceived by participants based on their overall perception of Kaludiya Pokuna was brought in to focus. Secondly the contribution of the elements rock and water to generate such qualities and its impact on the overall landscape perception was considered. Data has been presented and analysed to identify the relationship between the five visual concepts and thirteen landscape qualities. How each visual concept has been impacted by the characteristics which are created by elements of rock and water is being discussed. Furthermore, special behaviours, feelings, emotions and expressions regarding their most perceived sceneries have been recorded via sketches and photographs.

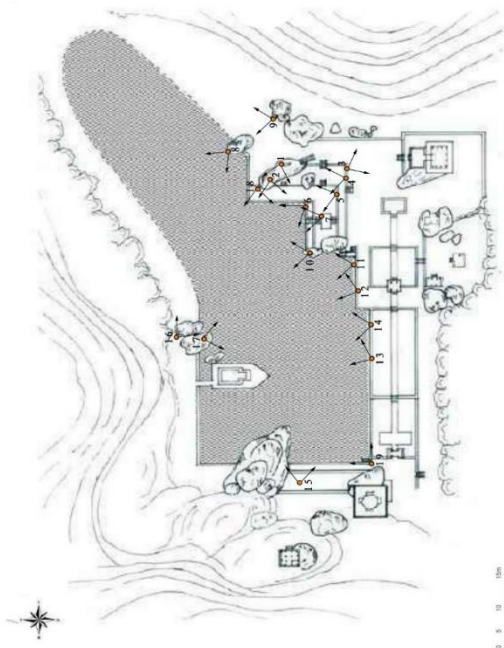


Fig. 6- Most preferred locations to perceive the best scenery of “Kaludiya Pokuna” by participants.

4.1 Landscape qualities in the overall Kaludiya Pokuna landscape

Participants were asked to walk around the landscape and find the location where they perceive the best scenery of Kaludiya Pokuna. Figure 6 presents the most preferred locations to capture the best scenery by each participant (n=19). They were requested to make sketches based on the elements/qualities present in the most perceived sceneries. It was found that the subjects have mostly selected sceneries with elements of rock, water, trees and monuments.

Figure 7 represents the landscape qualities perceived by subjects presented in relation to the five visual concepts.

Figure 8 reflects the fluctuations of five visual concepts with reference to the overall landscape perception. This can be

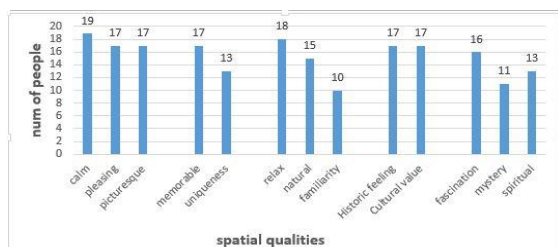


Figure 7

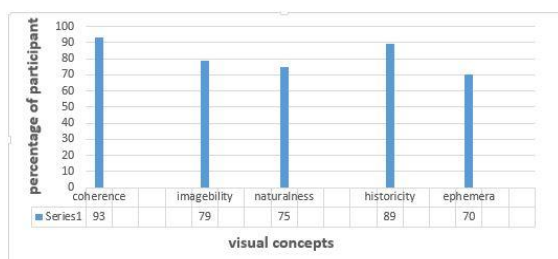


Figure 8

considered as a manifestation of all the elements, attributes of the Kaludiya pokuna landscape. According to the results 93% participants voted for coherence, 89% for historicity, 79% for imageability, 75% for naturalness and 70% for ephemerality. The most voted visual concept is coherence while the least is ephemerality. To get the mean value, it has been considered that all qualities give equal contribution to create a visual concept.

4.2 Contribution of rock and water to feel spatial qualities

The elements rock and water were recognised as influential factors for feeling specific qualities in a landscape. Figure 10 represents the rating for rock, water and overall landscape elements to create visual concepts with reference to the most perceived sceneries of participants.

According to the result, water and rock have highly influenced in creating coherence. But water has dominated in making people feel naturalness while rocks are highly dominating in making them feel historicity. However the results reflect that both water and rock are influential elements in creating visual concepts.

According to the findings, the hierarchy of visual concepts derived are as below.

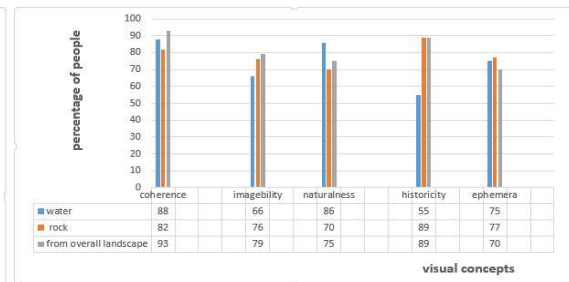
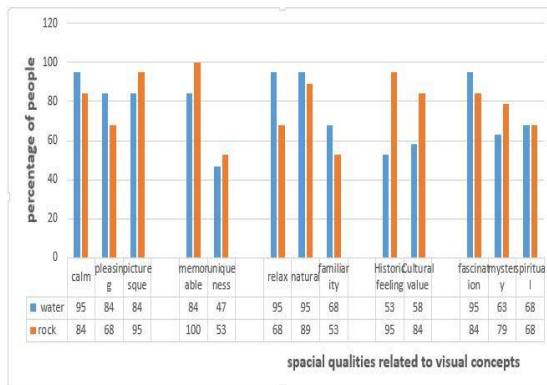


Figure 10- Fluctuation of visual concepts regarding rock, water and overall landscape.

Figure 9- Contribution of water and rock on the perception of special qualities with reference to visual concepts

1. Coherence 93%
2. Historicity 89%
3. Imageability 79%
4. Naturalness 75%
5. Ephemera 70%

designed space. According to the comments of participants it was found that,

- Satisfaction of fundamental needs - 21% of participants
- Satisfaction of spiritual and aesthetic needs - 79% of participants

As revealed by the interviews, it was the first time for most of the participants to visit

“Kaludiya Poking”. They selected sceneries around the pond focusing on the water surface, rock boulders and trees as most preferred, except one participant. Viewing natural sceneries while being in designed spaces of the “Kaludiya Pokuna” were preferred by 74% of the participants. That includes spaces where they have retaining walls and arrangements to sit and witness a natural scenery combined with the surface of water, boulders, trees and the mountain. 26% of the participants preferred to see sceneries which included more designed elements. Thus, a majority of the people preferred to see more natural sceneries with water surfaces, rock and trees while being in a physically comfortable and

As identified in the photographic analysis, though it was a novel space for the participants, they became familiar with the environment linking it with their cultural values and personal experiences. Rock and water were dominant in 95% of the participants’ photographs and 89% of the participants preferred to see a reflective water surface. It was found that people preferred to be in different levels to see the water surface with different viewing angles for a better degree of reflective surface. Further, the distance from the edge of the water surface also differed from person to person. 47% of the participants preferred to observe the scenery keeping a 1-2 meters level difference from the water surface. Significantly, female participants selected

locations which were very closer to the water surface and preferred to see more details in the scenery while males preferred much broader sceneries. Accordingly, findings of the photographic analysis have further strengthened the results of the questionnaire survey.

5. Conclusion

This investigation focused on seeking the impacts of elements rock and water on landscape perception and their influence in generating perceived qualities of a landscape characterised by corresponding human feelings, emotions, expressions, behaviour and consequently preference of a space. The study tested thirteen landscape qualities established to have an influence in generating five visual concepts namely coherence, imageability, naturalness, historicity and ephemera via a perception based approach. The objective was to find the most influential factor /factors on landscape preference and the contribution of rock and water combination in this regard. Two hypothetical questions were taken into investigation. It was found that biophilic association of humans have been influenced by rock and water combination in a considerable level in landscape preference. Further this combination was found to associate with aesthetic, mental and spiritual satisfaction of humans. The biophilia hypothesis was partially proven and it was placed as the fourth parameter (75%) in the hierarchy of visual concepts based on responses. Parallel with the philosophy of yin yang, being a combination of opposite/ complementary;

hard and soft elements, perception of rock and water combination has contributed in providing aesthetic and mental satisfaction for the participants beyond satisfying their fundamental needs. In addition, it was demonstrated that historical influence and cultural identity of rocks have influenced the familiarity and attachment to a space consequently transforming it in to a place. Thus, people become tied with the material environment due to love of place as mentioned in theory of Topophilia. The characteristics and secondary landscape effects created by rock and water combination have affected in creating a strong sense which trigger the human senses to convert even a newly perceived space into a place for people. Therefore topophilic hypothesis has been partially proven and found as the second parameter of hierarchy of visual concepts based on preference (89%).

Thus this combination was identified to satisfy both Biophilic and Topophilic aspects of landscape preference. Accordingly hypothesis one and two are partially correct. However, these are not the only aspects having an impact on landscape preference regarding rock and water element combination. Beyond the expectations of the study, the results revealed that the most influential factor to prefer a landscape is coherence (93%). As per literature, coherence refers to the manner as to how different elements of a composition have been combined together in correct proportions to generate a pleasing visual effect in the environment. Accordingly, harmonisation of rock and water in correct

proportions was identified to create a pleasing effect in a landscape scenery.

This combination was found to assist concentration and relaxation of the mind, releasing fatigue and making spaces more memorable and unique. Imageability (79%) was identified as the third in the hierarchy of factors influencing landscape preference. All the visual concepts were found to contribute in varying degrees with reference to the said combination as presented in figure 11.

It was found that information processing was dominant in perceiving a landscape over the biophilic and topophilic aspects of humans, in preferring a space with rock and water combination.

This study was delimited to the impacts of rock and water combination in the perception/preference of a religious landscape with reference to landscape qualities and corresponding visual concepts. Accordingly, the findings can be applied in future religious landscape solutions as well as for conservation of historical landscapes.

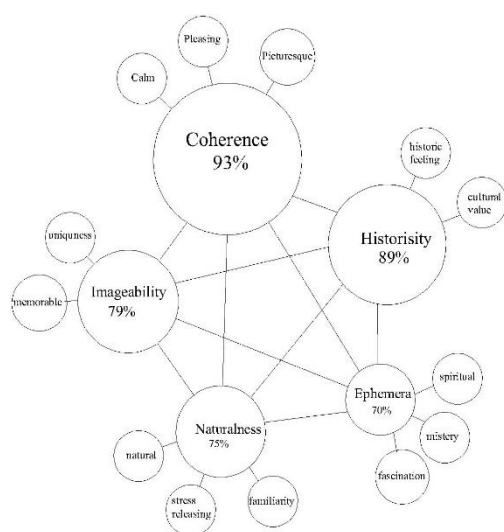


Figure 11– Preference hierarchy of visual landscape concepts regarding rock and water combination

It is recommended to execute the study with a diverse array of landscapes and samples representing the differences of age, education level, cultural background and ethnicity to generalize the impact of said combination to a wider context. Incorporating both male and female participation to equalize the impact of gender based perception and increasing the sample size can be suggested for a more valid result.

Further, a more analytical photograph analysis can be suggested; conducting a comparative volumetric analysis on proportions of the elements visible in photographs and locations of the participants.

Acknowledgement

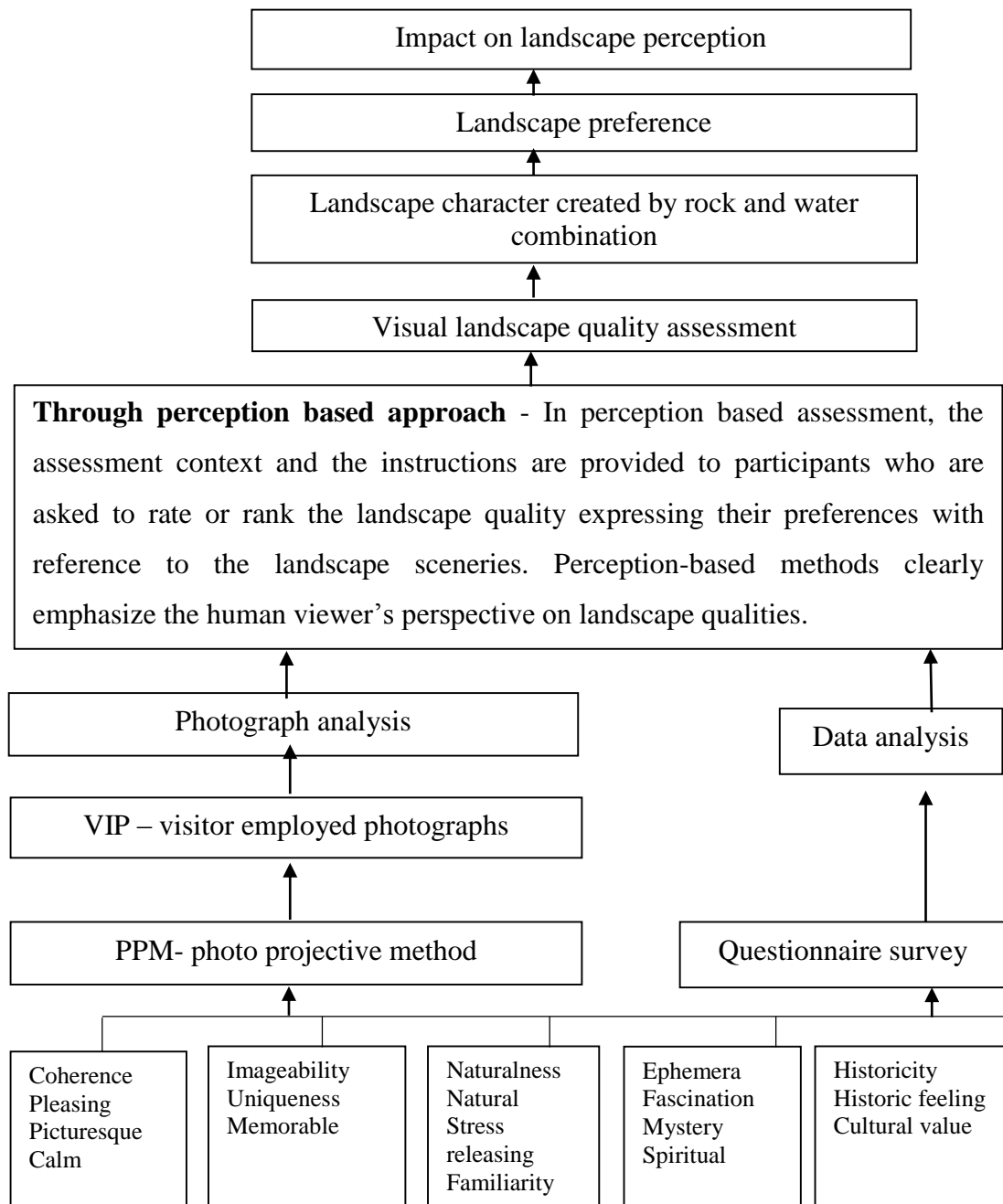
This is the opportunity to appreciate the persons who were behind me to make this dissertation a success. It was only because of the immense support, assistance, criticism and encouragement offered by many persons that I was able to complete the endeavor. I must mention the supervision and guidance of Dr. Anishka Hettiarachchi. Her commitment is appreciated through and through. And Prof. Shirani Balasooriya for her patient advice. And also thank department head Dr. Gamini Weerasinghe for his support, Prof. Samitha Manawadu for giving the directions. Archt. D. P. Chandrasekara and Archt. Janaka Dharmasena for guiding the whole way. I thank my parents for their support in every way. None of this would have been possible if not for them. And friends who helped me without even a little bit of hesitance must be mentioned Binushka Jayasanka, Aruna

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Appendix A



Research Design

Fig. 5- Summary of research design, compiled by author

A STUDY OF THERAPEUTIC LANDSCAPE AS A MEDIA ON REHABILITATION FOR JUVENILE DELINQUENTS

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Abstract

Current situation of Sri Lanka face critical conditions on therapeutic landscape installments. Juvenile delinquents in probation centers has unique refracted behaviors according to what they perceive. This study discusses if these landscape spaces truly fulfill their need or are these spaces functioning just because they doesn't have a better choice to satisfy their requirements.

Methodology of this study flows through a Literature survey and case study survey. Case study survey has done by using research tools like questionnaire, Behavioural mapping, observations and Social development scaling method through Linkert Scale.

Moreover, this study explores six factors of therapeutic landscape architecture. Namely these factors represents as variety, extent, scale, enclosure, fascination and interaction. Contribution of the landscapes in Thaldena and Weraluwatte child probation centers in Sri Lanka were critically evaluated. Finding shows the effect of these factors on rehabilitation of juvenile delinquents.

This study discusses on the issues related to less implementation and appreciation of therapeutic spaces. Furthermore it analyses how above therapeutic factors support to rehabilitate juvenile delinquents. The study will support to create guidelines for future landscape architects to overcome issues of designing therapeutic landscapes.

Key words- Therapeutic landscape architecture, rehabilitation, Juvenile delinquents

1. Introduction

Therapeutic landscape architecture has the ability on healing human critical psychological conditions. This landscape architectural method has being used as a media to rehabilitate scattered psychological conditions for Juvenile delinquents, Prisoners, drug addicts, cancer patients, elderly people and many distinctive conditions. [1](Darbouze, 2007), (Rebecca,

2007). Both natural and built environment helps to buildup such landscapes. Therapeutic landscapes lays its main foundation on an investigation on user behavioral, government regulations and restrictions, visual impacts on users, and interactions.

A landscape architect has the ability to give solution for dispersed psychological conditions. Among all the people who dealing with this situation juvenile delinquents are getting attention of a special

requirement of rehabilitation in the future. One of a restorative method that can heal wounded situation of a juvenile delinquent is therapeutic landscapes within outdoor space.

1.1. Research need

There are many juveniles that has not being able to rehabilitate properly through the appointed process. Current research shows that the environmental aspect plays a main role of the psychological restoration. Landscape architects has the ability to contribute a restorative media for human mind. When designing restorative spaces designers intend the space will benefit to people to stress restoration [2](Kaplan, 1992). Unfortunately, there are lacking areas in Sri Lankan restorative landscape designs. This situation effects negatively for people because landscape design is the main bridge between human and nature since it fills the gap in-between natural and built environments [3](Xiangqiao Chen & Jianguo Wu, 2009). As the matter of fact therapeutic landscape spaces is the key to ease human mind. When the connection between human and landscape loosened, human mind become more unstable and it is hard to heal human mind without the influence of landscapes.

The contribution to the rehabilitation is becoming low due to the less implementation and appreciation of healing architecture. This additionally effects on “spatial profitability” which can be defined as the profit we can gain from a landscape design project. If people uses the designed spaces for their wellbeing effectively, that landscape design is low in spatial profitability.

Delinquents’ ultimate rehabilitation outcome is becoming low due to this less

implementation of space. Which discourage safer future to the society.

To minimize this issue this therapeutic landscape designs must give much creative and satisficing solutions which are contributive to juvenile needs. For that, the factors which should be in this designs have to be found and the designers have to consider that factors to give much profitable, much responsive, much restorative and relaxing therapeutic spaces.

This study is an effort to study about the architectural attributes to create much effective rehabilitation media through landscape designs.

1.2. Research problem

Are there any factors in an effective therapeutic landscape designs which affect for juvenile delinquent’s successful rehabilitation? If so, what are they and how they affect?

1.3. Objectives

Objectives are to identify the factors which affects for rehabilitate juvenile delinquents within designed therapeutic landscapes, and to find how these factors support to create comfortable and effective rehabilitation through the process of juvenile rehabilitation.

1.4. Methodology

(See Appendix 1 for a flow chart showing the methodology) above diagram describes the flow of methodology. This methodology conducts a mixed method which involve qualitative and quantitative study.

1.5. Case study criteria

Weraluwatte and Thaldena rehabilitation centers in Sri Lanka will be selected to study the effect of therapeutic landscape effect. Above rehabilitation centers are popular among people as the best juvenile rehabilitation centers in the county. Both centers have their unique landscape qualities. These two probation centers has highly concern about the surrounding environment on rehabilitation. Furthermore these centers has applied therapeutic landscape measures on immediate landscape. Nevertheless these centers have comparative levels of therapeutic landscape implementations. These places are ideal for a comparative study to analyze the study criteria.

1.6. Outcome

This research will explore and present the factors which influence effectiveness of restorative therapeutic landscape design aspects with special reference on rehabilitation of juvenile delinquents. It will give guidelines for landscape architects to overcome issues of designing therapeutic spaces. Through that the utilization of therapeutic landscape designs will increase and also it will contribute to maximize the profit we gain from that space.

1.7. Scope and limitations

This study will be limited only to consider on rehabilitating juveniles through therapeutic landscape architecture. Juveniles are open to outdoor till morning to evening. These spaces are mostly functioning at day time, in cause of the government regulation

the study will be limited only to day time observations. There are many aspects to measure the effectiveness of designed landscape spaces, but this study will only be done by observing main user behavior. Also there are many factors which contributes to increase effectiveness of designed landscapes according to scholars' opinions, but in this study only six parameters will be measured out of them. Also there are number of methodologies to move on with this research area and only questionnaires, behavioral maps and cognitive scaling methods will be used to do this study. Only three case studies will be selected and this whole study will be done within a time lime limitation of five months.

2. Therapeutic landscape and rehabilitation of juvenile delinquents.

2.1. Therapeutic landscape architecture

Designed therapeutic landscapes are environments which can restore stressful mind conditions. These design interventions are popular for creating a rehabilitative surrounding for special need users. [4] (Sanoff H. , 1990) Restorative environments makes human restorative experience enhanced to reduce mental fatigue. [2] (Kaplan S. , 1992) These designs contribute users to be more tolerant, more effective and healthier lifestyles.

People always tends to navigate themselves by following surrounding environment. [5] (S. Kaplan & R. Kaplan, 1982) few restorative landscape architectural properties can build up a therapeutic landscape space. These spaces navigate human behavioural patterns by effecting on human cognitions.

[6] (Schulz & Christian Norberg, 1971) Surrounding landscape helps to rehabilitate juveniles' psychological conditions. In designed therapeutic outdoors juveniles acts calm and tamed with each other.

In addition to psychological and emotional benefits that the landscape can bring some studies suggest it could actually gain some positive social interactions as well. Such as these landscape open a chance for self-appreciate, helps to gain mind restoration and also to makes a room for interact with each other's. These value of benefits makes a child to uplift their positive behaviours toward the society.

2.2. Rehabilitation of Juvenile delinquent's psychology

Juveniles are separated from their existed social background, relatives, friend and family on their probation period. They begins a new life with a foreign society. Replacement of day today life is foreign to an adolescents, which may lead to stressful situations.

Studies shows juvenile delinquents behave very aggressively and untamed inside build surrounding. [7] (Glaser, 1992) although it is, the inner child behavior of a juvenile always outtakes on their play times. Outdoor spaces helps the children to integrate with themselves and also with the surrounding population.

Several rehabilitation centers around the world has respond to landscape architectural factors in terms of spatial qualities. Rehabilitation by designed spaces helps to achieve a successful outcome of a child.

2.3. Theoretical background based on therapeutic landscape architectural

solutions on rehabilitation of juvenile delinquents

When considering medical-geographical rehabilitation, therapeutic landscape plays a major role of emphasize human psychological recovery. Researches has found to heal broken philological conditions of human cognitions through medical geography. [8] (Smith, 2005)

Restorative experience can introduce through a form of therapeutic landscape architecture. An allusion to Kaplan, human mental fatigue can be reduces through restorative environment. [2] (Kaplan S. , 1992)

Sensory experience of the surrounding environment can appreciate physical and psychological wellbeing. Osei has found, special care needers gets a positive benefit through sensory design in therapeutic architecture. The human five senses stimulated by different sources provided by the environment.[9] (Osei, 2014)

3. Theoretical Framework and Methodology.

3.1. Theoretical framework of the study

When considering the studies of different articles there are many landscape architectural factors effect on juvenile delinquent's psychology. This factors are categorized as Physical landscape, social landscape and emotional landscape spaces. This study elaborates six factors which influence human behaviors.

1. Variety (Physical attributes)
2. Extent (Physical attributes)

3. Scale (Physical landscape)
4. Degree of enclosure (Emotional landscape)
5. Fascination (Emotional attributes)
6. Interacting areas (Emotional landscape)

(See Appendix 2 for a figure showing factors influencing juvenile's psychology)

3.1.1. Physical attributes of therapeutic landscape architecture

According to therapeutic landscape architecture many factors helps to elaborate human psychological rehabilitation. Physical attributes are the factors which created physically through built environment. These factors helps juvenile to accelerate their positive thinking and mind rehabilitation. Some of the factors can be identify as variety, extent and scale.

3.1.2. Emotional attributes of therapeutic landscape architecture

Above various factors of therapeutic architecture medicinal and most mind restorative attribute are emotional landscape attributes. Therapeutic landscape architecture has the ability to influence positive attitudes of human through mind restoration. Some unique factors of therapeutic landscapes can heal scattered human minds. These factors can be identify as Degree of enclosure, fascination and social interacting areas

3.2. Physical attributes

3.2.1. Variety.

Variety gives choices for people. Human mind always seek for various opportunities in environment. [10] (Eco, 1980) May be too much choices also can be uncontrollable, but in every space there should be variety to some

extent. Both functions and spaces should have variety to suite human needs and improve the opportunities to feel and enjoy that whole space. Variety of spaces can be created by giving various facilities, uses, forms, elements, etc. Variety can helps to accelerate mind enthusiasm without being board. Variety can enrich the therapeutic quality through a balanced involvement of it.

3.2.2. Extent.

Extent is highly effective factor of therapeutic landscape. [2] (Kaplan S. , 1992) one can encounter his or her spiritual contemplation through enjoying distance vicinities. Current researches shows that two different characters in distinct places which is visually connected, helps to rehabilitate scattered psychological conditions.

3.2.3. Scale

Scale effects for human mind and comfortability. Glaser has shown scale as an important factor of a therapeutic measure. Human scale is important to scale the elements around the therapeutic design. As delinquents psychological measures they get scared and nervous through huge elements on existence.

3.3. Emotional attributes.

3.3.1. Degree of enclosure

Degree of enclosure is very sensitive architectural factor that can effect a delinquent psychology. [11] (Thiel, 1986) On a perspective of a landscape architect, juvenile delinquents can be encourage to feel safe by controlling of the degree of enclosure of landscape spaces. Degree of enclosure of the space can offer in from different forms,

angles and special characteristics within the space.

3.3.2. Fascination

According to Professor Kaplan's findings fascination is one the most unique character of a therapeutic landscape. [5] (S. Kaplan & R. Kaplan, 1982) A designed landscape can cater for human's emotional fascination in order to generate restorative experience. Restorative experiences depend upon interest or fascination. Fascination allows juveniles to function without using direct attention.

3.3.3. Social interaction

As above statement social interactions helps to enrich restorative experience for mind rehabilitation. [8] (Smith, 2005) Juvenile delinquents are judicially appointed to being apart from the society. Although this is a judicial requirement for delinquent, in order to rehabilitate juveniles need to be expose to the society. Landscape spaces can enhance considerable amount of social interactions among outside people of the center and also within the center. This human relationship consolidation can help to heal bad influence, rage and fear of juvenile delinquents towards people.

3.4. Methodology

Most of similar studies have done by using mixed methods. Photographic surveys are usually used to prove and analyze observations. In some studies there are number of case studies and in some studies few cases were selected in within one case study. This method also seems to be effective. Also using cognitive mapping will be effective because this studies are dealing with adolescence behaviors.

So it will be better if this study also can move on with mixed method. Both Qualitative and quantitative. Also photographic survey will be important to prove and analyze observations. Selecting one or two case studies and within that case studies, selecting few cases to study will be effective. Use of tools like behavioral maps and cognitive maps will support to select this cases and to further study on human behavior within that spaces.

4. Case studies and data presentation

4.1. Case study 01 : Weraluwatte child probation center

4.1.1. Physical landscape attributes.

4.1.1.1. Variety

See appendix 3, appendix 4 and appendix 5 for bar charts showing data relatively on variety of space, variety of facilities and variety of visual experience in Weraluwatte child probation center.

4.1.1.2. Extent

See appendix 6 for a bar chart showing extent in Weraluwatte child probation center.

4.1.1.3. Scale

See appendix 7 for a bar chart showing scale in Weraluwatte child probation center.

4.1.2. Emotional landscape attributes

4.1.2.1. Degree of enclosure

See appendix 8 for a bar chart showing degree of enclosure in Weraluwatte child probation center.

4.1.2.2. Fascination

See appendix 9 for a bar chart showing fascination in Weraluwatte child probation center.

4.1.2.3. Social interaction

See appendix 10 for a bar chart showing social interaction in Weraluwatte child probation center.

4.1.3. Juvenile Behavior

See appendix 11 for a map showing juvenile behavior in Weraluwatte child probation center.

4.2. Case study 02: Thaldena Rehabilitation center

4.2.1. Physical landscape attributes

4.2.1.1. Variety

See appendix 12, appendix 13 and appendix 14 for bar charts showing relatively on variety of space, variety of facilities and variety of visual experience in Thaldena rehabilitation center.

4.2.1.2. Extent

See appendix 15 for a bar chart showing extent in Thaldena rehabilitation center.

4.2.1.3. Scale

See appendix 16 for a bar chart showing scale in Thaldena rehabilitation center.

4.2.2. Emotional landscape attributes

4.2.2.1. Degree of enclosure

See appendix 17 for a bar chart showing degree of enclosure in Thaldena rehabilitation center.

4.2.2.2. Fascination

See appendix 18 for a bar chart showing fascination in Thaldena rehabilitation center.

4.2.2.3. Social interaction

See appendix 19 for a bar chart showing social interaction in Thaldena rehabilitation center.

4.2.3. Juvenile behavior

See appendix 20 for a map showing juvenile behavior in Thaldena rehabilitation center.

5. Data Analysis.

5.1. Delinquent's behavior in designed landscapes

5.1.1. Design following behaviors

Design following behaviours are human behaviours which follows the expectations of designer which were tried to gain by measures, materials and other therapeutic elements used in that particular therapeutic landscape. These behaviours occur due to mind rehabilitation needs of delinquents through landscape. If the landscape has facilitate these needs it is comfortable to the user.

5.1.2. Design against behaviors.

Design against behaviours are human behaviours which doesn't follow the expectations of designer. These expectations were tried to gain by using standard architectural measures, aesthetical measures, materials and other landscape elements without considering therapeutic measures. As a matter of fact many unexpected user behaviours may occur. Ultimately designer's main target will be failed. These are design

against behaviours. These behaviours occurs due to specific therapeutic need of delinquents. Lack of therapeutic consideration leads to this kind of behaviours.

5.2. Weraluwatte rehabilitation center

5.2.1. Design following behaviors

Many of the designed spaces are represent positively on juvenile's behavior. As examples:

1. Playing and creating social bonds with other people through interaction in the play area as designer expected.
2. Pathways are designed to walk in a disciplined manner. Anthropometrical dimensions are used to gain this situation.

5.2.2. Design against behaviors.

Some of the design spaces are not functioning according to designer's expectation. As examples:

1. Looking through throne wrenches on to borrowed landscapes.
2. Exceeding expected users on seating designed to accommodate only one person.

See appendix 21 for a line graph showing Linkert social development analysis in Weraluwatte child probation center.

5.2.3. Linkert social development analysis

This chart indicates the average marks delinquents which has been given by their psychologist. These mark has being given on two months observation on their behaviour. Darker line indicates the scaling done after two months of first scaling. According to this chart it shows that the

juveniles' social skills has considerably upgraded.

Above analysis indicates delinquents are positively responds to the therapeutic factors of the landscape and successfully rehabilitate within the landscape.

5.3. Thaldena rehabilitation center

5.3.1. Design following behaviors.

Many of the designed spaces are represent positively on juvenile's behavior. As examples:

1. Views towards the lake
2. Integrating peers while gardening
3. Contemplating through spiritual landscapes, designed using scale and colour factors.

5.3.2. Design against behaviors.

There aren't many design against behaviors in this center. Although it is some of the spaces occur minor behavioral conflicts. For example unauthorized seating on the river bunt as unsafe behavioral pattern. See appendix 22 for a line graph showing Linkert social development analysis in Thaldena rehabilitation center.

5.3.3. Linkert social development analysis

According to this chart delinquents has develop their social skills through the landscape. Scaling done on July is higher than the scaling done on August. Therefore above ranking visualize juveniles needed therapeutic outdoor surrounding.

6. Conclusion

Weraluwatte child probation center and Thaldena rehabilitation center has provided therapeutic measures through landscape architecture. The administration in both facilities understand that outdoor space is essential to the wellbeing of delinquents and recognize the need bough from the government law. Since there are no regulations or represents for the outdoor spaces in probation centers, there can be installs mind soothing spaces in order to help rehabilitation process.

This study was started with the objective of finding the factors which influence effectiveness of juvenile behaviours in therapeutic landscapes. Through the study six factors which can be name as variety, extent, scale, Degree of enclosure, fascination and social interaction was identified as they can influence on juvenile's rehabilitation thoroughly.

A good therapeutic landscape should create a sense of place and make the expectations of complete rehabilitation on juvenile delinquents. For that, above six factors should be introduced to the designs to the certain extent they are required. This factors effect on healing scattered mind conditions and rehabilitate user perception.

To reach this absolute landscape architecture landscape architects, architects, designers, urban planners and many others in the field have to understand the human needs and human psychology. They should understand that following the standards is not designing. By solitary following the anthropometrical measures we can't achieve what we need. Designer or landscape architect have to understand human

dynamisms and locomotives. He should understand changing human needs and feelings. Also landscape architect should smoothly identify the opportunities given by the site and convert these opportunities to fulfill the needs of the user. Landscape architecture can be a killer or healer both. Landscape architects has the responsibility and the ability to heal people through their design.

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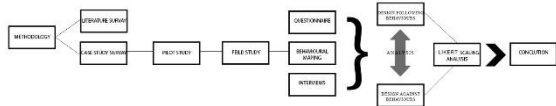
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Reference

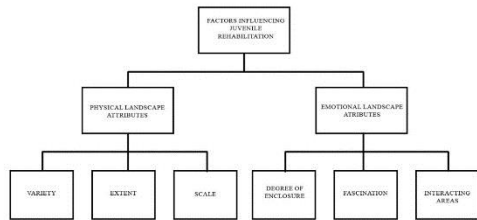
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Appendix

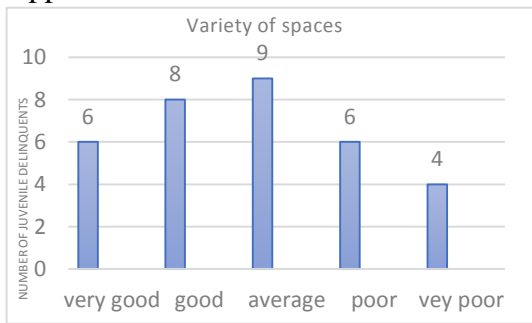
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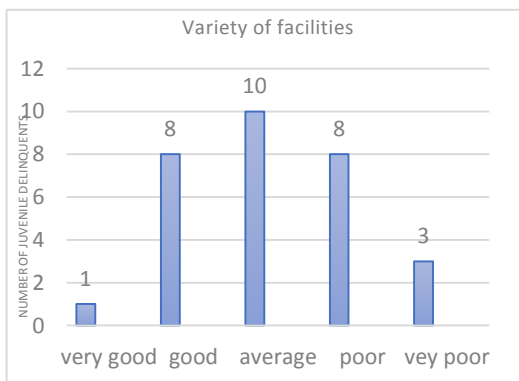
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Appendix 3



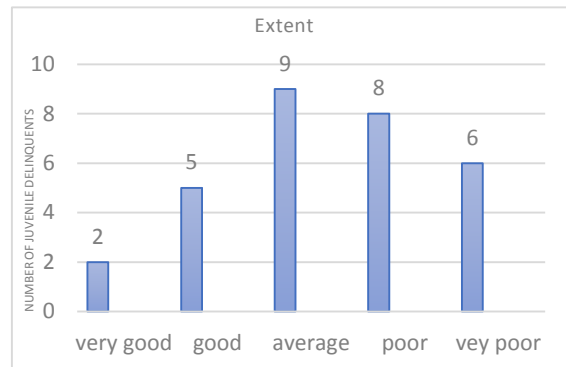
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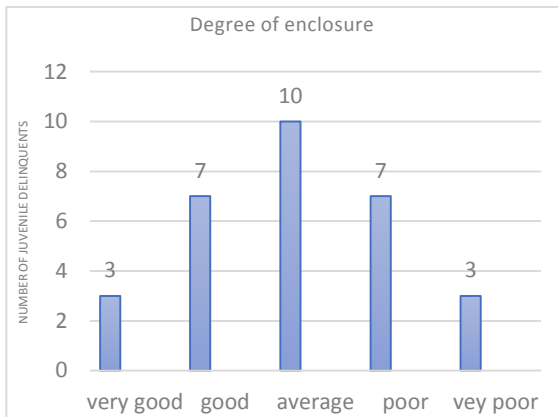
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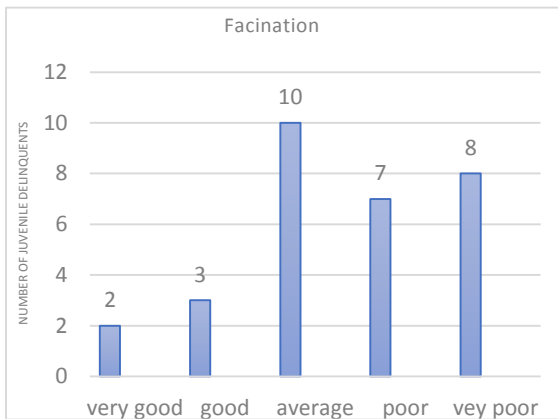
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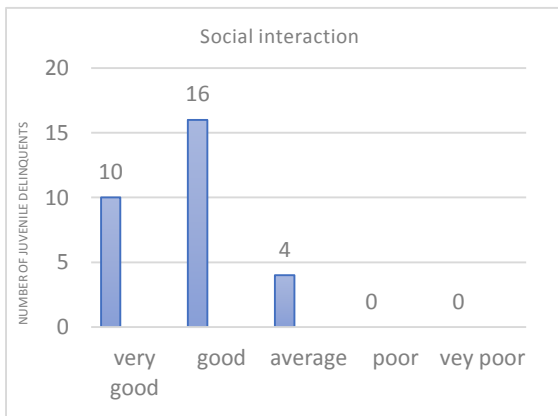
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Appendix 9



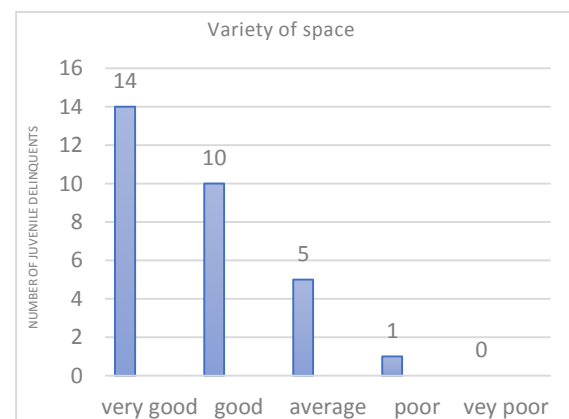
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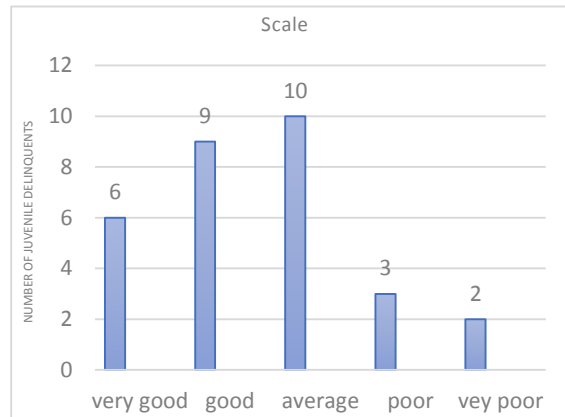
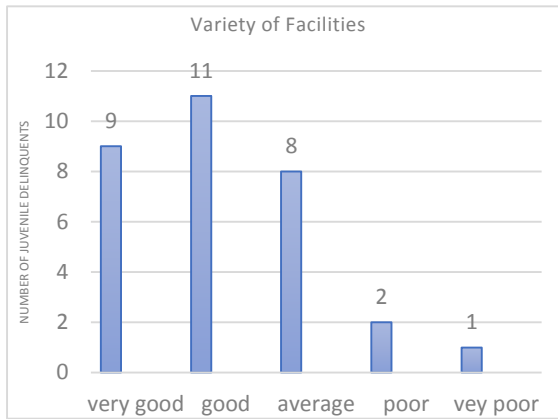
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Appendix 12

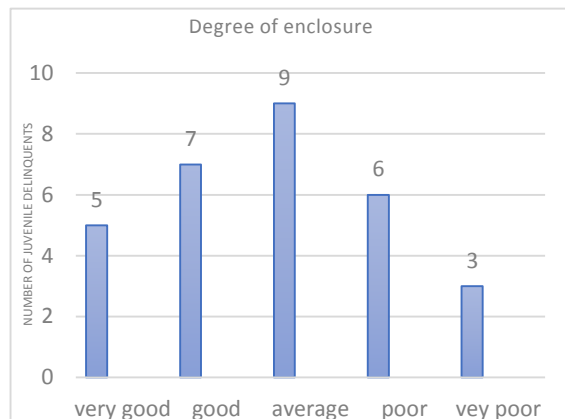
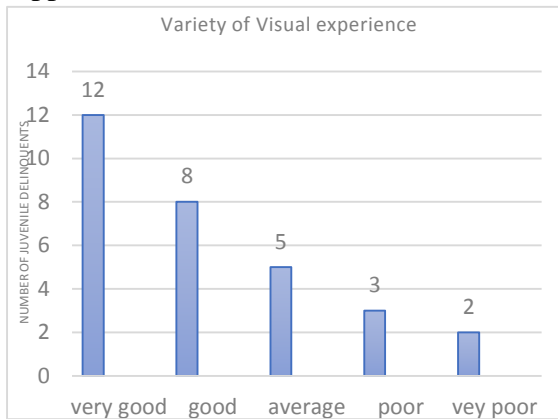


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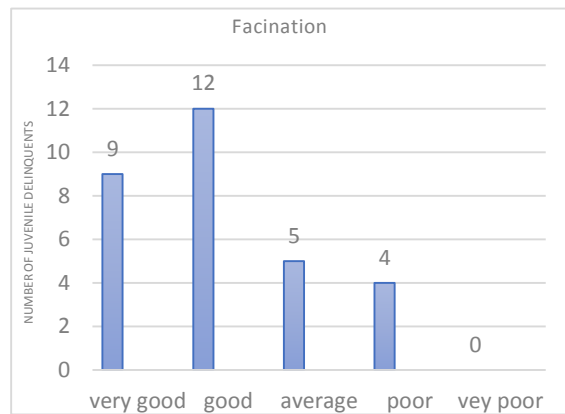
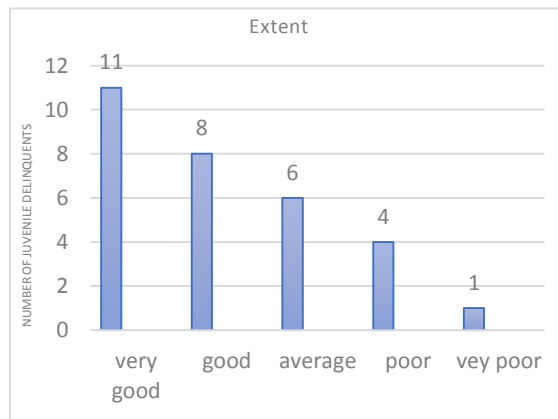
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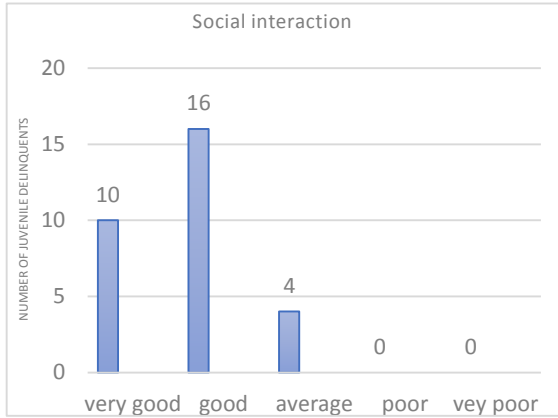
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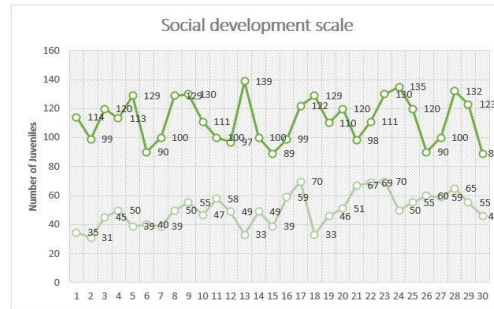
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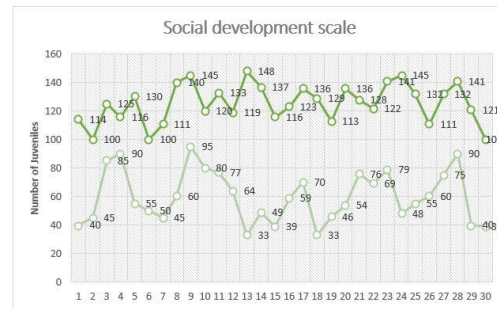
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Appendix 21



Appendix 22



Applied Biophilia to the AusZen Garden in Determining Visual Preference

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Abstract

There are visual factors that can determine possibilities of testing aspects of biophilia within a visual context. The biophilia concept utilizes a foundation for an environmental land ethic that E.O. Wilson characterizes as a genetic disposition that links human survival to valuing living systems. Considering biophilia or ‘the love of life’ (Kellert and Wilson 1993) as an interconnecting feature of biotic systems is a description rather than evolutionary as explained by J. Baird Callicott. Using biophilia principles as a primary reference of human relations to gardens; in this case a Japanese style links with its natural historical underpinning using current research, and to examine if this translation into Australia, using native plants effects the preference of the AusZen garden. Browning pronounced evidence-based biophilic design principles that results in positive outcomes including being ‘smarter at work.’(Browning 2012). Other factors including stress recovery and enhanced high order cognitive functioning identified previously by Ulrich (1993) where over 40 years of research conducted on aesthetic preferences for varying landscapes. This research provides empirical support for the biophilia hypothesis (Gullone 2000). Identified patterns of biophilic design summarised as ‘direct experiences of nature’, ‘representations of nature’, and ‘spatial experiences found in natural settings’ (Browning 2012) to results linked improvements in concentration, reduced stress, comfort, interest levels, heart rates and blood pressure, emotional responses, well-being and cognitive performance. Specific biophilia pattern aids production of creative, therapeutic, productive spaces. Evidence suggests effective biophilic spaces may display several of these patterns in tandem, either multiple possibilities or singular patterns. In testing the ‘AusZen’ design, the set of select and modified patterns replaced with an indicative visual plant focus. Examining Nature in the Space correlates with a visual connection to nature, from an observed view preference. Disseminated the Japanese garden style, ‘AusZen’ into quantifiable visual data patterns, derived from tangible principles collated from historical underpinnings. Applying Brownings’ 14 patterns and ‘visual landscape assessment statistical methodologies’ conducted from online databases including Science Direct, JSTOR, Taylor and Francis and EBSCOHOST and researchers including (Goto, 2012; Litwin et al., 2017; López-Martínez, 2017; Qi, Zhang, Wang, Liu, & Li, 2017; Roth, 2006; Seiko, Kamal, Puzio, Fujii, & Herrup, 2013; Sowińska-Świerkosz & Chmielewski, 2016; Sowińska-fwierkosz, 2016) and other key biophilic sources. Factors tested via Pearson's correlation coefficient. The analysis may

replicate a strong linear association of plant type measures and visual quality to be ascertained, (Ozkan, 2014) Examining native over exotic vegetation preference reliably by isolating processes and factors gleaned from visual assessments. Altering variables to native Australian vegetation and exotic (not naturally occurring in Australia) vegetation. Constraints used to ascertain ecological responses are restricted to preferences of five garden types, with the AusZen garden represented in the Melbourne International Flower and Garden Show (MIFGS) from March 21-25, 2018 at Carlton Gardens, compared with other exotic/native gardens, all of which are the same size 5m x 5m. The sample consists of two native gardens, one tropical exotic and two exotic gardens. Validity determined by the online survey conducted on site to allow visitors to authenticate preferences.

Datasets include age, gender, garden preference, location and education. The garden visitors complete a survey/questionnaire. Results that determine preferences for certain plants are homogenous regards to their landscape style. (Litwin, Bacior, & Piech, 2017) In this case, the Japanese design garden provided a cultural contradiction, which substantiated the hypothesis that the design style visually overrides the plant selection.

Survey and questionnaire results conducted from MIFGS, suggests there is a correlation of Visitors attending the show to a preference for Native plants and the AusZen Garden. The AusZen garden, which used Biophilic patterns and principles, reinforces the hypothesis as to why this particular garden is preferred over others.

Keywords: Biophilia, Satoyama, Senzai Bori, AusZen, Green Aesthetic

1. Introduction

Biophilia was segmented into 5 main factors that shaped the first prototype AusZen garden design after assimilating the initial research, including plant selection and design principles such as miegakure (*Biophilic Pattern 7 (BP)*), fuzei (*BP 6*), and mono no aware (*BP 13,14*) that has included the 14 Patterns of Biophilic Design (Browning, Ryan, Clancy, 2014).

Table 1 – The 14 Patterns of Biophic Design (Browning, Ryan, Clancy, 2014)

14 Patterns of Biophilic Design (BP)

Nature in the Space Patterns

1. *Visual Connection with Nature*
2. *Non-Visual Connection with Nature*
3. *Non-Rhythmic Sensory Stimuli*
4. *Thermal & Airflow Variability*
5. *Presence of Water*

6. *Dynamic & Diffuse Light*

7. *Connection with Natural Systems*

Natural Analogues Patterns

8. *Biomorphic Forms & Patterns*
9. *Material Connection with Nature*
10. *Complexity & Order*

Nature of the Space Patterns

11. *Prospect*
12. *Refuge*
13. *Mystery*
14. *Risk/Peril*

2. Ecological Restoration and Ethical Considerations

A balance of human values that respects nature's intrinsic values is an implicit foundation in the formation of the AusZen Garden. The process of Ecological restoration (Flannery, 2002; Griffiths &

Robin, 1997) should be initiated from factors impacting on ecological, economic, cultural, aesthetic and spiritual values, and in the case of the development of the Japanese Garden authenticity; from applying a cultural tradition that Satoyama embodies, a human–ecological systems based on rectifying historical decline with future management. (Indrawan, Yabe, Nomura, & Harrison, 2014; Takeuchi, Ichikawa, & Elmqvist, 2016). Such values simultaneously manages and repairs ecosystems for their underlying value, rather than for the benefit of humans alone. In practising ecological restoration, identifying a path for both ethical and satisfying relationship between humans and the rest of nature is crucial to the ongoing development of the AusZen Garden concept developed in 2015. Selecting *Doryanthes excelsa* stems (BP 9) as a replacement for imported bamboo in screens, provides a deliberate visual component of Satoyama, using local abundant material that was similar and lightweight, other examples is in the selection of stepping stones, crushed sourced locally and recycled timber treads.

3. Plant Preferences

There has been studies on landscaping preferences and socio-economic status of residents (Peterson et al., 2012). One study has addressed the value associated with the native plant labels, and suggests willingness to pay for landscaping plants increases when labelled plants are native and decreases when plants are labelled as invasive (Yue, Hurley, & Anderson, 2010). Martin, Warren, and Kinzig (2004) identified a positive correlation between vegetation richness and socio-economic status.

4. Psychological and Cultural

Research has demonstrated that Cultural patterns of categorization of colours exist as individuals actually perceive hues independently and categorise them differently (Bornstein, 1975) This suggests that plant hues should automatically attract specific racial groups. This investigation will form as part of the post survey questions.

5. Human health threats, allergies and seasonality.

Considerations such as external sources including LED lighting can impact on health (Geddes, 2018). In relation to Pollen Allergy specific plant selections were refined following evidence that; *Improved pasture grasses are more allergenic than Australian native grasses along with pollen from exotic trees, which are planted for their autumn colours, is more allergenic than pollen from Australian trees* (ASCIA, 2017). Connecting low allergenic selections to the metabolic plant feedback hypothesis (Gertsch, 2016) would benefit humans in close proximity to plant materials.

The World Health Organisation notes Green spaces are important to mental health. Ascertaining exact spatial requirements considered by limiting the initial garden project scale to a small courtyard or public space. Having access to green spaces, which is increasingly denser and reduced can reduce health inequalities, improve well-being, and aid in treatment of mental illness. Some analysis suggests that physical activity in a natural environment can help remedy mild depression and reduce physiological stress indicators.(World Health

Organisation, 2016) Aromatic and edible plants including *Goodenia macmillanii* produce stimulating or calming reactions identified in therapeutic research (Seiko, Kamal, Puzio, Fujii, & Herrup, 2013). Seasonal preference (Buhyoff & Wellman, 1979) and bias is one of the key factors in consideration for any garden show. It is possible that the seasonality effect may not be that prominent in Australia, but flowering times are important indicators (Entwisle, 2014). Research suggests winters that include significant snowfall are stimulated by spring, and conversely, autumn and colour associations strongly differentiates a summer landscape (Schloss, Nelson, Parker, Heck, & Palmer, 2017). This preference has to be tested in Australia which has contingent seasons, ‘Sprinter and Sprummer’ (Entwisle, 2014) and climate itself is to be an important factor in accepting personal preferences.(Schloss et al., 2017) along with duration of exposure to the landscape. (BP 1, 2, 3, 4, 5, 6, 7)

6. The Green Aesthetic (Ryan, 2012), and Stratacell Technology

The Green Aesthetic encompasses the Corporeal Aesthetics of Plants, where the ‘aesthetic attraction is not a superficial concern—it’s an environmental imperative. Beauty could save the planet.’(Hosey, 2012).

Attractive design discourages abandoning or demolishing it: if one appraises the garden, it will be a valued amenity.

Long-term value is impossible without sensory appeal, because if design does not inspire, it is destined to be discarded. ‘In the end,’ writes a Senegalese poet, ‘we conserve only what we love.’ (Baba Dioum, 1968.)

Hidden technology repurposed and reapplied via the Citygreen Stratacell; initially developed for street tree planting in urban areas extrapolated. The 500mm x 500mm x 250mm recycled plastic interlocking cells now used for producing levels for aboveground; in this case as the formwork of the AusZen garden, with plants placements into, around and onto the cells, building height profiles from ground level to two metres. The pieces are interchangeable, stackable, easily installed and removed. There is no mess or waste which followed biophilic principle - Pattern as Precedent (BP 8) (Browning, Ryan, Clancy, 2014).

7. Terra nullius

Where land belongs to nobody that initiates a reaction to recreate place, where absence invokes a new ecological consciousness, predicated on what is in and around that place. Ascertaining connection to the land from one’s location and dwelling. (BP 14)

The location of the site in Carlton. The Royal Exhibition Building and its surrounding Carlton Gardens designed for the great international exhibitions of 1880 and 1888 in Melbourne. Joseph Reed designed the building and grounds. The site, (**Error! Reference source not found.**) managed by a World Heritage Committee, with the Melbourne local Council conducts maintenance of the site for the public. This place in the growing hub of Melbourne can offer the visitor the opportunity to view the landscape within its boundaries.

8. Governmental Inputs and Legislation

State plans include Environmental Planning and Assessment Act 1979, and State Environmental Planning Policies. The NSW State Department's 'Better Placed' policy incorporates residential, mixed-use and commercial, affordable housing, education, health, Green Grid (Metropolitan Greenspace Program administered by the Greater Sydney Commission), public art and master planning. This policy, launched in 2017 to tackle issues including enormous powers of developers; where they will give more to communities, NSW Government Architect Mr Poulet notes. 'It's a complete change from when Meriton developer Harry Triguboff said 10 years ago that if people wanted to see trees', 'they can go to Katoomba, there are plenty of trees there'.(Williams, August 18, 2017). The Green Grid established to be the ultimate green infrastructure, design-led strategy network of interlinked open spaces, parks, bushland and waterways for people moving in and around the city to access green space. (BP 10)

9. Heritage and Historic Urban Landscape (HUL)

Carlton Gardens (S37 48 22 E144 58 13), was World Heritage Place listed in 2004 (Ref: 1131bis), and has as part of the regulations for site protection imposed by Melbourne Council. Tree and root protection zones (**Error! Reference source not found.**), impaction on the ground and garden structure should be considerate of the location, based on negative feedback

directly related to MIFGS noted in 'Alienation of the World Heritage Carlton Gardens' by residents and the Carlton Gardens Group in 2008.

From reviewing this literature, the garden structure developed carefully to resolve issues of weight, material use, and respect for avenue plantings.

Japan enacted the 'Landscape Law' in 2004 to highlight the importance of preserving landscapes in improving the quality and viability of community life. HUL and its links with authenticity (Rey Pérez & González Martínez, 2018) provides the impetus approach of developing an authentic Japanese Landscape Garden emerged in conjunction with ICOMOS heritage guidelines. The focus on integrating goals of urban heritage conservation with social and economic development currently in local Government Plans of Management, and providing a garden style that works within these particular requirements is a useful tool for the landscape architect. Noting 36C, 'cultural heritage, emphasis needs to be put on the integration of historic urban area conservation, management and planning strategies into local development processes and urban planning, such as, contemporary architecture and infrastructure development, for which the application of a landscape approach would help maintain urban identity.' When all towns and cities considered historic, and the ICOMOS guidelines applied, the incorporation of a garden developed from either a local, state or national heritage significant list provides support to adopt such developed landscape formats.

The HUL approach is a paradigm shift that puts heritage management as part of a

centralized effort for the sustainable development of urban areas. Such non-traditional, multi-disciplinary efforts are key in creating new knowledge pathways in solving urban challenges of the future. Looking Back to the Future.

10. Values

An analysis of the heritage values (social,

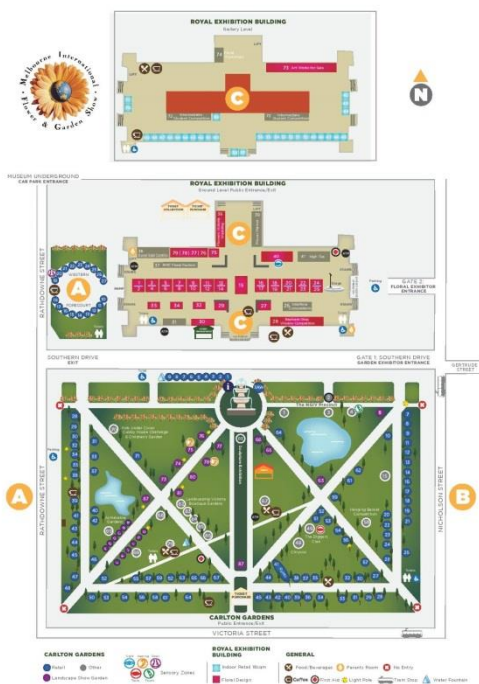


Fig. 1. MIFGS Layout of Carlton Gardens

scientific, historic and aesthetic/symbolic) assists in allocating the threshold that varies between UNESCO world (Outstanding universal level), commonwealth National Heritage (Outstanding heritage value to the nation), state and territory (Importance in the state or territory) to local heritage (importance to the local community). The heritage values inherent in the AusZen Garden identified with the goal of achieving

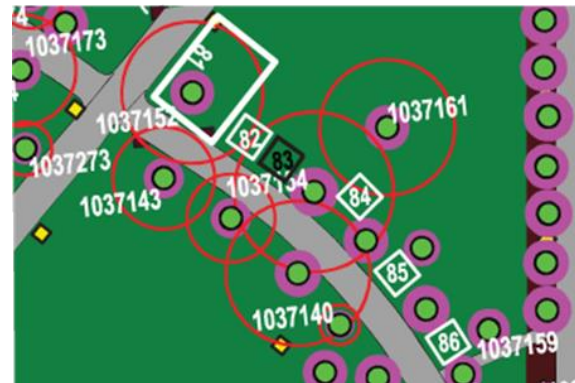


Fig. 2. Specific Site Layout with Tree Protection Zones

outstanding universal value. The Garden biophilic considerations is directed at that same specific criteria of World Heritage Listing – ‘to exhibit an important interchange of human values, over a span of time or within a cultural area of the world, on developments in architecture or technology, monumental arts, town-planning or landscape design’

11. Methods

Pearson correlation analysis conducted using SPSS 16.0 (SPSS Inc., Chicago, USA) (Pallant, 2003)The online survey for garden

preference focused on general questions Regarding the boutique gardens, including types of plants and style. The survey contained questions about education levels, gardening experience and practices, and demographic information. Specific questions about plant choices from plant preference to garden style preference from the online survey was concentrated in the impromptu questionnaire immediately recorded against the online survey. Rationale behind this

Figure 1 – Specific Site Layout with Tree Protection Zones

method was to ensure there was no bias directed to the AusZen garden. The purpose of these questions was to gauge and validate the preference for flowering plants in the AusZen Garden.

Questions include:

- were you attracted to any plant(s)
- Do you know the name of any plants in the AusZen garden?
- What was your first impressions of the AusZen garden as compared to the other gardens?
- Did you know that the AusZen garden consists entirely of Australian native plants?
- Did prize panels affect garden preference?

Analysed data from interviews and survey was combined using JMP Pro 11 statistical software (SAS Institute, Cary, NC). For interview data, we compiled basic descriptive statistics from visitors' responses to all questions. Post surveys questions produced onsite probed preferences regarding experience in gardening (Chart 1) with the data providing this randomly selected demonstrated a particular interest in the garden and flower show focus should correlate with, having interest in gardening, and flowers and not in the Formula One Grand Prix, which was on that weekend approximately 3kms away.

Motivations and knowledge by examining relationships between key categories of information. To determine if the sampled groups' preference for a particular garden style, (Chart 1) survey included a Likert scale range for the five show gardens, where participants had time to review each garden to aid recall.

Analysis of the age group dataset highlights Diversity and variability regarding the sample population with average age of 56 with standard deviation of 15 reflects the current demographic age distribution weightings for this event, from the median age of people in Australia was 38 years (ABS, 2016)

The position of gardens along one of the main avenues of the show (**Error! Reference source not found.** & 2) was the site for completing the online survey and questions about garden style preference. The boutique garden competition ranged from traditionally used European styles, one with plant beds and sunken fire pits with native plants, to exotic plant selections including a secret garden with rigid rectangular stone raised beds and hidden water feature. One garden presented a corporate style garden with large, exaggerated pillar funnels and hard, industrial materials with exotic, tropical plant selections. One garden used unnaturally shaped circular blue rings, with cut foliage hanging from the top that separates nature from construction. The Japanese Style garden using only Australian natives was located off centre. The education level (potential plant knowledge) and household location (less or greater access to a garden or park/ natural location). We coded gardeners' responses to open-ended questions about plant preference (exotic or native or both) and garden style setting to characterize their knowledge and practices. To evaluate if 'gardeners' attending the show were generalists or specific in relation to plant and garden preference (Chart 4Chart 4 – Categories of Visitors to MIFGS)

12. Survey

The Gardens at MIFGS was identified due to the exact size limitations of 5m x 5m which is listed with title, position number and plant selection is RAW - A86 (native) (Fig.5), L'orb Du Plantes - A85 (exotic) (Fig.6), Secretum Hortus - A84 (exotic) (Fig.7), AusZen - A83 (native) (Fig.8), and Patina Garden - A82 (tropical/ exotic) (Fig.9), see (Table 2)

The case study at MIFGAS provided the venue to present the following queries.

- Do the socio-demographic and location correlates with landscaping preferences?
- Is there a bias towards native plants currently in the gardening community that attending MIFGS?
- Does that bias continue in the type of garden style choice?
- Are the visitors at the show capable of identifying native from exotic plants?
- Can visitors distinguish the Japanese garden (AusZen) style as a native or exotic garden?
- Did prize label (1st, 2nd, 3rd) displayed on signage next to the garden impact on preference? (Fig. 1, Chart 3)

Datasets include age, gender, garden preference, location and education (Chart 4). The garden visitors complete a survey/questionnaire. Results determine preference for certain plants that are homogenous in regards to their landscape style (Litwin, Bacior, & Piech, 2017)

The survey had to include the competition aspect of the Boutique Gardens at the show

due to the display board presenting the results of the competition to the front side of the garden in a prominent position (Fig. 1).



Fig. 1 – Prize placed on panel consideration for landscape preference

13. Statistical analyses

58.67% of survey sample comprised of females, which is a higher percentage than females in the Australian general population with a standard deviation of 0.49, which is reflected in the current population (ABS, 2016). 89% noted they lived in a house, situated in a rural or urban setting, which is higher than current census data of 72.9% (ABS, 2016). There is a greater representation of TAFE/University educated in the survey sample of 77% than is the current norm, of 22% (ABS, 2016) (Chart 4). During the show, the Australian Landscape Conference 2018 'Design with Nature' was being conducted at the Melbourne Conference Centre where attendants visited the garden on Saturday after 5pm. None of this group was surveyed.

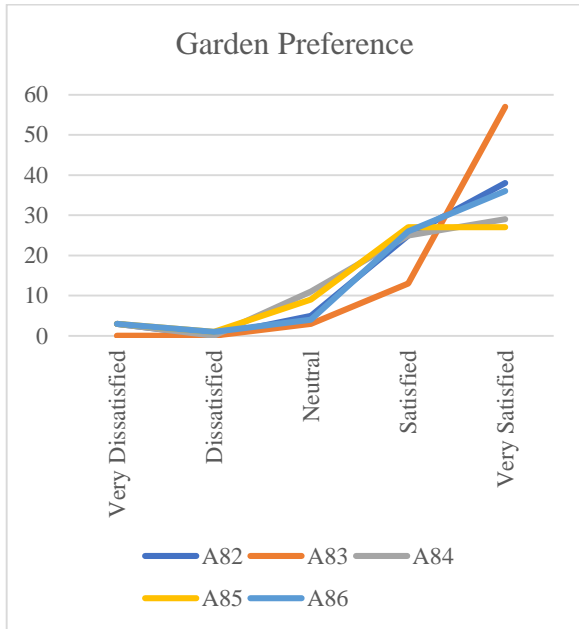


Chart 1 - Plant Preferences

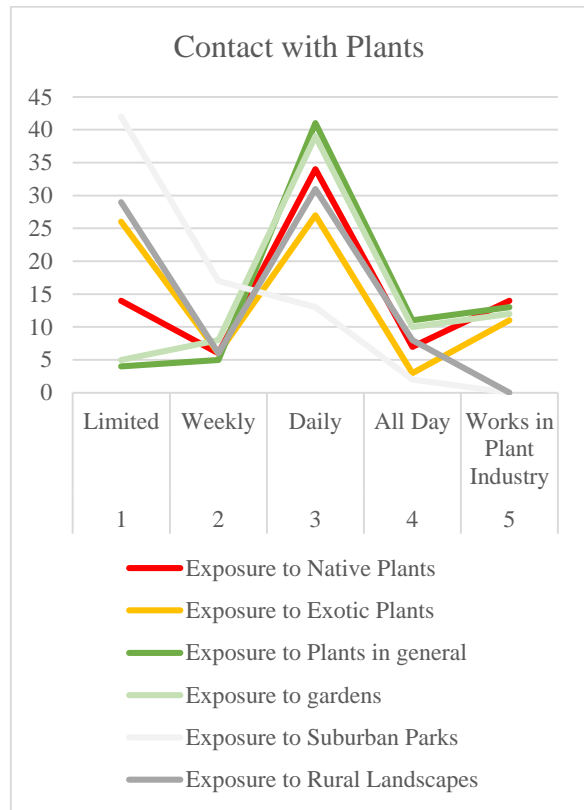


Chart 3 - Plant Exposure



Fig. 2 - Wollemia or Wollemi Pine Main Focal Element

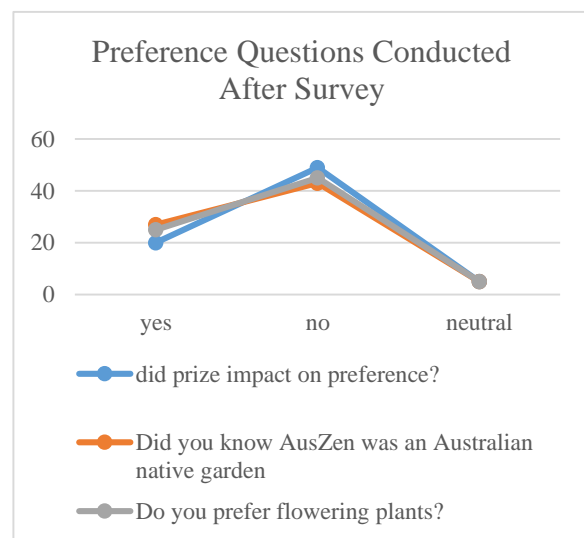


Chart 2 - Post Survey Questions

14. Results

Over 90,000 visitors was recorded Melbourne International Flower and Garden

Show in 2018 (MIFGS) from March 21-25. From the 75 surveys completed at the site, and follow up questions highlights a 44% preference for the flowering *Grevillea 'Cooroora Cascade'*, a gold coloured large flowered ground cover, whilst the standard *Casuarina 'Cousin It'* drew attention due to its novelty (not widely seen in nurseries) could not be determined in terms of preference. The plant in the garden that drew instant attention was the *Wollemia* or *Wollemi Pine* (Fig. 2), possible due to its size (being the first release of the plant, with most visitors acknowledging its size and health).

The *Wollemi pine* captured the sampled visitors' attention whom all but 14 ignored the place result recorded on the panel next to the garden. When queried regarding if the 75 visitors' responses regarding plant preference impacted by the prize; 80% of the sample stated that they did not notice (Chart 3). Observations was recorded that the press and a large number of visitors who did not want to complete the survey, or whom did not spend enough time viewing the gardens, which was recorded (over 335) were attracted to the winner of the Boutique Garden, which also attracted the bulk of the media attention. The AusZen garden did attract plant enthusiasts compared to the other boutique gardens whom had a strong plant vocabulary and knowledge. A group whom conducted the survey did affect the findings. It was difficult to attract a greater range of visitors; however, there was a number of overseas visitors.

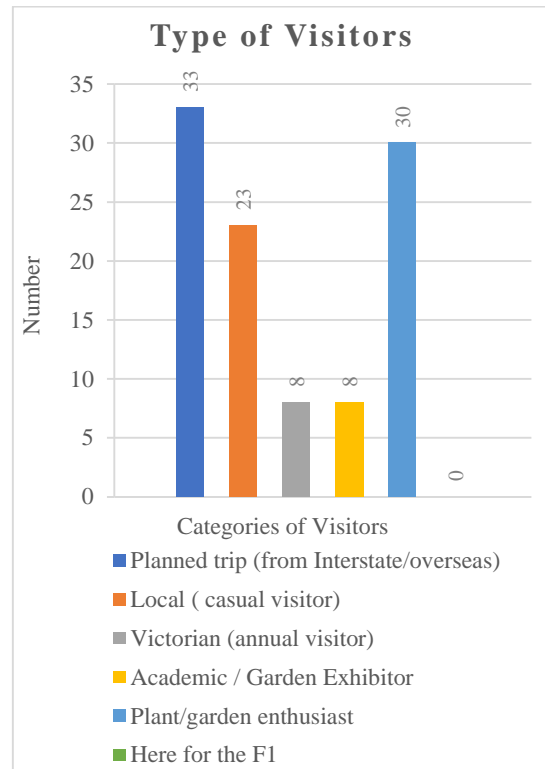


Chart 4 – Categories of Visitors to MIFGS

The predominant preference for the Boutique garden was the AusZen (Fig. 6), when questioned to those who completed the survey online at the Show, 80% noted that it was due to the 'tranquillity' produced by the garden (*BP 11, 12*). The results initially indicate that the Japanese Style Garden type preferences among residents along with visitors were consistent with those found by Seiko Goto (Goto, 2012), type predominantly with a Japanese 'Zen' design aesthetic.

15. Discussion

The best way to integrate biophilic civic-led interventions into landscape planning can

Table 2 - Boutique Gardens in Competition



Fig. 3 - A86 Raw



Fig. 4 - A85 L'orb Du Plantes

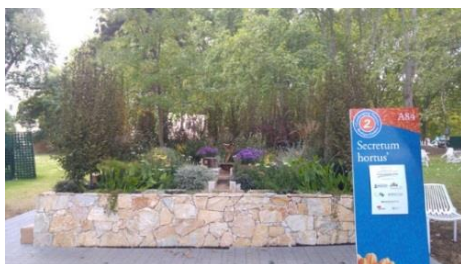


Fig. 5 - A84 Secretum Hortus



Fig. 6 - A83 AusZen Garden



Fig. 7 - A82 Patina Garden

stimulate improvements for those, in particular workers who do not have the opportunity or access to parks or green spaces remains to be determined (Chart 3). The more colourful plants with stronger tones, especially found in with the *Grevillea 'Coorora Cascade'* (Proteaceae) (Fig. 10) reinforces the findings on hue bias (Bornstein, 1975)



Fig. 10 - *Grevillea 'Coorora Cascade'* in flower

Results from this study indicate that visitors with high levels of home ownership may prove most receptive to designs and native plant selection that reinforces an increase in the use of more sustainable landscaping biophilic principles.

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MIFGS 2018
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A City of G20: the Path towards Eco-urbanism of Hangzhou

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Abstract

The G20 summit which was held in 2016 presented Hangzhou to the world as a garden city. In this paper, we explore how the concept of nature and the natural environment were developed and embraced in Hangzhou's urbanism. Since early 1980's Hangzhou was re-decided a cultural and tourism city. It is argued that in the following four decades the city has made effort in preserving existing natural features as well as creating new ones, making the city one of the greenest in China. By reviewing historical background of Hangzhou and its development strategies in corresponding to national policies, it is revealed that the city's eco-urbanism is long supported by both the general public and the government. Behind the case of Hangzhou is current Chinese government's attempt of encouraging urban transition, while the G20 summit was simply the opportunity of indicating it.

Keywords: Garden city, G20, Chinese urbanism, environmental governance, national policy

1. Introduction

Today China among all countries is expected to endure the largest urban growth in the coming decades. By the end of 2016, 57.4 percent of the total Chinese population lived in urban area [1], meaning Chinese urban population will reach 790 million in total. Megacities (exceed 10m) and big cities (5m-10m) in particular suffer from various urban issues: housing shortage, air pollution, breaking down of the natural ecosystem, decreasing of green space and beyond. Although the central government has started to downplay the importance of GDP growth in assessing the performance of local officials in recent year, local governments are still much interested in developing economy rather than to put their focus on how to make cities better places to live.

Hangzhou is the capital city of Zhejiang province, one of the most developed provinces located in southeast China. By the end of 2017 the area of Hangzhou city reached to 16,847 km², its population reached to 9.468 million. September 2016, Hangzhou embraced the opportunity of hosting G20 summit. As a growing big city the successes of Hangzhou in presenting itself as a green city seems to indicate Chinese government's attempt of developing eco-urbanism. However, this success was also criticised as a 'product' made by the government's temporary policies during the summit. In this paper we aim to explore below research questions to challenge this criticism: What are the strategies of

Hangzhou's path to building a garden city and how they are established? Our main focus of below discussion will be put on the city centre area.

2. A Review of Hangzhou's urban history

2.1. Introduction to Hangzhou's Cityscape

How to involved city landscapes in the process of urbanization? In centre Singapore the Central Catchment Nature Reserve is proposed, occupies a considerable amount of green space. By doing this Singapore has provided its people an untouched nature in its highly urbanised environment. People in Hangzhou enjoy the similar privilege, only it is granted by the city's natural cityscape.

Hangzhou is much known for its unique cityscape throughout history, and the well-known impression of 'Paradise in Heaven; Hangzhou on earth' remains of importance in its current development. The world heritage site West Lake, or the Xihu Lake in literal Chinese (650ha, listed in 2011), locates in the west of the city centre. In Figure 1 we can see the lake is surrounded by mountains on the north, the south and the west, its east connect to the city's most centre area. The lake and its surrounding mountainous areas have long functioned as the city's cultural and tourism centre. The Grand Canal, which was listed as a UNESCO heritage site in 2014, connects the north and south ends of the city. The historical centre of Hangzhou was built around the West Lake and along the Grand Canal, while the city's east edge is defined

by the Qiantang River (Figure 2). Now following the expending of Hangzhou's urban area, the river has been included in the city and functions as another important natural feature.

Hangzhou's urbanism has an undeniable close relationship with its natural/semi-natural features. These features have provided the foundation for its ambitious to becoming biophilic in the past two decades. This recognition however, remains general. In below we shall further explore how these features are treated by local urban policies in order to achieve an ecological city environment in details.

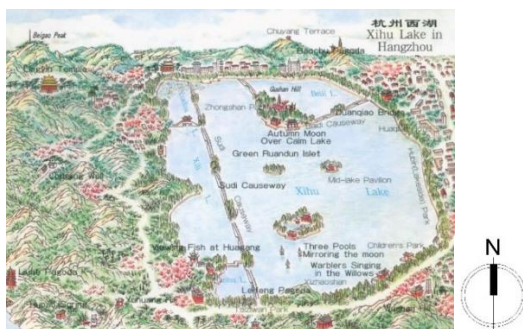


Figure.1. The West Lake and its Relationship to surroundings



Figure.2. Major Natural Features in Hangzhou

2.2. Hangzhou's urban history

As above-mentioned Hangzhou's urban development long relied on its city landscapes. In the Sui dynasty (581-619) the Beijing-Hangzhou Grand Canal was constructed, making the city one of the most important economic centre national wide. In the Tang dynasty (618-907) local governors of Hangzhou introduce the water to the city for irrigation and mitigating the drought problem. The lake was treated, expanded and designed. In this process, this natural lake has become of great aesthetics and cultural value. Since then urban living in Hangzhou is more or less associated with the lake. The city was the capital of the Southern Song (1127-1279) dynasty for one and a half century. It grew as the biggest city in China – even among the biggest in the world – during the time period. [2] Yet the political importance of Hangzhou did not last much longer after the collapse of the dynasty, instead it remained an important cultural centre in south-east China as well as a famous tourism city.

Also similar to Singapore, today Hangzhou's image as a city with abundant lush greenery and a clean environment is not easily created. Despite its natural advantages Hangzhou has had suffered from the consequence of inappropriate urban planning which ignored the value of the urban environment. The first city plan of Hangzhou since the founding of the People's Republic of China was established in 1953. In the plan, Hangzhou was decided an 'artsy scenic-tourist city. Its main development focus is its tourism and culture', whilst 'certain consideration on light industry' was

also proposed. Yet in the former half of Cultural Revolution Hangzhou was decided ‘a heavy industrial city’ in order to keep up with the Great Leap Forward (1958-1962), an economic and social campaign by the Communist Party of China from 1958 to 1962. Multiple heavy industries were launched in the north of the city, while the lake and the canal were greatly neglected in the development. Urban environment was reported greatly decreased during this time period, which has had left many difficulties to the city’s future development. During 1966-1976 the situation was not much improved, although heavy industries were not as highlighted as they were a few years before. After the Opening Up and Reforming in 1978 local government seek to re-plan the city as a ‘historic cultural and tourism city’. [3] This proposal was approved by the central government in 1983. However, urban issues appeared in the decades of 1950’s to 1970’s were still considered a great distraction to modern urbanism during the 1980’s. By reviewing these historical plans it is for us to realise that the actual history of Hangzhou’s modern planning which highlights its cityscape and natural features has only been four decades (Figure 3-5).

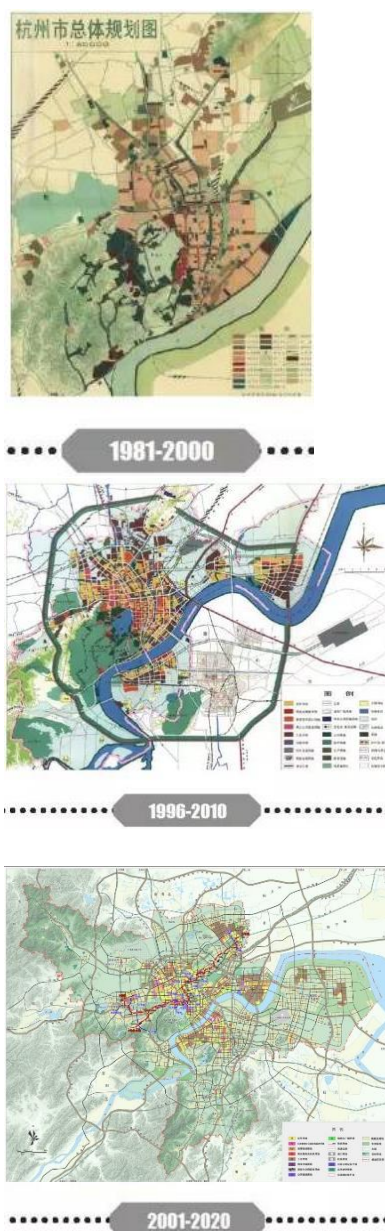


Figure.3-5. An overview of Hangzhou’s city plan from 1981-2020. (Source: <http://www.hzplanning.gov.cn/hzzg/lng5.html>)

3. Building Garden City: Local Strategies

3.1. *The Perseveration of Existing Natural Features*

As Hangzhou's city characteristic has been re-defined back to cultural and tourism, preserving existing natural features has become one the main focus in its recent urbanism.

Figure 6 and 7 presented the approved city plans during 1978-2000 and 1996-2010 respectively. Comparing the two plans we can notice the west lake and its surrounding urban area remain almost unchanged, despite the obvious expanding of the city itself. This suggested that the West Lake and its areas are being carefully protected during the city's development. It is worth to note that both of these two plans were published before the West Lake was listed a UNESCO site, suggesting the city's spontaneous awareness of preserving this important natural feature. The specific West Lake Cultural Landscape Protection Regulation (西湖文化景观保护条例) which required building heights control around the lake was published in 2011 in responding to its successful application of World Heritage site.

As the city has grown rapidly since the founding of PRC, the urge of preserving city centre arise particularly when we considering the area's significant historic and cultural values. If we take a further look at Figure 4 and 5, it could be noticed that new urban areas have been planned along the Qiantang River. This indicates one of the most important urban transition of

Hangzhou in the past two decades, which is to enter 'the Era of Qiantang River' from 'the Era of West Lake'. Qiantang River, which locates at the south-east of the city, has officially being highlighted in Hangzhou's development. The notion was first suggested by the local government and approved by the central government in 1983. Further developing the plan, Hangzhou government has decided that 'the city shall expend to the east (of the city), tourism should be led to the west (of the city). Future development of Hangzhou shall be proposed across the Qiantang River' in 2001. [4] Known as Qianjiang New District, the area developed along the river is now announced as the new economic centre of the city (Figure 8). This decision has released a lot of pressure in dealing with urban issues in the city centre area. Successful preservation of city centre has therefore become more likely.

To avoid possible challenges brought by the city's rapid development, urban development around all these natural features, the lake, the canal and the Qiantang River, are now under careful consideration. This is particularly emphasised in the most recent city plan which was published by the Zhejiang provincial government and approved by the central government in late 2016. The response to this plan from the central government was even more explicit: it was addressed that 'architectural heights surrounding landscape style areas such as the West Lake, the Qiantang River, the Grand Canal, and the Xixi Wetland, should be strictly controlled'. [5] It was also required that the city's characteristics, particularly the cultural landscapes and the

natural landscapes, should be highlighted in future urban design.

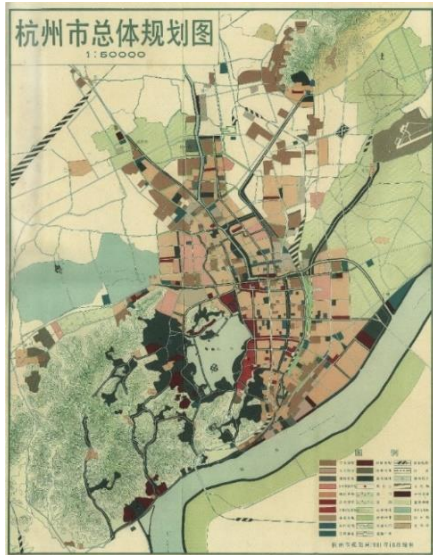


Figure.6. Hangzhou City Master Plan (1981-2000)

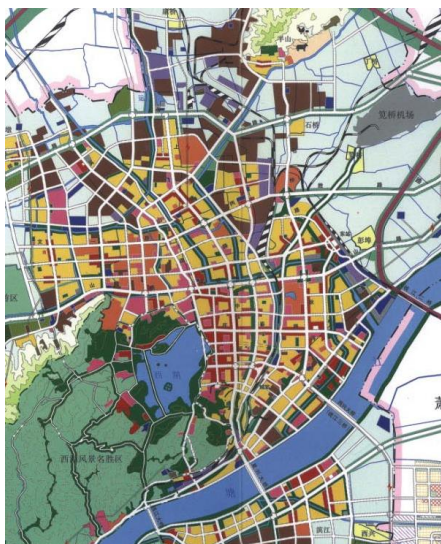


Figure.7. Hangzhou City Mater Plan (1996-2010)



Figure.8. The Qianjiang New District

3.2 Building New Green Spaces

By reviewing city plans in above Figure 6 and 7 we can notice an obvious increase of public green space in the city centre area. In cooperation of the preservation of existing features, local planning strategies of Hangzhou has also addressed the importance of increasing green space no later than the 1990's. In 1994 Hangzhou was already listed one of the earliest 'National Garden Cities' by the Ministry of Housing and Urban-Rural Development of the People's Republic of China, meaning its effort of building green infrastructure was recognised.

In the urban scale, newly planned green spaces – city parks, ecological landscape corridors and are designed to either connect or respond to aforementioned major natural features in the city. It is expected that the city's green spaces will be eventually constructed into a web-like green space system. Multiple acts regarding urban green space were published since 2000, including the Hangzhou Park Management Regulations (杭州市公园管理条例,

published in 2001, revised in 2014), the Hangzhou City Green Management Regulations (杭州市城市绿化管理条例, published in 2011) and the (杭州市城市绿化管理条例实施细则, published in 2012). In below Figure 9, which is the 2016 version of the city plan, we can see how green spaces are designed on the urban level for the time period from 2001 to 2020.

The city's enthusiasm for building green infrastructures is now greatly supported by local residents. In a smaller scale, the building of green spaces, particularly green walls and roofs, is actively participated by the public during the past two decades. These activities are often community-led (although financially supported by the government), giving the general public much more power in deciding the location and type of green space. At the same time, supervision and maintenance of green space has become more efficient, as communities and residents often take over the responsibility spontaneously. The rising influence of public participation in making the city greener is particularly observed in the city's historic areas and old communities, where their green coverage is often lower than new districts. The government and local communities provided free cane seedlings to community residents through volunteers every year, encouraging citizens to plant vertical greening on conditional walls and roofs (Figure 10).

Since 2010, 420,000 square meters of green roofs has been increased in the city centre, the majority of these greens were created and owned by the local community. From 2007 to 2017 314 urban parks and

green areas were newly built within the city centre, meaning a total of 58.56 million square meters of green space has been increased. [6] By the end of 2016, the average green area and urban parks were 14.3 square meters per capita. The urban green space rate in the central urban area was 37.2%. The green coverage of built-up areas was 40.5%. [7] These numbers are expected to reach to 15.1 square meters per capita, 38% and 41% respectively by 2020.

Along with the increasing green rate, the emerging of diverse urban green spaces further proved that Hangzhou has fully recovered from afore-mentioned damages and once again started focusing on its relationship with the city's natural environment. Since this stage we can expect the increasing significance of urban design and landscape architecture in Hangzhou's city development.

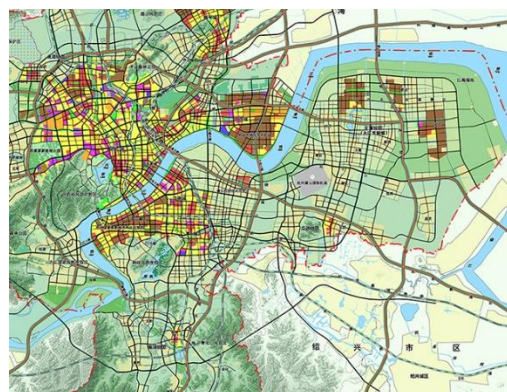


Figure.9. Hangzhou's urban green spaces at the city level



Figure.10. A plant corridor built by the local community

(Source:

http://news.ifeng.com/a/20170620/51287493_0.shtml)

3.3 Garden City for the Public or Garden City of Particularity?

In the past decade Hangzhou further developed above strategies in dealing with its urban environment. The G20 summit held in 2016, as an international event which received great attention, greatly reflected Hangzhou's ambition of becoming a garden city. Using preparing the summit as an opportunity the government of Hangzhou investigated 50 billion yuan (8.2 billion U.S. dollars) in improving city environment. 605 projects which aim at improving local environment were initiated and completed during the preparation period which lasted over 400 days. When hosting the summit Hangzhou surely was expected to be presented as a positive example of Chinese urbanism.

One might question Hangzhou's achievement during G20 is of particularity: during the whole week when the G20 was

held, traffic in city centre was restricted; a week-long vacation during the summit was granted to local residents, as they were encouraged to travel out of town; Factories in the surrounding areas and cities were shut weeks before the summit. In the Report on the Development of China's Eco-cities 2017 (中国生态城市建设报告) which was published by the Chinese Academy of Social Science, Hangzhou's response to the G20 summit was included as one of the ten most noticeable events in regard to promoting eco-urbanism. It was considered a positive example by the report as the success of the city's achievement during the summit is almost undeniable. However, it is also noticed that such achievement was, and is still, supported by considerable effort both politically and financially. It would not be too difficult for us to imagine that other cities might not have similar resources.

When admitting Hangzhou's urban environment presented during G20's has certain particularity we shall still ask the question: was the city's achievement as a garden city a temporary result as criticised? We have already reviewed Hangzhou's local development strategies and plans during the past few decades, now it is worth to explore how the city's strategies interact with national policies.

If we look back to the time period during 2002-2007 when president Xi Jinping was the party chief of Zhejiang province, evidences of Hangzhou being highlighted as a garden city on the national level long before the G20 could be revealed. Hangzhou government initialed its plan of 'ecological city development' in 2002 – back when Xi

was just appointed to Zhejiang province. In 2003 the Zhejiang government announced the central government’s determination of building the province into a ‘green province’ by publishing the Hangzhou Ecological City Construction Plan (杭州生态市建设规划), notions in this plan has been promoted since after. Two years after, in 2005, Xi proposed his famous quote ‘lucid water and lush mountain are invaluable assets’ during his visit to Anji, a county locates in the north-western Zhejiang province. This notion was only greatly highlighted national-wide since the 18th National Congress of the Communist Party of China which was held in 2015. In comparison, Zhejiang province has already been developed under its guidance for over a decade. What has been promoted in Zhejiang province was a pilot of Xi’s notion, and now it reflects the central government’s consideration of China’s new urbanisation. [8] In this sense, both Hangzhou being selected for hosting the G20 and being introduced as the ‘paradise’ by President Xi in the summit closing ceremony can be considered a signal.

In June 2017, which was a year after the G20 Summit, Hangzhou was nominated ‘National Ecological Garden City’ from over 300 ‘National Garden City’ by the Ministry of Housing and Urban-Rural Development of the People’s Republic of China. In comparison to the concept of National Garden City which emphasises green rate solely, the National Ecological Garden City has introduced the broad concept of ‘urban ecology’ into its assessment. How urban residents react to the urban environment has also been included as an important aspect. In detail, indicators

such as urban heat island effects, comprehensive species indices, local plant indices, and public satisfaction with urban eco-environment have been added (table 1-2). Hangzhou’s version of building itself as a garden city has been further accelerated.

Criteria	Expectation
Public green space per capita (m ²)	7.5
Green coverage of built-up areas (%)	31
Green coverage (%)	36

Table.1* Selected assessments for National Garden City (for cities of 1million population and above)

Criteria	Expectation
urban heat island effects (°C)	≤ 2.5
Public green space per capita (m ²)	≥ 12
Green coverage of built-up areas (%)	≥ 38
Green coverage (%)	≥ 45
Comprehensive species indices	≥ 0.5
Local plant indices	≥ 300
Treatment rate of domestic sewage (%)	≥ 70
Public satisfaction with the urban ecological environment (%)	≥ 85

Table.2* Selected assessments for National Ecological Garden City

*Note that above-expected numbers are only cut-off numbers for the assessment rather than the city's actual indicators.

4. Conclusion

This paper has reviewed Hangzhou's urban history, local development strategies and related national policies in relation to its concept of the garden city. Despite its long history, Hangzhou's urban planning history which emphasised on its city characteristics has only been less than four decades, but its accomplishment is quite noticeable. In current stage the conservation of existing natural features and creating new green spaces are considered of significance in Hangzhou's urban planning. Today the city enjoys an obvious improvement of urban environment from multiple aspects.

Hangzhou was chosen and designed as a representative of the garden city on the national level. Its historical background and natural cityscape provided foundations to this decision. Meanwhile, the city's path to becoming a garden city is long supported by both local and central governments, as well as its prosper economy. It is revealed that the central government's current eco-development policy represented by the 'lucid water and lush mountain are invaluable assets' in fact has its long history in Zhejiang. Local cities' urban policies have had been greatly influenced by this notion during President Xi's tenure in the province. The G20 summit certainly accelerated the central government's determination of promoting Hangzhou's city image, but it was hardly the deciding factor in the city's garden city notion.

By exploring the case of Hangzhou it is indicated that the relationship between China's rapid urbanism and carefully crafted strategies for achieving eco-urban living is now gradually being highlighted. How urban

designers and landscape architects should respond and contribute to this new notion has become of importance.

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Fault gardens in Kyoto : their suggestions for the city being with nature

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Abstract

In this study, we present a new perspective on Japanese gardens by analyzing the manner in which the gardens in Kyoto take advantage of the naturally occurring differences in elevation due to faults and by searching for the relation using the area's topographic classification. This analysis is intended to highlight the manner in which human design can be made more harmonious with nature. 15 gardens that belong to the temples that are built near the faults running through Kyoto are analyzed. The results show that a high percentage of gardens that were located near the fault lines utilizes the difference in heights that were produced by the faults either as a part of the landscaping of the gardens or as the main feature of the garden. Further, the utilization of terraces that were produced by faults could be divided into two groups: those that include stone arrangements in the main feature and those that use the terrace as a base for presenting the greenery that is observed in front of a beholder as the main feature. Furthermore, the gardens can be divided into those that form a landscape using the difference between elevations as a pedestal for presenting the shrubs and stones and those that form landscapes by maintaining individual outlines while helping the formation of the main features of the landscaping.

Keywords: Japanese garden, terrain, land form, temple, view

1. Background and Purpose of the Study

Since ancient times, gardens in Kyoto have been designed with an objective to create an environment that provides visual and acoustic pleasure to people when the gardens are observed from a particular perspective. These beautiful landscaping features hide a secret that can be traced back to the time during which the topography of Kyoto was formed. The Kyoto Basin contains many active faults that constitute a fault zone. Most

of these faults run through mountains. Additionally, several temples are located at the foot of or between the mountains, and these temples have become indispensable because they are built near the faults of Kyoto.

Previous studies about the gardens and topography of Kyoto include investigation of the environmental features by performing quantitative analysis of the inclinations and elevations of landscaping^[1], investigation of the topographic classification of the Kyoto Basin^[2], and investigation of the relation

between Shinto shrines and faults [3]. No study has been published yet that elaborates on the formation of topographic features by faults, which are considered to be the landscaping features for the gardens in Kyoto.

In this study, we present a new perspective on Japanese gardens by analyzing the manner in which the gardens in Kyoto take advantage of the naturally occurring differences in elevation due to faults and by searching for the relation using the area's topographic classification. This analysis is intended to highlight the manner in which human design can be made more harmonious with nature.

2. Study Method

2.1. Research Method

This study analyzes 15 gardens that belong to the temples that are built near the faults running through Kyoto. All of these gardens are included in "Nihon Teiensi Taikei" [4]. The gardens are listed in Table 1, and their locations are mapped in Figure 1.

Table 1. List of gardens and the dates of visits to perform the study.

Garden Name	Research Date & Time
① Tenryu-ji Garden	Jun/2/2017 9:00 a.m.
② Funda-in Garden	Jun/10/2017 1:00 p.m.
③ Fumon-on Garden	Jun/10/2017 2:00 p.m.
④ Shoren-in Garden	Jun/11/2017 0:00 p.m.
⑤ Chion-in Garden	Jun/11/2017 2:00 p.m.
⑥ Entoku-in Garden	Jun/11/2017 4:00 p.m.
⑦ Kodai-ji Garden	Jun/11/2017 5:00 p.m.
⑧ Shisen-do Garden	Jun/16/2017 11:00 a.m.
⑨ Ginkaku-ji Garden	Jun/16/2017 0:00 p.m.
⑩ Nanzen-ji Hojo Garden	Jun/16/2017 2:00 p.m.
⑪ Tenju-an Garden	Jun/16/2017 3:00 p.m.
⑫ Konchi-in Garden	Jun/16/2017 4:00 p.m.
⑬ Ryosoku-in Garden	Jun/17/2017 11:00 a.m.
⑭ Sanbo-in Garden	Jun/19/2017 1:00 p.m.
⑮ Kanju-ji Garden	Jun/19/2017 4:00 p.m.

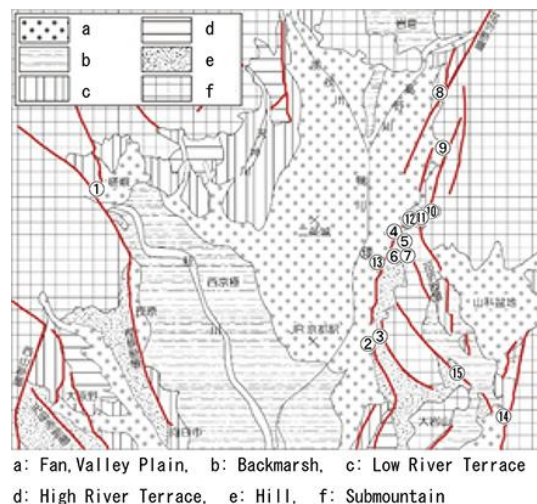


Fig 1. Locations of the gardens and faults and the topographic classifications [5].

We captured photographs from some parts of gardens that were designed to be the highlights of the viewing experience such as the center of the abbot's quarters or the stepping stone. From these centerpiece positions, we conducted a photo shoot of the surroundings to capture the major features of the garden landscape such as waterfall stones. We additionally measured the inclinations and elevations (Table 2), prepared cross-section plans and sketches of the gardens, and catalogued the flora. For gardens with water features, such as ponds or streams, the sources of water were verified with the temple staff.

The height of the point of view was set in the following manner: the ground level (hereinafter, GL) was 0 m; the garden wherein the abbot's quarters was accessible

to the public was set to be GL + the height of the abbot's quarter + 0.8 m; and the gardens wherein the abbot's quarters was not accessible to the public was set to be GL + 1.55 m.

Table 2. Measurements of inclination and elevation.

Temple	elevation angle (°)			depression angle (°)		
	1st	2nd	3rd	1st	2nd	3rd
① Tenryu-ji	17.4	17.2	16.8	2.8	2.8	2.6
② Funda-in	37.6	38.8	37.6	17.0	16.0	16.2
③ Fumon-on	26.4	27.2	27.2	5.6	5.2	6.0
④ Shoren-in	29.2	29.6	29.6	5.2	4.8	4.8
⑤ Chion-in 1	48.4	48.2	48.8	5.2	6.0	6.4
⑤ Chion-in 2	25.2	24.0	23.6	2.4	3.0	3.6
⑥ Entoku-in	33.6	33.6	33.8	12.0	10.8	12.0
⑦ Kodai-ji	18.4	20.8	20.0	8.0	7.2	7.6
⑧ Shisen-do	28.4	28.0	28.2	8.8	8.5	8.8
⑨ Ginkaku-ji	27.6	27.2	27.2	16.8	17.6	16.8
⑩ Nanzen-ji	24.0	24.8	24.6	8.0	8.0	8.0
⑪ Tenju-an	28.6	28.7	28.8	10.0	9.6	9.6
⑫ Konchi-in	27.6	27.2	27.6	6.0	5.7	5.6
⑬ Ryosoku-in	29.1	28.8	29.2	7.8	7.2	7.1
⑭ Sanbo-in	18.8	18.8	18.4	2.8	2.8	2.6
⑮ Kanju-ji	12.0	12.4	12.8	28.0	28.8	28.4

2.2. Research Method

In this study, tracings of the plans and photographs of the gardens' main features were prepared. The landscaping elements of the main features and their usage differences in terms of the elevation were categorized into 1) outlines of faults or terraces produced by faults, 2) ponds and rock gardens, 3) maple trees, and 4) stone arrangements to discover the similarities and differences between the gardens. For instance, using the plans and the pictures of the Tenryu-ji temple garden in Figure 2, we could categorize garden features for which the faults themselves or the terraces produced by the

faults were used to form the landscape and for which the garden features were not related to the topography. According to the landscaping elements, topographic factors, and other factors, we divided the 15 gardens into various groups based on their similarities. Furthermore, to investigate the relation between topographic classification and the use of faults in landscaping, we sketched cross-sectional plans according to the topographic classification.

3. Results

3.1. Whether Terraces Produced by Faults Could Be Used as the Main Features of a Garden

A location at which fault-based terraces are successfully used as the main feature is the garden of Tenryu-ji temple. The garden of Tenryu-ji is located to the western side of the Kyoto Basin in the Saga Arashiyama area (Fig 1). This neighborhood is also a famous tourist destination, and the garden is designated as a Class 1 Special Place of Scenic Beauty for the Nation. The garden features natural scenery due to the mountains of Arashiyama, Kameyama, and Ogurayama; all of the aforementioned mountains have faults running through them. The three terraces that are produced by the faults are located in the garden itself. As depicted in the photographs that are provided in Figure 2, maple trees are planted and stones are arranged on the fault-based terrace that is located in front of the garden to create the main feature of the garden.

A location at which terraces were not used as a main feature is the Abbot's Garden of Nanzen-ji temple. As depicted in Figure 3,

this garden is located parallel to the fault line, and its design is self-contained without any elevation changes. The terraces that are produced by the faults cannot be used as the main feature of this garden.

The gardens in which the terrace is used as the main feature are 12 examples in total; 1, 3, 4, 5, 6, 7, 8, 9, 12, 13, 14, 15.

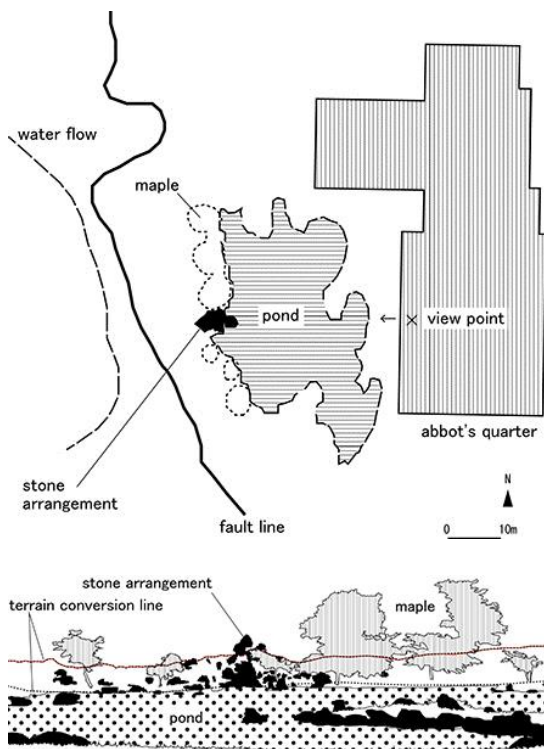


Fig 2. Plan of the Tenryu-ji temple garden (above) and the tracing of its main features (below).

3.2. Stone Arrangements on Terraces Produced by Faults that were used as the Main Feature

An example of stone arrangements on fault-based terraces is the Tenryu-ji garden. At the center of a terrace that runs across the front side of the garden landscape, stone

arrangements that utilize the differences in elevation level were observed (Figure 2).

The gardens in which the terrace is not used as the main feature are 3 examples in total; 2, 10, 11.

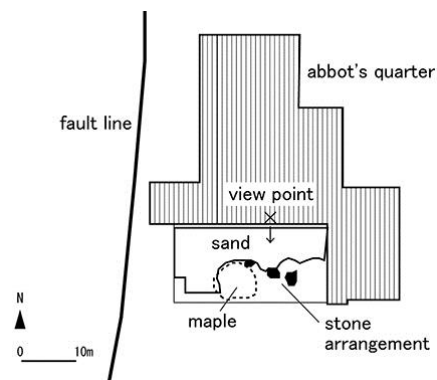


Fig 3. Photograph of the main feature of the Abbot's Garden of Nanzen-ji temple (above) and its plan (below).

An example without the presence of stone arrangements is the Ginkaku-ji garden. As depicted in Figure 1, several faults exist in the eastern side of the Kyoto Basin. Ginkaku-ji, which is located in the area where several faults are concentrated, is extremely famous along with the Kinkaku-ji temple on the

western side and is busy because of several tourists and students, who visit this location during school trips, throughout the year. Terraces produced by the faults continue into the mountainous surroundings of this temple. As depicted in Figure 4, although stone arrangements are placed on these terraces, they are obscured from the chosen points of view by garden plants. Therefore, these stone arrangements are not a part of the main feature of the garden.

The gardens in which stone arrangements on terraces produced by faults that were used as the main feature are 7 examples in total; 1, 3, 4, 6, 12, 13, 14. The gardens in which stone arrangements on terraces produced by faults that were not used as the main feature are 5 examples in total; 5, 7, 8, 9, 15.

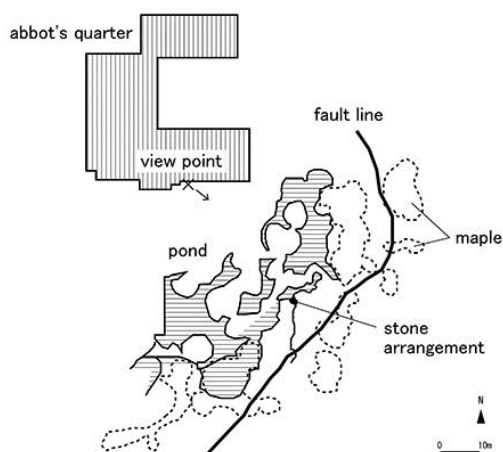


Fig 4. Photograph of the main feature of the garden of Ginkaku-ji temple (above) and its plan (below).

3.3. Linear or Planar Topography

As depicted in the tracing in Figure 2, the garden of the Tenryu-ji temple is an example of the topography that appears as lines. In this garden, the edge of the terrace is visible through the trees that include maples. An example in which a particular topography appears as a plane is the garden of Ryosoku-in, which is illustrated in Figure 5, where rhododendrons and stones are placed on the slope for presentation to convert the entire slope into a landscaping feature.

The gardens in which topography is visible as lines are 4 examples in total; 1, 4, 6, 14. The gardens in which topography is visible as planes are 3 examples in total; 3, 12, 13.

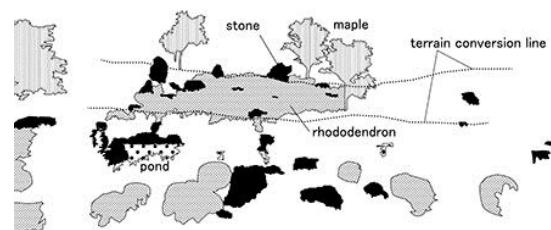


Fig 5. Photograph of the main feature of the garden of Ryosoku-in (above) and its plan (below).

3.4. Water Systems and Topographic Classifications

When faults are present, there is a high probability that flowing water will exist. From among the investigated gardens, 10 gardens depicted the presence of the flowing water. At the gardens of Tenryu-ji and Ginkaku-ji, we even observed water flowing out of terraces that were produced by faults.

Further, according to Uemura (2004) [6], different types of topography were observed above and below the faults. As can be seen in Figure 1, the following differences were observed when the locations of the 15 gardens and the topographic classifications were superimposed.

We observed four cases of transitions (9, 10, 11, 12) from an alluvial fan or a valley plain to a sub mountain. Transitions from an alluvial fan or valley plain to low terraces were observed in two cases (1, 14), and transitions from an alluvial fan or valley plain to a hill were also observed in two cases (2, 13). Further, transitions from a hill to a sub mountain were observed in five cases (3, 4, 5, 6, 7). Only one transition from a low terrace to a sub mountain was observed (8), and a transition from a high terrace to a hill was observed in (15).

Results that were obtained from all the 15 gardens are presented together in Table 3.

Table 3. List of the research results.

Temple	Fault Line /Fault	Landscape Element				Topographic Element	
		Maple trees	Rhodo-dendrons	Stones	Garden Style	Flowing Water	Topographic Classification
① Tenryu-ji	+	+	+	+	Pond	+	a - c - f
② Funda-in	N/A	N/A	+	+	Dry	N/A	a - e
③ Fumon-on	+	N/A	+	+	Pond	+	e - f
④ Shoren-in	+	+	+	+	Pond	+	e - f
⑤ Chion-in	+	+	+	N/A	Pond	+	e - f
⑥ Entoku-in	+	+	N/A	+	Dry	N/A	a - e
⑦ Kodai-ji	+	+	N/A	+	Pond	+	e - f
⑧ Shisen-do	+	+	+	N/A	Dry	+	c - f
⑨ Ginkaku-ji	+	+	+	N/A	Pond	+	a - f
⑩ Nanzen-ji	N/A	+	+	+	Dry	+	a - f
⑪ Tenju-an	N/A	+	+	N/A	Dry	+	a - f
⑫ Konchi-in	+	N/A	+	+	Dry	N/A	a - f
⑬ Ryosoku-in	+	+	+	+	Pond	+	a - e
⑭ Sanbo-in	+	+	+	+	Pond	+	a - c
⑮ Kanju-ji	+	+	+	N/A	Pond	+	d - e

a: Fan, Valley Plain, b: Backmarsh, c: Low River Terrace, d: High River Terrace

4. Conclusion

Gardens that satisfied various conditions were classified and organized into the tree diagram that is depicted in Figure 6. This diagram can be considered as an index for viewing gardens in a manner in which they exploit fault-produced topography. As could be observed from these results, it is clear that a high percentage of gardens that were located near the fault lines utilizes the difference in heights that were produced by the faults either as a part of the landscaping of the gardens or as the main feature of the garden. Further, the utilization of terraces that were produced by faults could be divided into two groups: those that include stone arrangements in the main feature and those

that use the terrace as a base for presenting the greenery that is observed in front of a beholder as the main feature. Furthermore, the gardens can be divided into those that form a landscape using the difference between elevations as a pedestal for presenting the shrubs and stones and those that form landscapes by maintaining individual outlines while helping the formation of the main features of the landscaping.

These results indicate that the ideal presentation of natural topography was chosen by people who lived several hundred years ago and has been maintained in the form of a beautiful landscape until today. Faults may, at times, be harmful for humanity in the form of natural calamities, such as earthquakes, and their secondary disasters. At the same time, faults are agents that depict the beauty of humanity coexisting in harmony with various natural features.

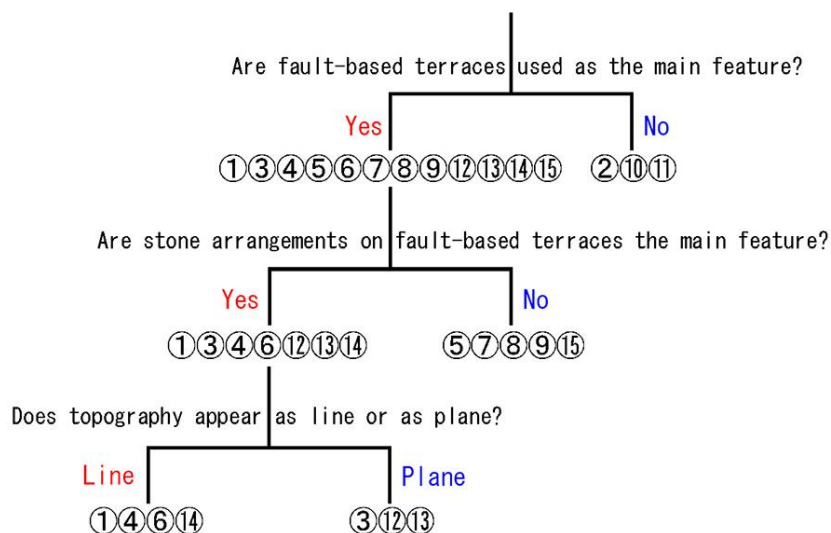


Fig 6. A tree diagram depicting the results.

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The role and needs of animals in the definition of urban landscape architecture

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Abstract

Inter-relationships among humans, animals and landscape have always been historically very important. There is an increasing number of animals in the cities. Some of them are pet animals (dogs and cats in particular, but new species are increasing, e.g. ferrets and certain birds). Some others are simply attracted by cities, like pigeons or seagulls. For some extents, humans are more and more concerned about the possibility of providing good conditions of welfare to their pets, in terms of quality of life. But gardens and parks, for different reasons, are not always open to the dogs, and even the small areas that are provided seem not to be always suitable. Moreover, a lot of animal places are in poor conditions due to low quality design or insufficient daily maintenance. This situation will worsen with the undergoing pet animals overpopulation. The choice of dog breeds is also changing, and breeds with increasing needs in terms of habitat are rising. An approach for integrating human and animals habitats could be very interesting in terms of approaching biophily in other terms. The rising interest for animal welfare will push researchers to find solutions for this integration.

New species are also seen today as pets, in particular, in urban environment, the number of poultry animals, horses or small ruminants is increasing, and this will diversify the needs for comfortable animal environments.

Parks are other habitats that are undergoing deep changes in this particular moment that involves massive extinctions and biodiversity reduction.

From the other hand, some animals are not welcome, because they are pollutant, undesired or dangerous in terms of public health. The example of rats or pigeons, is important.

Then, there is a need for a new definition of urban landscape architecture, to build healthier places for pets, to avoid undesired health risks induced by the presence of humans and animals, and to increase the “one health” concept and the welfare of pet animals and owners. Bird gardening can be considered as a part of this concept.

In this paper, examples of landscape design coherent with animal needs, and a perspective of this issue, are given.

Keywords: landscape architecture; urban; animals; pets; welfare

1. Introduction

The XXI century fixed the birth of a new paradigm for cities planning, design and management: the multifunctional role of the green infrastructure was recognized and became a goal to be achieved for all the cities in developed and developing Countries. The urbanization and land consuming, together with the growth of people living in and around cities, enhanced the need to take care of the quality of the urban environment. Since 1990s, scientists started working on urban ecosystem, urban ecology, and urban nature. New methods and indicators were developed outlining that the quality of urban green spaces is one of the key factors for improving the quality of life in such dense urbanized environments [1].

At the same time, inter-relationships among humans, animals and landscape have changed. The consciousness about the needs of animal in urban environment is a new issue in architecture, but also at technical and political level. Due to the important rise in biophilic sensibility, there is an increasing number of animals in the cities. Some of them are pet animals (dogs and cats in particular, but new species are increasing, e.g. ferrets and certain birds). Some others are simply attracted by cities, like pigeons or seagulls. New species are also seen today as pets, in particular, in urban environment, the number of poultry animals, horses or small ruminants is increasing, and this will diversify the needs for comfortable animal environments.

Humans are more and more concerned about the possibility of providing good conditions of welfare to these pets, in terms

of quality of life. But in urban environment, gardens and parks, for different reasons, are not always open to the dogs, and even the small areas that are provided seem not to be always suitable. Moreover, a lot of animal places are in poor conditions due to low quality design or insufficient daily maintenance. This situation will worsen with the increase of pet animals population.

Creating healthy and resilient cities, integrating the urban ecology principles into design and management actions, is recommended [2]. Urbanization affects ecosystem services in terms of habitat loss, habitat fragmentation, storm water management, water and air pollution and loss of cultural values. Multifunctional networks (greenways, ecological networks, blue-green networks, river ways, and parkways) provide the connectivity in urban ecosystems [3], enhancing the habitat size and quality for wildlife and domestic species.

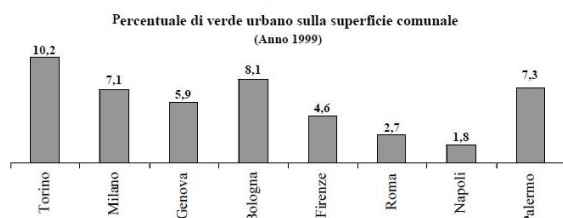
In this paper, some examples of inter-relationships between human and animal populations in particular in urban environments are given, together with an outlook of possible interventions to approach this problem in the next years.

2. Urban green utilization

Urban landscapes are the everyday environment for the majority of the global population: since 2015 almost the 80% of the Europeans lives in urban areas.

Urban green has many different reasons to be increased and managed. Historically, we define Parks, Equipped areas, Historical areas, fitment and special areas.

Figura 1: percentuale di verde urbano sulla superficie comunale



(Fonte: ISTAT, 2002)

All of them are important. Sanesi *et al.* [4] conducted a study on the perception of green spaces by citizens, showing how they are perceived as essential elements to mitigate heat waves. The citizens have a clear perception of the poor size of the green spaces in their city, and they underlined the lack of maintenance, especially in periurban locations. In addition, women and pensioners pointed out problems related to the lack of security and surveillance, especially during the evening.

In Italy, Bologna has always been at the forefront of urban green management, especially with regard to urban agriculture and horticulture. Mapping and quantifying flat roofs suitable for gardening, Orsini *et al.* [5] determined that the city has a potential of 82 ha of rooftop gardening surfaces, enabling the annual production of over 12,000 t of vegetables a year, covering the 77 % of the urban vegetable requirement. Also the Turin metropolitan Authorities have been recently involved in several projects in order to improve the quantity and quality of local food production, and to promote an informed consume by citizens. With the idea that urban agriculture can also contribute to reduce the cost of managing urban green areas and to introduce alternative forms of management of public spaces, in 2013 the Turin municipality promoted the project ‘Torino città da coltivare’. The surface of urban gardens in the last five years enhanced up to more than 100 ha (5 m²/inhabitant) and in 2017, the

first report for the urban food strategy was launched. European and Regional research projects are in progress in order to assess the urban strategy for the implementation of the ecosystem services provided by urban agriculture, horticulture and, more in general, green areas [1].

3. Animal welfare

The management of urban green areas took into account the presence of animals, but the new perception of animals changes the framework.

As an example, the surface required by horses (paddocks, boxes) to express their normal behavior is often conflicting with the limited surfaces available in cities.

The assumption that animals are conscious and capable of experiencing negative sensations and emotions is at the core of most people's concerns about animal welfare. Investigation of this central assumption should be one goal of animal welfare science articles [6].

Different approaches have been proposed to assess animal welfare. Welfare is multidimensional, comprising good health, comfort, expression of behaviour, and so on. Its overall assessment therefore requires a multicriteria evaluation [7]. The most common list to evaluate animal welfare is the so called list of the five freedoms [8] including:

Freedoms

1. Freedom from thirst, hunger and malnutrition

2. Freedom from discomfort and exposure

3. Freedom from pain, injury, and disease

4. Freedom from fear and distress

5. Freedom to express normal behavior

But this concept, dating from early '90, is nowadays even unable to refer to the new biological knowledge, and is undergoing a revision process [9]; new tools have been developed to study animal behavior to assess their level of wellbeing [10]. Unfortunately, on the other hand, the new concepts of welfare are not taken into account widely when planning for new buildings or cities.

4. Animal populations

Animal population, in developing countries, is quickly changing. As an example, the Italian population in 2016 was 60.6 million, while a ISTAT [11] survey in 2017 listed for our country this amount of livestock:

Bovines 5,775,000
Buffaloes 405,000
Swine 8,775,000
Sheep 7,284,874
Goats 1,026,263
Horses 388,324
Donkeys and mules 74,215.

In the same year, Assalco-Zoomark [12] reported, for pets, 60,459,000 animals, and in particular:

Dogs 6,967,000
Cats 7,482,000
Small mammals (rabbits, ferrets, hamsters...) 1,833,000
Reptiles, turtles, iguana, snakes 1,364,000
Aquarium fish 29,915,000
Small birds 12,898,000.

From these data, pets population equals human one; cats are more than dogs, and bovine are less numerous than dogs. Indeed, this is the mirror of a changing society. Pet animals, in developed countries, are largely living in urban environments. In 2017, in Great Britain, the estimated population of

dogs was 11,599,824 and for cats 10,090,924 [13] and it is estimated that the density of pets varies substantially, with the lowest densities in rural areas, and the highest in the centers of large cities where each species could exceed 2,500 animals.km-2 [13].

This situation must be managed also in terms of human health. Research suggests that pet animals are deeply relevant to people's health (negatively and positively). Pet bylaws adopted by town and city councils have largely escaped notice, yet they are meaningful to consider in relation to everyday practices, social norms, and cultural values, and thus in relation to population health [14], [15].

Moreover, the reasons to keep animals close to cities changed: in ancient times, cats were kept to deter rodents and exploited for their fur, dogs were protectors of the home and pigs were not only food, but helped to reduce the amount of rubbish where they were kept [16].

The proliferation of urban livestock, especially chickens, rabbits, bees, and goats, has also posed particular regulatory challenges to cities. Scant planning scholarship on urban livestock focuses mostly on how cities regulate animals, but few studies attempt to characterize urban livestock, ownership and management practices, *e.g.* in the US, in relation to these regulations [17].

5. Controlling populations and urban spaces

A limitation in the possibility of managing animal populations is the level of knowledge about their consistency. This is particularly true for pets. In Italy, there is a canine registry office, but the efficacy of this

registry is questionable: if we look at the following table [18], we can see that the ratio humans / dogs (third column) in Italian cities varies deeply. In Torino, there is 1 dog for 13 inhabitants, while in Palermo the ratio is 160. Doubts can rise.

The quantity and quality of urban spaces intended for dogs is also a major concern: in spite of the large quantity of green areas of Italian cities, the availability of areas for dogs is not wide.

We count in Torino, for example, 54 areas for dogs, with a total surface of 90,008 m². However, only 16 of these areas are equipped with separate sectors for large dogs and small dogs! This is, obviously, a great concern for owners.

6. Birdgardening

Urban environments present unique challenges for landscape designers wishing to incorporate wildlife attractants into their designs. Cities are surrounded by relatively large expanses of native vegetation and provide many opportunities for effectively enticing native wildlife into urban spaces. Patches of landscape can be designed that mimic vegetation composition found on the peripheral edges and may potentially lure wildlife by providing food and cover. These areas may also provide regenerative patches of native vegetation within the urban matrix, thereby offering connectedness to larger areas of native vegetation. Such corridors encourage wildlife movement and may aid in the retention of wildlife populations [19].

Social factors reflecting increased urbanization are on the other hand negatively correlated with bird species richness. However, noise is the factor that explained most of the variability. Anthropogenic noise can have a significant negative impact on the conservation value of urban parks for bird species [20].

7. Biodiversity

For many, urban areas are sometimes viewed as concrete jungles, with depauperate fauna and flora dominated by non natives and homogenous taxa across regions. Although such views are understandable, in truth, urban areas house a great deal of species both native and nonnative to the surrounding region [21].

Green spaces in cities, such as parks, allotments, cemeteries, and wastelands, are important components of green infrastructure and provide habitats for numerous animal and plant species. Over the last decades, many studies have shown high species richness and abundance in urban green spaces. This has particularly been the case for studies on birds and plants, but also for other taxa such as mammals, butterflies, and carabid beetles [22].

Urban areas across all of Europe seem then to contain higher levels of biodiversity than unpopulated areas. Surveys of 15 urban and suburban parks in Flanders, Belgium, revealed that the 15 parks contained about 30%, 50%, 40%, and 60% of the total number of wild plant species, breeding birds, butterflies, and amphibians still occurring in Flanders, respectively. Urban parks therefore function as an important reserve of biodiversity in Flanders [23]. Urban ecosystems can support bees with trees, shrubs, herbaceous plants, flower

Grandi città	Spesa Euro a cittadino	Anagrafe Cittadino / cane	Soluzioni Cani / adozioni + restituzioni	Spazi Cittadini / aree cani
Padova	n. i.	10	1	12.600
Firenze	1	n. i.	n. i.	12.376
Verona	1,3	8	1	n. i.
Torino	1,8	13	1	n. i.
Genova	0,6	n. i.	0,9	67.545
Venezia	n. i.	13	1	22.574
Catania	2,5	42	2,5	97.819
Trieste	0,6	11	0,4	n. i.
Roma	3,4	n. i.	2,5	n. i.
Palermo	1,2	160	3,3	n. i.
Napoli	1	20	30,7	n. i.
Bari	2,6			
Messina	1,4	n. i.	2	n. i.
Bologna	-	-	-	-
Milano	-	-	-	-

beds, weeds [24] as well as selected edible plants [25]. However higher levels of spontaneous species and cultivated plant communities are present, including more exotic species than rural plant communities, that supply floral resources all year long. Moreover, urban sites are often warmer than surrounding landscapes. Extent of green areas, plant species diversity, floral density have positive effects on plant-pollinator interactions [26]. In addition, green urban areas are rarely treated with pesticides respect to agricultural areas.

In addition, it is essential to increase people awareness of biodiversity, highlighting that the richness of species in natural environments deserves to be protected for the benefit of both nature and individuals [27].

8. Risks and pest animals

From the other hand, some animals must be controlled, because they can become a problem in urban environment. The best example are pigeons (carriers of ticks), that are harmful for monuments, buildings and even for human health. Other animals can be cited as rats (carrying fleas), seagulls, crows, magpies, mouse, coypus, mosquitoes and tiger mosquitoes. Pet animals can also become a problem: in the city of Detroit, there is an emerging problem of roaming dogs presence. The primary cause this problem in the city is the poor economy and the problem is worse in the most distressed neighborhoods. Several factors serve as barriers to addressing the issue. First, the actual number of roaming dogs is a question of contention in the city. Second, weaknesses in the city governing system and scarce resources have limited the public response to the problem [28].

Conflicts between people and wild animals in cities are as old as urban living itself. In the United States it is only recently, however, that many of the species now found in cities have come to live there.

The increasing kind and number of human-wildlife conflicts in urbanizing environments makes it a priority that effective and humane means of conflict resolution be found. The urban public wants conflicts with wildlife resolved humanely, but needs to know what the alternative management approaches are, and what ethical standards should guide their use [29].

Animals can also be seen as a potential harm for the transmission of pathologies, also for the presence of parasites. The Lyme disease is a good example. Increased urbanization globally and increasing access in developed countries to open urban spaces (e.g. unbuilt areas that are vegetated or sites with exposed soil, including floodplains of waterways) provide also potential increased risk of exposure to environmentally acquired pathogens (including helminths). Cities are also prominent entry points for air travel, thereby potentially increasing inputs of pathogens [30].

9. Conclusions

From this paper, the need for more conscious management of animals (both domestic and wild) in urban environment, and urban green areas in particular, is evident.

Raising education, culture and awareness on urban horticulture and ecosystem services topics is the further aim, together with the promotion of monitoring programs in order to gain the quality of the urban ecosystem and citizens well-being. A new planning and design multidisciplinary strategy in cities requires the integration

among agronomists, ecologists, landscape architects, urban planners, biologists and veterinarians, politicians, and representatives of the civil society using an inclusive approach [1].

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Biophilic Design applied to the Outskirts of Metropolis City of Jakarta

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Abstract

A metropolis city is an important city in a nation, and Jakarta as one of the metropolitan cities should show the best of what it could offer. One of the things includes a healthy environment for the citizens to live in, however, seeing the devastating environmental condition of Rawa Buaya village located in West Jakarta has proven otherwise. The Rawa Buaya village has a limited land area and a great part of the people living in the village is a low class economic society. Most of them has very little knowledge about the importance of having a healthy environment and did not have the will to make a change. Biophilic design is an innovative way of creating a healthy place where nature blends together with a modern built environment and this was the answer to recreate and renew the village of Rawa Buaya. In addition to that, the basic human needs include a green open space and a healthy environment to live in everyday, which a biophilic design can offer. The first phase of the project was to counsel the citizens about the importance of having a healthy environment and how to build a vertical green space infrastructure in their own backyards, letting them understand that what they create provides the 'elements' to solve urban and climatic challenges by the help of nature and creates a healthy environment. The last phase of the project involves a routine check up on the vertical garden and examine the difference after the green infrastructure has been done. However, the project itself cannot be accomplished well unless the citizens participate in taking care of what they have built. Therefore, by this project we hope that more people will realize the importance of the strong bond of the relationship between the nature and the people, and that the benefits; improves mood and relieves stress could be felt by the citizens.

Keywords: green infrastructure; healthy environment; metropolis city; vertical greenery

INTRODUCTION

Rawa Buaya is a small yet populous village located near the river bank with an area approximately 4,67 km² filled with complicated housing areas, warehouses,

small pathways that are mostly not up to standards. There are 10.779 head families living in Rawa Buaya and realizing how limited their sources, it seems that this village needs a repair. A lot of universities, organizations had tried to come and create

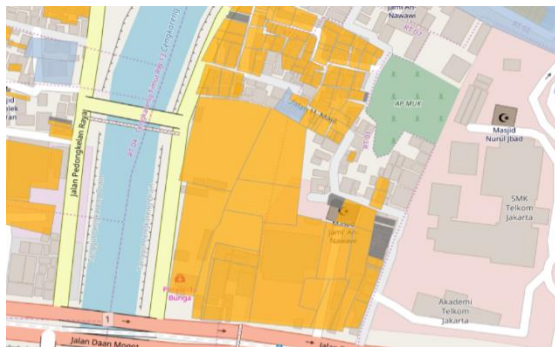
programs, counseling sessions, activities that would help the villagers to understand better about what they should and should not do about the way they organize their lifestyle. Indonesian people likes to plant their yard with plants that could be use every day as a food, such as *Solanum lycopersicum* (Pohon Tomat) or herbs like *Allium sativum* (Garlic). Therefore, they each have their own plants on pots in front of their houses or across their house on the street, which could block the pathway of the vehicles passing by.

GOALS

This study’s aim is to examine the significance of applying biophilic design such as building green infrastructures for Rawa Buaya villagers in order to provide a healthy environment for children and adults.

METHODS

This research was conducted with a descriptive method of analyzing the behavior of the villagers on how well they are capable of taking care of their own environment. The collection of secondary data such as soil fertility, climate data and the history of Rawa Buaya itself are done by literature study.



Soil fertility

This alluvial soil contains high fertility and is good for planting as a agricultural land. Since Indonesian people likes to plant, then this kind of soil suits their lifestyle. This soil does not have a stable profile because the age of this type of soil is still young so it does not have a solid soil structure. In the event of a severe flooding, this type of soil will be easily washed away and dissolved in water which will then undergo a deposition process mixed with mud.

Land use

Rawa Buaya used to be a swamp that cannot withstand the weight of towered buildings or heavy equipments in the warehouses. There have been enormous changes that could cause the village to tear apart in the future time.

Urban sustainability

The Rawa Buaya Village could be called sub-urban since many development has been done, creating a biophilic environment in Rawa Buaya is one way of sustaining their lifestyle.

Lack of space

The lack of space in the village in one of the problems they are having, what could be the solution to creating a biophilic environment in a crowded village, what can be applied to a limited space to create a healthy lifestyle that these villagers can live by.

It should be done by analyzing which part of Rawa Buaya need the most reconstruction because the number of people and houses are so overcrowded that renovation is unwanted.

Biophilic design in villages

Children that play around in nature has a better cognitive response, they are more

active and know how the world works, they are better at being creative and capable of creating something new or innovative. In this era, technology, TV, video games and phone limits their capability of being innovative and stopping them to do instead make these children watch more.

Since Rawa Buaya has a huge number of families in such a small village, creating design with the purpose of 'outdoor lifestyle for children' could be a great idea. Keller (2006) lists four basic principles (translated from German language) that says:

1. Nature, with its vast sources for play provides a lot of things for children to fantasize and help build their creativity.
2. A direct contact with nature allows the mind of children to develop a sensitive appreciation for earth.
3. The forest provides an ideal place for children to freely run and move around, that could develop trust and children gains self-confidence.
4. Children gain competence in social relationship by playing around with other childrens.

CONCLUSION

Biophilic design correlates to almost every part of Rawa Buaya Village, from its purpose to sustain the village itself.

However there are socioeconomic factors that is possible for a biophilic design cannot be applied here in Rawa Buaya. The villagers may not welcome the new infrastructure, second, the length of time needed and the urgency of creating a biophilic village in Rawa Buaya is so minimum that it will not be posed as an important work by the government.

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Investigating the Use, Preference and Constraints of Green Outdoor Environments at Workplaces in Kuala Lumpur

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Abstract

In 2002, Malaysia Quality of Life report, the frequency of park user in Malaysia is still low although the benefits of green outdoor environment as a restoration site is being recognised in most of modern cities. Therefore, there is a need to investigate the use and constraint of green outdoor environment at workplace in order to identify the preference of green outdoor environment among office employees. A survey was conducted involving 32 respondents as sample of the study (20 females, 12 males) aged between 20 and 59 years. Participants were office employees from various industries randomly selected in highly compacted areas with offices in Kuala Lumpur and which consists of green outdoor environment. This study aims to identify the use and constraints of using outdoor green environments by office employees and investigates their preferences for outdoor green environment. It was found that most of the employees visited green outdoor 3-2 times per week (43.8%) over the last six months by doing various activities such as walked to and from public transportation or parking space, meeting colleagues and others. The results were leading towards positive perceptions towards green space in the work environment and increased positive workplace attitude and recommendations for integrating a green space for offices in Kuala Lumpur. It was found that green outdoor environments were health-promoting assets at workplaces, and that increased access to such environments for the employees can lead to decreased levels of stress. Furthermore, green outdoor environments at workplaces were related to a positive overall attitude toward the workplace (81.3%). However, due to the time limit during lunch break or after working hours, 62.5% of the employees were unable to spend much time at green outdoor area. The findings from this survey has the potential in providing information for the planning and management of green outdoor environment in Malaysia. This information is vital for the local town councils in providing the management plan for green outdoor environment in Malaysia in the future and also to the National Landscape Department to enhance the current policy on urban green spaces.

Keywords: Biophilia design; office green space; work-related stress; self-reported health

1. Introduction

Worldwide, work-related stress is considered a major challenge to workers' health and the health of their organisations (World Health Organization, 2011a). The European Agency for Safety and Health at Work (2000) reports that work-related stress is one of the most significant European health and safety problems, and it affects nearly one in four workers. Work-related stress can impair an individual's psychological and physical health, as well as an organisation's effectiveness (World Health Organization, 2011), and studies suggest that between 50% and 60% of all lost working days are related to stress (European Agency for Safety and Health at Work, 2000b). This represents a major cost in terms of human distress and impaired economic performance (*ibid.*). Work-related stress was previously considered as being primarily a problem in the developed countries, but it is now also an issue of growing concern in developing countries due to processes of globalisation and the changing nature of work (World Health Organization, 2007). A review on qualitative research, which addressed work related stress, found that stressors at work were reported more frequently than stressors associated with other role areas, and concluded that research on occupational stress is especially relevant to efforts aimed at reducing overall stress levels (Mazzola, Schonfeld, & Spector, 2011).

Against this background, it is hardly surprising that individuals, companies and communities are very concerned about the topic (European Agency for Safety and Health at Work, 2000) and that a lot of resources are invested in stress management programmes (Goetzel & Ozminkowski, 2008; World Health Organization, 2004). Contemporary stress management programme at workplaces typically focus on psychosocial factors, and do not address the

growing body of research on the environmental psychology of workspace (for a meta-analysis see van der Klink *et al.*, 2001). However, studies show that the physical working environment is significantly related to employees' stress-level (Rashid & Zimring, 2008; Vischer, 2007). The effect of the workplace outdoor environment for employees' level of stress has mainly been ignored, even though the relationship between access to green outdoor environments and human stress in other contexts is supported by a vast body of empirical evidence (Nielsen & Hansen, 2007; Stigsdotter *et al.*, 2010; van den Berg, Maas, Verheij, & Groenewegen, 2010). Theoretical explanations for this relationship are based on cognitive or evolutionary perspectives.

Few studies have addressed the potential benefits of access to a green outdoor environment at work for employees, companies and societies. However, the few that have indicate that access, either visual or physical, to such environments during the working day is related to increased health (Kaplan, 1993), wellbeing (Hernandez, 2007; Leather, Pyrgas, Beale, & Lawrence, 1998), job satisfaction (Kaplan, Bardwell, Ford, & Kaplan, 1996; Kaplan, 1993; Leather *et al.*, 1998; Shin, 2007) and work performance (Kaplan *et al.*, 1996; Pati *et al.*, 2008), and to decreased perceived levels of stress (Pati *et al.*, 2008; Shin, 2007). Recent studies show that, despite the potential benefits, the majority of office workers do not go outdoors during the working day, mainly due to a perception of being too busy and a working culture that does not include outdoor behaviour (Hitchings, 2010; Lottrup, Stigsdotter, Meilby, & Corazon, 2012).

Therefore, this research sought to study the use and preference of green outdoor environment at workplaces by office employees in Kuala Lumpur, whilst

investigating the effect of green outdoor environment use and self-reported mental health.

2. Methodology

2.1 Participants

The total participants for the study were 32 respondents who worked within the area of offices with access to the green outdoor environment in the city of Kuala Lumpur (Figure 1). Kuala Lumpur as the capital city of Malaysia is the main choice of local and international real estate investors (Boo, 2003) and deemed as the major provider of office space in the country. In term of occupancy rate, Kuala Lumpur peaked the highest among the major city in Malaysia. To further identify what are the existing office spaces offered in Kuala Lumpur, reference is made with Property Market Report published by National Property Information Centre (NAPIC) (Figure 2).

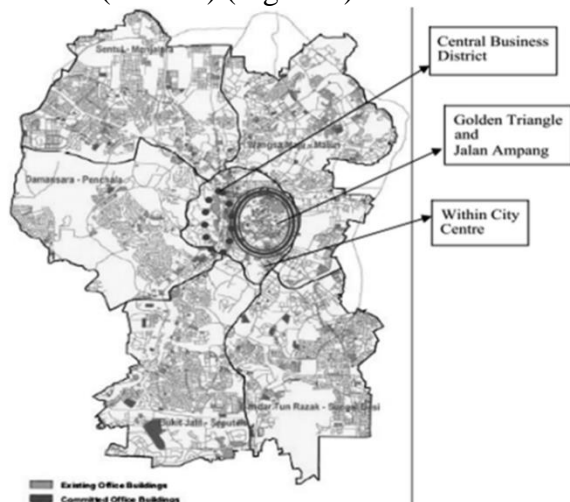


Figure 2: Location of Central Business District, Golden Triangle and Within City Centre in Kuala Lumpur (Source: Kuala Lumpur City Hall)

According to the survey, all participants were being employed at the time of participation and came from various sectors including finance, oil and gas industry, retail, business, education, government agency, real estate, construction and health.

2.2 On-site survey

A survey was conducted for four weeks in a month of February 2018. The questionnaire contains thirty (30) questions, both closed-ended questionnaire with multiple questions and open-ended questions. The questionnaire's sections were inspired by several other studies on use and users of green outdoor environment (Gobster, 1995; Lindsey, 1999; Schipperijn *et al.*, 2010). The survey was conducted in two languages, namely Malay and English to cater for the cultural diversity in Malaysia including the expats. (Sreetheran, M., 2017).

The users at each green outdoor area were surveyed on-site on weekdays, in the afternoon from 12.00 until 3.00 pm; and evening from 3.00 until 7.00 p.m. (Sreetheran, M., 2017). The sample was taken during the lunch break and after work where the number of office employees being outside of their offices is high. Typical working hours in Malaysia are from 8.00 am until 5.00 pm and lunch break from 1.00 to 2.00 pm.

The first part of the questionnaire consists of respondents' physical work environment and the distance from their office to the nearest urban green outdoor. Distances were broken into: less than 300 metre; 300-500 metre; 500 metre to 1 kilometre; and more than 1 kilometre. The respondents were also asked for the frequency of use of the green outdoor (daily, several times per week, weekly or never) and duration of use (less than 5 minutes, about 15 minutes, about 30 minutes, about 1 hour, and more than 1 hour). The respondents were also asked the reasons of using the green outdoor near their offices. Their choices included the following options: to walk, having meal, meeting colleague, exercise and other reasons. The respondents are allowed to choose more than one reason. They were also asked

characteristic of green outdoor environment according to their preferences.

Section B until Section G of the questionnaire contains about the physical work environment; the emotion while visiting green outdoor environment in term of time balance, social and community, lifestyle, nature surrounding, and perception towards green outdoor environment. They need to rank their responses on five-point scale ranging from ‘very agree to very disagree’ (Lottrup *et al.* 2012). The final section of the questionnaire consists of respondents’ socio-demographic status such as gender, age, race, education level, occupation and how long he/she has been employed in the company.

All data was recorded into database and analysed accordingly using Microsoft Excel.

Section	Question focus
A	Physical Work Environment
B	Emotional Aspect
C	Time Balance
D	Social & Community
E	Lifestyle
F	Nature Surrounding
G	Perception Towards Green Outdoor Environment
H	Socio-demographic

Table 1: Sections and questionnaires

3.0 Result and Discussion

3.1 Demographic background

The results of the study presented the information from 37.5% (12) male and 62.5% (20) female respondents. Respondents between ages 30-39 were the majority with 47% (15) participations while respondents between ages 50-59 were the minority with 6% (2) representatives in the survey. Ninety four percent (94%) of the office employees have the access to green outdoor.

Table 2: Demographic background

Categories	Sub categories	Number	Percentage (%)
Gender	Female	20	62.5
	Male	12	37.5
Age	20-29	6	19
	30-39	15	47
	40-49	9	28
	50-59	2	6
Access to green outdoor	Yes	30	94
	No	2	6
Distance	≥ 300m	8	25
	300-500m	13	41
	500-1,000m	8	25
	Not sure	3	9
Visit frequency	≥ 5 mins	19	59
	15 mins	8	25
	30 mins	5	16

3.2 Visit frequency

It was found that most of the employees visited green outdoor 3-2 times per week (43.8%) over the last six months by doing various activities such as walked to and from public transportation or parking space, meeting colleagues and others. Although 59% of the respondents claimed that they only ‘visited’ green outdoor just by walked to and from certain places, they do not perform physical activities which allow them to utilise the facilities that are available or enjoying the scenery at green outdoor area.

3.3 Use patterns and constraints

The majority of respondents (62.5%, n=20) reported that they were experienced obstacles to go out and visit green outdoor during working hours because of the time limitation and indicated they were too busy. This result is connected with Lottrup *et al.*

(2012) and Hitching (2010) discussed in their studies where the employees were too busy to go outdoors during their working hours. Three of respondents also stated that they only have an hour of lunch break and managed to grab a quick lunch before heading back to their offices and after working hour, they have to rushing back to pick up children from school and day care (Bonke, 2002). Therefore, these employees were unable to spending off more time visited green outdoor area outside of their offices during their working hours or after. According to 59.3% (n=19) respondents, he/she preferred to visit air-conditioned place compared to green outdoor area during lunch break due to the hot weather. This finding is similar to the study that was conducted by Sreetheran (2017) who mentioned that the user chose to visit outdoor in the morning or later in the evening in a tropical country like Malaysia. Other researches by Jim and Chen (2006) and Wong (2009) also stated in their papers that users avoided hot afternoon to visit outdoor in other highly dense Asian cities like Guangzhou and Hong Kong.

3.4 Perception towards green outdoor

The respondents were asked to rate their emotional aspect before and after visiting the green environment outside of their workplaces using a 10-point grading scale; one for 'very unhappy/feeling stress' and ten for 'very happy/joyful/satisfy/free from stress'. Almost half (43.8%) of the respondents rate 5 (neutral) before visiting green outdoor area and rate more than 5 after their visits (81.3%). As reported by several studies, this finding is similar with Biophilia Hypothesis where natural settings have restorative capacities to the visitor (Ulrich, 1984; Hartig, Mang & Evans, 1991; and Besthorn & Saleebey, 2003).

Using dichotomous questions, the respondents were asked to answer 'Yes, Not Sure or No' on their perception towards the

nearest green outdoor environment at workplace. Figure 3 was obtained from respondents' responses. In addition to the perception of green outdoor, 31.3% gave opinions on green outdoor environment near their offices.

For example, a female respondent from green outdoor C (Jalan Tun Perak) suggested that to improve the facility such as more benches, tables, and potted plants to make it more friendly-user. These characteristics were being cited by Schroeder (1982) where urban visitors preferred man-made feature contributing to high site quality such as paths and other features for passive activities (sitting and relaxing). One male respondent from green outdoor B (Jalan Raja Laut) suggested relocating the green outdoor area far from the busy road to more quiet and serene area with café or smoking zone. This finding is consistent with the study conducted by Lottrup *et al.* (2012), Grahn and Stigdotter (2010). In the study, the green outdoor visitors preferred to be in serene place, close to nature and having a space to perform a certain outdoor activities during the working hours, in line with perceived sensory dimensions (PSD) which has been identified by Grahn and Stigdotter (2010).

4.0 Conclusions

Green outdoor environment may comprising natural landscape or built landscape. Therefore, in this study, the focus was on the green environment at workplace which includes green space outside of their offices where people can do common activities such 'walk-throughs', having lunch, sitting and talking, and relaxing (Faris *et al.*, 2008; Hernandez, 2007; Sherman *et al.*, 2005). The good impact on the exposure to the green outdoor environment was also stated by De Vries *et al.* (2013) that green outdoor environments promote positive social contact among its visitors. According to Sianoja *et al.* (2017), current working life is

demanding. Therefore, there is a need to gain more theory-based knowledge on how to optimise the lunchtime or before leaving work for recovery from work, for example by brisk walk in the park or green outdoor area.

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Appendix 1




No.	Green outdoor	Nearby offices	Features
1.	 Green Outdoor 1	Akademi Etiqa Muamalat Bank Address: Jalan Melaka Coordinates: 3.1504° N, 101.6975° E	Bench Art installation Flowerbed Trees Pathway Hardscape Grass
2.	 Green Outdoor 2	Kuala Lumpur City Hall Employees Provident Fund Building Address: Jalan Raja Laut Coordinates: 3.1537° N, 101.6948° E	Trees Steel benches Water fountain Pathway Hardscape
3.	 Green Outdoor 3	OCBC Bank Address: Jalan Tun Perak Coordinates: 3.1502° N, 101.6960° E	Palm trees Water fountain Shade canvas Pathway Hardscape

Figure 1: Green outdoor within the area of high rise offices. Features are adapted from McCormack *et al.* (2014)

Appendix 2

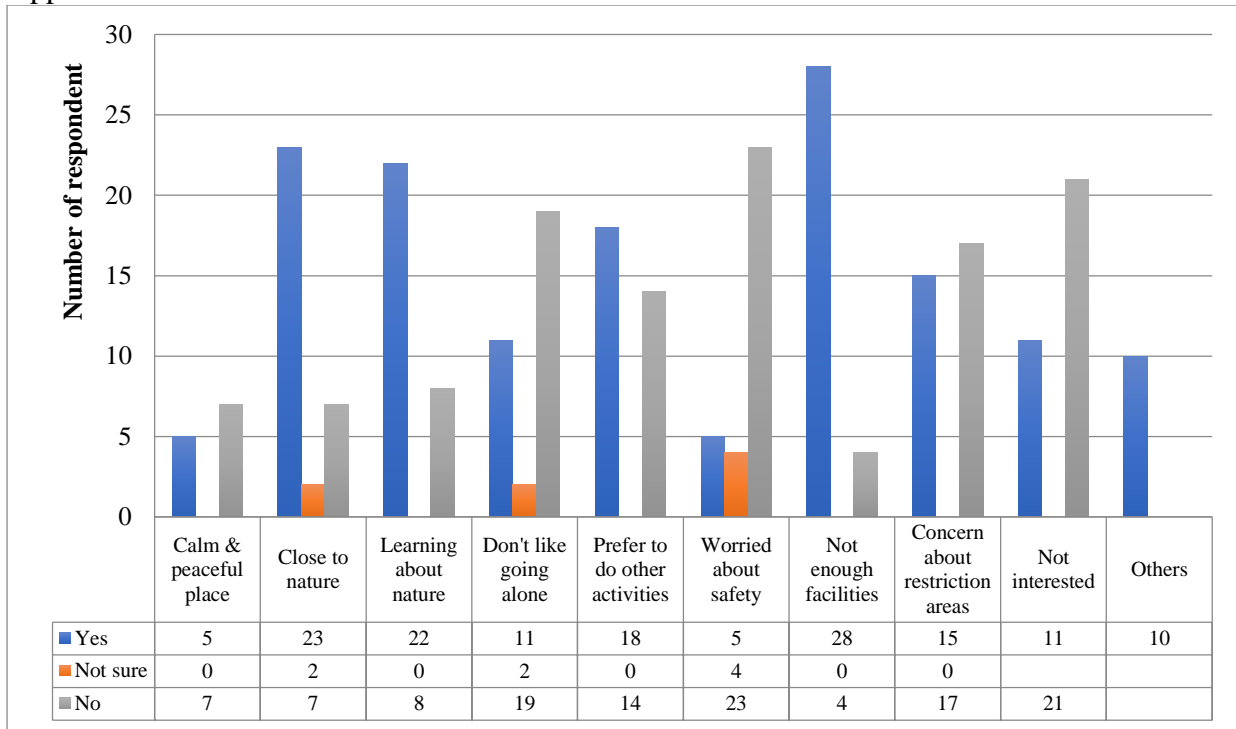


Figure 2: Perception towards green outdoor among office employee

SMART NATION



FULL PAPERS



A comparative study of the application of the Storm Water Management Model in the construction of urban green space under the perspectives of sponge cities

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Abstract

Recently, the acceleration of urbanization leads to the serious hardening of the underlying surface in cities that are located in China and the waterlogging caused by the hardening damages the development of cities. According to the <Basic Situation of Natural Disasters in China (2016)> published by Ministry of Construction, about 90% counties in 31 provinces, autonomous regions and municipalities in China were affected by different degrees of natural disasters, losses caused by flood significantly expanding compared with the damages in 2015. Rain and flood in urban cities become an issue that must be solved in China's urbanization procedure.

Aiming at the social background, the Ministry of Construction has published <Work Plan 2014>, clearly indicated 'speed up researching policy measures on the construction of sponge type city'. In December of 2014, <Technical Guidance of the Construction of 'Sponge Cities' (For Trial Implementation)> was published, which introduced the concept of 'sponge cities'.

However, because the construction of sponge cities in China starts fairly late, China's sponge cities are experiencing limitations and disadvantages compared with those cities in other countries. The most important is that China underestimates the bearing pressure of green space counter to rain and flood.

At the beginning of twentieth Century, the United States proposed the model of Best Management Practices; at the end of twentieth Century, the United States proposed the model of Low Impact Development; Australia proposed the model of Water Sensitive Urban Design; the British proposed Sustainable Urban Drainage; also the theory of Active, Beautiful, Clean Waters Programme in Singapore was proposed in 2006. All these has been tested by time and well accepted by people.

To conduct a more concise quantitative analysis on rain and flood in urban cities, the research found that researchers represented by American, Danish, Englishman studied and developed a series of models to manage rain and flood in urban cities. They conceive an idea that is based on and refers the calculation and stimulation conducted by computer model. Those models

aiming to different scales, environment and requirements are designedly optimized and they have different functions and range of use.

Based on the view of the designing and construction of green space in sponge city, by the stimulation of the green corridor project that was conducted at Binhu East road, Qian'an, Hebei Province, the research illustrates the application and academic achievements gained in the procedure of the location, effectiveness evaluation and effectiveness estimation of the designing of green space in sponge cities via the comparison and analysis of the modules and functions of various rain and blood management models(SWAT, SUSTAIN, SWMM etc.) which are developed by China and other countries, trying to generalize the application channel of the various modes in the designing and construction of green space in 'sponge cities' in China so as to find the possibilities of the localization and promotion of the above modes.

Keywords: sponge city; model for stormwater management; urban green space; green corridor

1. Introduction

In recent years, the progress of urbanization in our country caused more and more serious degradation phenomenon of hardening city underlying surface. It leads to frequent phenomenon of urban waterlogging, which has brought the serious crises and challenges to the development of the city.

According to statistics, many domestic tier-1 cities suffered serious waterlogging phenomenon only in two months of May and June of 2013, like Changsha, Chengdu, Xiamen, Fujian province, Kunming, and more than 270000 people were injured ^[1]; In May 2014, a heavy rainstorm occurred in Qingdao and Shenzhen, resulting 18 people casualty and 3 injured ^[2]. In 2015, the Ministry of Civil Affairs released the "2015 Basic Situation about National Natural Disasters"^[3]. The total of 36 times of heavy rain occurred in China with serious waterlogging disaster in tier-1 cities like Nanjing, Wuhan, Shenzhen, Shanghai. In mid-November, rare winter flood season happened in Jiangxi, Hunan and Guangxi with more than one million people affected; In 2016 and the "2016 Basic Situation about National Natural Disasters" ^[4], nearly 90% of nationwide county-level administrative

region of 31 provinces were affected by different degree of natural disasters, which includes heavier floods and geological disaster losses than in 2015. Among which, sponge pilot cities in provinces like Hebei, Hubei, Jiangxi and Anhui still had more serious disaster. Serious waterlogging even happened in early July in Wuhan of Hubei due to heavy rainfall, which caused serious influence to people's life and property safety.

The safety of rain-flood has become a problem that must be solved in the process of urban development.

2. Present situation of sponge city construction

In the '2014 Key Point Work', Ministry of National Housing and Urban Development determined "the urge to speed up the distributary transformation of rain and wasted water to improve the level of city drains, to greatly push forward the low impact development mode, to accelerate the policy measures of construction of the sponge city "; From 2014 to 2015, the first announced batch of 16 urban construction pilot cities began to be built, with a planned investment of 30 billion yuan in three years and a construction area of over 400 square

meters^[5]. The construction of sponge city has attracted the attention of social media and the masses.

Compared with the mature urban sponge system in foreign city, China's urban construction sponge started relatively late with shortcomings and limitations. For instance, a large amount of present construction of sponge cities in China transfer urban rain flood pressure to the urban green land, which ignores the basic natures of green land and the limit of rain flood carrying capacity of green land, leading to the overload of rain flood pressure of green land. Not only did it not cut off the expected urban rain flood problem, the basic functions of green land have also been damaged to a certain degree.

How to scientifically and accurately conduct the quantitative analysis about the rain flood control index and flood control ability of sponge city in the process is an urgent problem in the urban green land design.

3. Brief introduction of water management models

Under the drive of this issue, researchers represented by the United States, Denmark, Britain have developed a series of urban water management models for the sake of the quantitative analysis with higher precision of urban rain flood indexes by using the computer model for calculation simulation to provide the analysis method of auxiliary parameter for the design. These water management models are specially designed and optimized for different scales, environments and requirements with their different application range and function.

3.1. Watershed scale simulation models

With the development of computer technology, the watershed hydrological model appeared as early as in the 60 s and 70 s of the 20th century. Its development focus on is in the large-scale basin analysis with core functions mostly made up by the measurement of a wide range of runoff, ecological stock estimation of watershed scale, designation of watershed response unit, and so on. Among which being widely used are the Sacramento model developed by the NWS and the SWAT model developed by the USDA.

3.1.1. Sacramento

Being a continuous operation model of lumped parameter, Sacramento model is improved and developed on the earliest Stanford river basin model by the Sacramento prediction centre of hydrological office of NWS. By mathematical calculation, its main function are years of simulation for runoff confluence, distribution of rainfall and snowmelt runoff based on the soil moisture content, osmotic quantity, drainage and evapotranspiration process of the river basin scale runoff.

3.1.2. SWAT

SWAT (Soil and Water Assessment Tool) model is an open source plug-in model through secondary development on ArcGIS platform by USDA and its prototype is the field scale non-point source pollution model CREAMS in the 1970s. Its main functions are the predicting simulation of land management and regional meteorological impact on supply of river basin water environment under the complex and diverse conditions of soil conditions, land usage

mode and management mode in the large scale basin. The SWAT model is a widely used watershed simulation model both in China and abroad.

3.2. Urban green land scale simulation models

Green land is one of important undertaking unit in urban rain flood control. Faced with small scale cities or urban green land space, countries continue to develop a great deal of water management models targeting the city and urban green land on the basis of watershed hydrological models, among which the widely used is basically the model developed by the EPA. Especially the SUSTAIN model plug-in based on ArcGIS platform and independent software model SWMM are most widely applied.

3.2.1. SUSTAIN

SUSTAIN (System for Urban Storm-water Treatment and Analysis Integration) is a plug-in model through secondary development on ArcGIS platform by EPA in the 1970s and 1980s. The model combines the partial algorithm model and genetic algorithm in the early SWMM5.0 to apply the analysis models of hydrological, hydraulic and water quality. With comprehensive consideration of cost control and optimization method, it uses ArcGIS platform to couple the simulation and optimization phase, which can not only develop, evaluation, selection and settings of BMP in construction region with different scale from two aspects of cost and efficiency, it can also provide comprehensive and practical evaluation from the perspectives of

economy, environment and engineering for the management measures.

3.2.2. SWMM

As a city heavy rain management developed by USEPA between 1961 and 1971, SWMM (Storm Water Management Model) can simulate the accumulation and erosion of urban rainfall runoff and various pollutants. Its transmission system can realize hydrological, hydraulic and water quality simulation and its results can be output in a variety of ways, and be modified and updated in recent years. Presently, SWMM model is also the most widely used in the construction of the development of low impact model in China.

3.3. Urban pipe network simulation models

3.3.1. MOUSE

MOUSE (Model for Urban Sewers) is a urban storm runoff Model developed by DHI in 1984 to simulate the urban runoff and pipe flow. At present, MOUSE mainly provides design basis for LID by predicting water level changes in urban pipe network while also compares the purification efficiency of pollutants targeting on different models of LID.

3.3.2. Info Works

Info Works is a hydrological water quality model for urban drainage systems developed by Wallingford in 1997. Being mainly used in the planning and design of urban water supply and drainage, sewage system, river and coastal engineering projects, this model provides technical support for many domestic practical projects, such as drainage, sewage pipe network analysis, drainage system

selection and surface source pollution control planning.

3.4. Model selection

First of all, according to the basic attributes of each model, this paper compares and

analyzes the water management models from the above five aspects of the docking platform, scope of application, simulation program, simulation function and data requirements. The results are shown in table 1.

Table 1 The comparison of storm-water management models ^[6]

Model name	Sacramento	SWAT	Sustain	SWMM	MOUSE	Info Works
Docking platform	Mathematical concept calculus	ArcGIS、AutoCAD、Microsoft Excel	ArcGIS、AutoCAD、Microsoft Excel	Image	ArcGIS、AutoCAD、Google Earth	ArcGIS、AutoCAD、Google Earth
Scale type	River basin, city	River basin, city	City	City green land	City pipe network	City pipe network
Simulation program	Hydrological/hydraulic	Hydrological/hydraulic/The water quality	Hydrological/hydraulic/The water quality	Hydrological/hydraulic/The water quality	Hydrological/The water quality	Hydrological/hydraulic/The water quality
Simulation function	Quantitative analysis of runoff and rain pollution; Simulation of melting snow and evaporation	BMP location choosing analysis; Quantitative analysis of runoff and rain pollution; BMP efficiency analysis; Efficiency cost curve, etc.	BMP location choosing analysis; Quantitative analysis of runoff and rain pollution; BMP efficiency analysis; Efficiency cost curve, etc.	Quantitative analysis of runoff and rain pollution; Pipe network overflow analysis, etc.	Pollution load distribution, etc.	The flow area of open channel flow and water gathering area of pipeline network; Water pollution analysis, etc.
Data requirement	Meteorological data; Land information data; Soil seepage parameter, etc.	Meteorological data; Land information data; Hydrological water quality data; Accumulation parameters of pollutants; BMP structure parameters, etc.	Meteorological data; Land information data; Hydrological water quality data; Accumulation parameters of pollutants; BMP structure parameters, etc.	Hydrological water quality data; Accumulation parameters of pollutants; BMP structure parameters, etc.	Hydro meteorological parameters; Land information data; Accumulation parameters of pollutants.	Hydro meteorological data; Land information data.

The result of simulation model by comparing shows that in basin scale model, data demand of Sacramento model is bigger compared with the SWAT model and the water quality simulation could not be conducted. Among the simulation model of cities and urban green land scale, SUSTAIN model and SWMM model all have emphasis on their functions. SUSTAIN is more about detailed quantitative analysis for BMP measures while SWMM focuses on

quantitative calculation of runoff rain pollution. MOUSE and Info Works model are more focused on the analysis of city pipe network simulation. Based on the actual demand of Chinese sponge city green land design, SWAT, SUSTAIN and SWMM model are selected for further comparison of functional modules.

4. The application of water management models in the green land construction design process of sponge city

This study sums up the six design processes in the “Sponge Urban Construction Technology Guide”^[7] to be four steps of the targets determined of the early stage, plan forming in the initial stage, effectiveness evaluation of middle stage and plan optimization in the later stage to consider the application possibility in the design process at different stages of the green land construction of sponge city based on different functional modules focuses on SWAT model, SWMM model and SUSTAIN.

4.1. Control target determination

Construction goal of sponge city green land is to have a certain degree of control on the rain runoff pollution problems of the city instead of bearing the pressure of urban rain flood completely. Thus, before sponge city green land construction, the construction position of green land in urban overall planning and construction needed to be clear to determine its runoff control rate, pollutant removal rate and related specific indicators. The simulated objects in this stage are the city scale runoff and precipitation distribution, and the runoff estimation of the specific region.

The SWAT model mainly adopts the concept of the representative basic unit to determine the corresponding simulation parameters and results by generating HRU according to the specific soil types and land use methods of each sub stream. At the same time, the modelling definition and basic simulation of the responsive units can reduce modeling simulation time cost by

guaranteeing simulation precision under the condition of large deviation greatly.

Some kind of hydrological response unit were obtained by inputting the SWAT model after the terrain data, basin data and soil type data vectorization processing to carry out generalization process of underlying surface type scale of the same corresponding unit and initial calibration of sponge city renovation or generalized index. Through the secondary simulation of the SWAT model, the reasonableness of its runoff pollution control was verified to identify the corresponding land use planning and control objectives. This goal can guide the design method and scale of sponge system in the next green land design plan.

4.2. Plan forming

In the design of sponge city green land, the corresponding scale estimation and spatial distribution simulation should be carried out for the low impact development measures. The simulation object of this stage is the estimation of runoff and pollution abatement of green land scale and the distribution simulation of the low impact development measures of the facility scale.

The efficiency of this phase estimation is only a rough simulation forecast. SUSTAIN model in rain pollution effectiveness evaluation phase needed a large number of detailed data and land information data, which is difficult to get. So the choice of SWMM to estimate the size of low impact development measures is made. In the estimation, the distribution relationship between the same kind of low-impact development measures and the flow direction of each other can be ignored to be calculated in the model after the same kind of low-

impact development measures and are combined and simplified.

Distribution simulation measures in this phase can choose SUSTAIN model which is based on ArcGIS platform of low impact development measures of spatial distribution simulation and the main uses two modules of its framework of management and BMP layout. After drawing sketches plan, it can be input into ArcGIS platform after its vectorization on CAD platform for and corresponding standards of site selection can be determined, such as a number of indicators of rainwater catchments area, slope, impervious rate, depth of groundwater and

road buffering area distance. By the overlaying analysis of the module in figure 1, the possible spatial distribution of the corresponding low impact development measures was determined with results example shown in figure 2. On which basis, it is further screened according to the specific site conditions, the rain flood control target and policy measures to enable designers to make specific design by combining the functional requirements and landscape requirements to get the rain preliminary design plan of flood control.

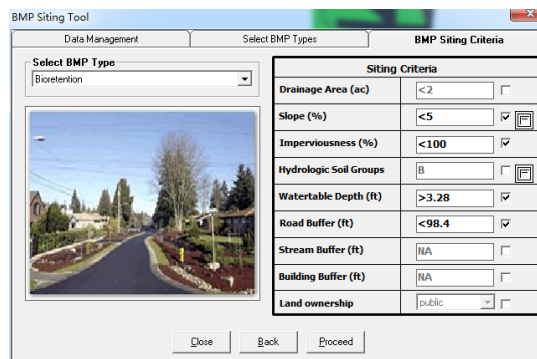


Fig.1 The site selection module of SUSTAIN model [8]



Fig.2 The sample of siting analysis result [8]

4.3. Effectiveness evaluation

After completing the design of green land program, it is necessary to carry out an accurate assessment of the efficiency of runoff and pollution to determine of the result of the plan has reached the goal of the first step. The simulated object of this stage is the

estimation of runoff and pollution abatement of green land scale.

The accuracy requirement of effectiveness evaluation of this phase is high. As a simulation model of vectorization quantization based on ArcGIS platform, the accuracy of SUSTAIN model can be guaranteed more compared with the simulation of the vector quantization of SWMM model. Mainly by four modules of

framework of management, land, BMP and transmission simulation in SUSTAIN model^[9], this process inputs the corresponding land information data, soil conditions, design information onto ArcGIS platform to form the model base, and builds structure for each measure and tube drainage in low impact development measures simulation module of SUSTAIN model for to provide a basis for simulation in runoff calculation and the rain pollution reduction. In the process of the urban green land construction of sponge city, policy makers can compare the simulation results with project control objectives at this stage to further adjust the design details on the basis of the comparison results to complete the basic control requirements of the project.

4.4. Plan optimization

One of the important factors of the design of sponge city green land is the design stage of the plan extended to the later stage of construction drawing design and the balance control between the plan and the cost. The simulation object at this stage is the relationship between plan efficiency and plan cost.

This stage mainly uses integrating unique module of SUSTAIN model to make cost optimization analysis. The model integrated the two algorithms of SSM and NSGA - II for the plan optimization^[10], including the improved genetic algorithm NSGA - II can generate effectiveness evaluation curve for BMP and LID facilities construction and maintenance cost to assist designer to determine the optimal design plan. It requires researchers to determine the plan of the structure of BMP facilities variables according to the required optimization goal and make decisions for each variable parameters interval and incremental settings, which uses the Sustain model to do a large number of combinatorial optimization calculation, and output the corresponding calculation results in the form of chart as shown in figure 3. In urban green land construction in the process of sponge city, cost and benefit calculation curve provided by the Sustain model can aid decision makers in making the final adjustment and choice in such aspects as overall cost control and the plan optimizing to reach the optimal effect.

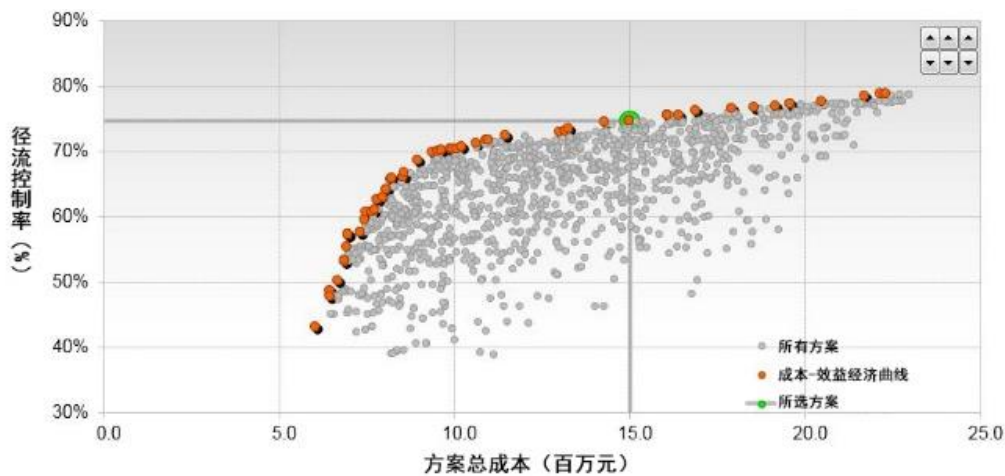


Fig.3 The sample of the cost-effectiveness curve of average flow volume reduction [8]

5. Conclusion

In the construction of sponge city green space, the designer must adopt both qualitative and quantitative analysis methods to ensure the reasonable and effective design scheme. Water management models provided the corresponding calculation way, but from a single water management model analysis, the inevitable exist error and function of lay particular stress on, and errors. Relative on the whole, because each model has different characteristics and focusing on the function, if through the basic modules, use and expanding functions of contrast research, applying the linkage, can result in sponge to different stages of the urban construction to provide important role.

6. Acknowledgments

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The presentation strategy of virtual reality based on the comparison with traditional visual communication methods in landscape design

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Abstract

Compared with traditional visual communication methods, virtual reality can utilize and integrate high-presentation computer software and hardware and various advanced sensors to create an immersive and interactive information exchange environment, providing landscape architecture design various possibilities in education, research and design process. Landscape design presentation is mainly a way to convey the design's work to other people. It is an important and direct way for designers to communicate design concepts and express spatial environment between clients and their counterparts. Till now, there has been various ways for presentation, such as rendering images, diagrams, solid models, and animation presentations. Compared with the traditional representation methods, virtual reality technology has its own advantages and disadvantages. Due to the higher complexity and possibility of virtual reality technology for equipment, platforms, and transmission methods, its display strategy in design presentation needs special consideration.

Four process of presentation work was summarized to compare different presentation methods, including modeling, environment rendering, displaying and public participation. Two basic types of virtual reality technology are represented: the fixed-end VR and the mobile-end VR. A comparative study between two different scales of projects - the plan of Jingzhang High-speed Railway Green Corridor and the design of the Central African Garden in the Beijing World Horticultural Exposition - were down to explore complexity and potential of the two virtual reality technologies, and try to build strategies for presentation with virtual reality.

Through the research, a strategy framework of virtual reality design is summed up. The strategy is based on four aspects mentioned above, and started from the complexity and potential of the two aspects, VR and the combination of VR and other methods. Finally, the suggestions of model building, rendering and selection of equipment are proposed.

Keywords: Virtual Reality; Presentation Strategy; Visual Communication Methods

1. Introduction

The presentation of landscape design is mainly a way to convey the scheme of design to other people. It is an important and direct way for designers to communicate design concepts and express spatial environment between clients and their counterparts. Till now, there are 4 traditional ways to display landscape architecture design: single-image renderings; diagrams to express design structures and design processes; solid models built from various materials; animations with continuous illustrations by editing and rendering.

Compared with traditional image propagation technology, virtual reality (VR) can utilize high-presentation computer hardware and various advanced sensors to create an immersive and interactive information exchange environment, providing landscape architecture design various possibilities in education, research and design process ^[1].

This paper will do research on two types of VR mode, which are based on two different types of VR playing devices, including fixed-end VR and mobile-end VR. Fixed-end VR refers to Oculus Rift, HTC Vive and Sony PS VR represented with external computers and professional sensors device. Mobile-end VR refers to devices that use Gear VR, Days VR, and Google Cardboard, kinds of low-cost recommended glasses, as the main device and mobile phones as players ^[2].

Virtual reality has become an important way to express the landscape design, and it has its own advantages and disadvantages compared with traditional visual communication methods. Due to the higher

complexity and possibility of virtual reality technology for equipment, platforms, and transmission methods, its display strategy in design presentation needs special consideration.

2. Methods

2.1. Single Scene - Contrast in 4 Processes

The research divides the post-design presentation work into four processes: modeling, environment rendering, displaying, and public participation. Taking the presentation of one scene as an example, the workload and presentation characteristics of different ways are compared.

Among them, modeling and environment rendering are part of the workload, which reflects the input of the design team to the project, including manpower, equipment and capital. The lower the investment in the process, the higher the efficiency of the process itself. Displaying and public participation is the process for expression and feedback evaluation. It reflects the actual output effectiveness of the project. The better the results presented in this part, the more satisfying the clients and user groups will be, and the feedback evaluation of the project will be clearer and more accurate, which can reduce duplication of work and repeated trials and have a positive effect on the promotion of the project.

The factors that measure input include the human resources, the time it takes, the demand for work platforms and equipment, and additional capital investment (such as cooperation and consulting). Measured output factors include the attractiveness of the attraction to clients, the ease of platform

construction for displaying information, the accuracy of the client's understanding of the presented information, and the effectiveness of the client's feedback to the designer that can be more clear to understand client's demands, thereby reducing the possibility of repeated work and accelerate the overall process of the project.

Modeling

Modeling is the process that the designer build a 3D digital model in the computer using modeling software such as Sketch Up, Rhino, 3DMax and other tools after the designer completes the design. This process mainly prepares for the later environment rendering. It is a key step in the transformation of the design scheme into the physical space model, and it is also the most workload-concentrated step in the work flow. In this process, due to the need to present a 360-degree scene, the fixed-end VR and the mobile-end VR need a large amount of work; the scene of rendering and animation can be selected at a relatively fixed angle, so the workload is smaller than VR; the solid model (mainly the pre-cutting preparatory work) and diagrams often require different depths of modeling based on the intent of presentation, so the workload is more flexible.

Environment Rendering

The environment rendering is the process of rendering and adjusting the model to make it into a finished product that can be used for actual presentation. The rendering processing equipment and processes between different representation methods are quite different. Among them, VR, rendering images, and animation often rely on V-ray, Lumion, 3D MAX and other rendering software rendering the light environment and material on the

model to obtain a realistic or artistic image. Fixed-end VR and animation often needs continuous images that cost more workload than rendering images and mobile-end VR. Larger and more detailed models need more workload cost and higher equipment requirements.

In the rendering process of rendering images and diagrams, it is often assisted with post-processing software such as Adobe Photoshop, or directly using it to create matte painting, to make the image closer to the real environment, or to highlight a stylized atmosphere. Animations are often edited by editing software like Adobe Premiere and after effects software like Adobe After Effect, including music and dubbing direction. The processing of the solid model is independent of several other presentation methods, mainly the cutting and erection of the physical model. According to the purpose of expression, the workload and requirements for the equipment are also different.

Displaying

Displaying is the process by which designers present their designs to clients. The mobile-end VR often utilizes the linkage between the cloud platform (like 720yun.com) and the mobile phone software. The hardware end only needs to provide the mobile player and VR glass like Google Cardboard. Logging in to the cloud platform allows you to view the uploaded panoramic images, which is very convenient. For 360-degree immersive experience, this method is conducive to clients for experiencing a more realistic environment. In particular, it can help clients experience a more realistic sense of scale and spatial experience.

The fixed-end VR has a deeper immersive experience than the mobile-end VR. Since the device can capture the user's activity status and feed back into the VR environment, the user can directly interact with the design program, which enables users to more accurately assess the design. The platform display of the fixed-end VR often needs to construct an independent VR experience space, which includes the construction of sensing devices, transmission devices, and calculation devices, and requires a certain amount of space. It is more complicated and requires higher equipment that is less convenient.

The display modes of rendering images, diagrams and animations are more diverse. Compared with VR, they often have lower costs, more flexibility, and greater controllability. However, there is a lack of immersion.

Public participation

Public participation mainly refers to the feedback process of clients after they have hearing designer's solutions. Different types of expressions often leave different impressions and feelings on clients, and evaluations and feedback on design plans will also vary. This indicator mainly shows the accuracy and effectiveness of customer feedback: accurate feedback means that clients can better obtain the ideas that designers expect to convey, and their own appeals can be more accurately conveyed to designers. This will ultimately reduce repeated changes and adjustments to the project and optimize the entire design process.

VR can give the customer a more comprehensive and real experience.

Therefore, direct and effective feedback can be obtained. Among them, the amount of information displayed by the fixed-end VR is more comprehensive than that of the mobile-end, so the feedback result is more effective. In addition, the presentation of VR is more interesting and attracts more public to participate in the evaluation of the project.

The display of diagrams, images, and animations is often performed on clips of project segments. Therefore, the transmission of information are not comprehensive compared with VR. The feedback results are often one-sided.

By comparing the 6 methods, the characteristics of them in the 4 processes can be summarized as the following table, where “■” represents the input generated by the workload, and “◆” represents the output of the project.

	Fixed-end VR	Mobile-end VR	Rendering image	Animation	Solid model	Diagram
Modeling	■ ■ ■ ■	■ ■ ■	■ ■	■ ■ ■	■ ■	■
Environment Rendering	■ ■ ■ ■	■ ■ ■	■ ■	■ ■ ■	■ ■ ■ ■	■ ■
Displaying	◆	◆	◆ ◆	◆ ◆ ◆ ◆	◆ ◆ ◆	◆ ◆ ◆ ◆
Public participation	◆	◆	◆	◆ ◆	◆	◆ ◆ ◆

Fig. 1. Characteristics of presentation methods in 4 processes

2.2. The additive effects in the complex presentation of plural scenes

In a complete project composed of a plurality of scenes, the input process and the output process are often repeated.

The repetition of the input process is reflected in the repeated use after the construction of the 3D mold, that is, after completing modeling, it can be used to render a variety of presentation methods. Therefore, the workload of various expressions in the actual project is not linearly stacked. Once the VR or animation modeling is completed, the modeling workload of the renderings, models, and diagrams can be greatly reduced. The more presentation methods used in the design, the more reduction of workload in single way is, but the total workload is still rising.

The repetition of the process of output is also reflected in the repeated use of multiple expressions, that is, the same scene is repeatedly used in different ways. Due to the overlapping of information, the output effectiveness of each expression is weakened. . The more presentation methods used in the design, the less effective the single method will be, but the overall effectiveness of the information conveyed will increase. While it is worth noting that clients are not precisely the machines that receive all the information they are given. Excessive repetitive methods may enhance the impression of a certain scene or idea, but it may also create annoying negative emotions that may affect the evaluation of the project.

The accumulative changes of different presentation methods are various. When choosing expression ways of a project, it is possible to choose inputting repetitive ways to reduce the workload, and to choose the ways that with low output repeatability to enhance presentation effectiveness. The accumulative effects of different expressions are shown in the table below. The more “-”,

the more repetition of input accumulates; the more “+”, the more repetitive the accumulation of output. In general, the more “-” and the less “-” the closer the combination is to an ideal process.

	Fixed-end VR	Mobile-end VR	Rendering image	Animation	Solid model	Diagram
Fixed-end VR		-----	--	---	----	-
Mobile-end VR	++++ +		----	---	----	-
Rendering image	++++	++++ +		---	----	-
Animation	+++	++	++		----	-
Solid model	++	+	+	+		-
Diagram	+	+	+	+	++	

Fig. 2. Accumulative effects of different presentation methods

2.3. Particularities of the Project - Comparison of Project Size

In practical projects, the scale and presentation are closely related. The study compares the presentation of the two basic types of projects. One is a larger-scale, conceptual plan, and the other is a garden design with small size. There is a big difference between the needs of the two sides from clients.

Large-scale planning

The scale of this kind of project is huge, and the client's appeal tends to focus on a clear and attractive target, concept and structure. A large number of possible image scenes are often used for the intuitive translation of the concept to achieve the possible effects, so presentation methods are mainly based on diagrams, expressing research and analysis of the project environment, the overall structure of the project, and planning strategies at multiple levels. In order to reduce the workload of modeling and rendering, the scene created

through VR, renderings, and animations that reflect the scenes are often clearly distinguished from the small-scale design. On the one hand, the bird's-eye view are often used, reduce the expression of details, and enhance the expression of overall structure; on the one hand, only the core section of the projects are modeling and rendering.

The Jingzhang High-speed Railway Green Corridor Project is an experimental project that the research team has participated in. It mainly transforms and upgrades the abandoned railway land in the section of the urban area of Beijing, forming a 9.6-kilometer-long green corridor connecting the city's core area with the suburbs. In this project, VR is used for the presentation of the hubs and the presentation of a partial bird's-eye view. In addition to this, many other methods except the physical model are used in the project. According to the survey of presentations and exhibition results, VR did not bring a clear understanding of the design to the experimenter, and even produced some misunderstandings, but most of the experiencers expressed that they were very interesting and had a strong interest in the project.

The output of VR in large-scale planning is often limited. Due to the tendency to express the overall atmosphere rather than the simulation of the actual space environment, VR that consume a lot of modeling and rendering workload are often not as effective as other methods. The essence of the problem lies in the fact that the amount of information that the project itself needs to convey and the amount of information that VR displays are unequal, resulting in a lot of wasted work. In the display of large-scale planning projects, a

large amount of information is often required to be conveyed to clients in a centralized way, which is too complicated. Therefore, ways like animation and diagrams that is recapitulative are more able to avoid unless expressions and allows clients to receive the core content of the project. However, VR can also create some special spatial feelings, especially non-normal viewing angles such as bird's-eye view, which can be enhanced through VR to enhance the feeling of space and bring a deep impact to the clients.



Fig. 4. VR experience of Jingzhang High-speed Railway Green Corridor Project

Small-scale Design



Small-scale design, such as garden design, urban plaza, or detailed design of a large-scale project node, often has low requirements for goals, concepts, and structures, but it has high requirements for spatial environment and design details.

Scenes that are closely similar to the constructed projects built in the future allow designers and clients to avoid repeatedly evaluation and revise of the program. In this kind of scale, VR can exert its characteristic to a greater extent. On the one hand VR can bring the most real space feeling to the customer, this is that any other presentation methods is difficult to reach, the fixed end VR can even bring feedback that simulates people's movements such as sit-downs, and lookouts in the scene, so that people can clearly feel the changes in space. On the other hand, since the perspective viewed by the customer in the VR is free, it is beneficial for the customer to review the details of each part and make more accurate assessment of the details in the scene.

The research team used VR to display the entire garden scene in the design of the Central African Garden in the Beijing World Horticultural Exposition. In the actual experience, the customer had a deep impression on the whole trace and spatial experience of the garden, and the evaluations and suggestions from clients showed that the design are not misread and has a good guiding role in the in-depth design of the project.

Fig. 5. VR rendering of the Central African Garden

The effectiveness of different scales of expression is summarized in the following table:

	Fixed-end VR	Mobil e-end VR	Rendering image	Animation	Solid model	Diagram
Large-scale	■ ■	■ ■ ■	■ ■ ■ ■ ■	■ ■ ■ ■ ■ ■	■ ■ ■ ■	■ ■ ■ ■ ■
Small-scale	■ ■ ■ ■ ■	■ ■ ■ ■ ■	■ ■ ■ ■	■ ■ ■ ■ ■	■ ■ ■ ■	■ ■ ■

Fig. 6. Effectiveness of different presentation methods in two scales

3. Conclusion

. Through the comparison of various angles, this paper summarizes the following strategies for the selection of VR:

- VR has its own great potential for excavation, and it has accurate and attractive features in information transmission. However, its high demands on workload, equipment, and communication platform are undeniable problems.
- Give priority to project characteristics and client needs, and determine the necessity of using VR in the project first. In the large-scale projects with strong conceptual and focus on the overall structure as well as atmosphere of image expression, VR has a low efficiency of project output and will also increase a large amount of workload. For some small-scale designs with spatial feeling perception, VR has obvious advantages.
- After deciding to use VR, coordinate the entire project workflow based on cumulative effects of different presentation methods. The combination of different presentation methods makes the project more effective to be expressed.

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Research on the Mitigating Effect of Urban forest on the Heat Island Effect——A Case Study of Beijing City

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Abstract

As the scale of the city continues to expand in China, the urban heat island effect has become an urgent problem to be solved. Urban green space is an important component of urban ecological system, which can effectively relieve the urban heat island effect. This article chose Beijing city for study object area where the speed of urbanization and land use situation altered obviously and quickly. Some remote sensing images from 2002 to 2017 were employed. Calculation of vegetation fraction and land surface temperature was based on the software of ENVI 5.1. The trend of summer land surface temperature alternation in study area was concluded by using the statistical data from ArcGIS 10.2 software. The coupling relationship of NDVI and land surface temperature were studied. Some suggestions in urban planning and Urban forest built were put forward in the end.

Keywords: Urban forest; remote sensing; land surface temperature retrieval; vegetation fraction

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With the advancement of urbanization in China, a large number of construction activities have resulted in excessive carbon dioxide and heat emission; At the same time, the city underlying surface have also changed, and a large number of high-accumulation bodies such as buildings and roads have led to the "high temperature" in city [1]. Urban forests, as a kind of urban landscape, play an important role in improving the urban thermal environment. How to quantitatively assess the cold island effect of urban forest is the focus in this study.

As a capital city, Beijing is a high leveled urbanization city, and the heat island effect is prominent and complex. At the same time, it is also a pioneer area for urban forest construction. At present, Qiu Hailing studied the coupling relationship between vegetation coverage and land surface temperature in Beijing [2]; Jia Liuqiang et al studied the green space shape in Beijing and the influence of area on its cooling efficiency, and he proposed that the area, perimeter, and cooling efficiency in the park are clearly positively related. [3] This paper selects the inner region Wuhuan as the research object, based on the Landsat7 ETM remote sensing image, inverts the vegetation coverage and surface temperature data at the regional scale, studies the temporal and spatial variation between the two, and quantitatively explores the correlation between them. The conclusion can provide a scientific reference for the urban forests construction that alleviate the heat island effect in large cities.

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1. The area overview

Beijing, as the capital city, has a relatively complete urban development. With its strong urban construction and dense population, which will inevitably lead to the urban heat island problem. Therefore, this study selects a relatively complete construction and a relatively significant heat island effect within the Wuhuan area in Beijing as the study area (Figure 1).



Fig. 1 The scope of the study

2. Data sources and preprocessing

The remote sensing image from the United States Landsat 7 ETM satellite was selected as the basic remote sensing data. The study area was located in the strip number: 123, line number: 32. The imaging time for the four remote sensing images was August 3, 2002 , September 3, 2007 , August 16, 2012, and September 7, 2017. The remote sensing image from Landsat 7 ETM satellite includes 8 universal bands. In this paper, the 3rd and 4th bands are used to extract the normalized vegetation index (NDVI) in the study area, and the 6th thermal infrared wave band is

used for land surface temperature inversion. The spatial resolution of the 6th band satellite image is 60m*60m, and the rest are 30m*30m. First, ENVI5.1 calibrates the image data during the four periods to eliminate the radiation error caused by atmospheric scattering, and then uses the vector boundary layer to crop the image data in Wuhuan area, and then selects the corresponding remote sensing data to calculate the normalized vegetation index and surface temperature inversion. Finally, using ArcGIS10.2 software to process the data, compare and calculate the correlation between surface temperature and vegetation coverage.

3. Calculation method

3.1. Vegetation coverage calculation

The method extracting vegetation coverage using remote sensing data mainly includes empirical model method, vegetation index method and mixed pixel decomposition method. In this paper, vegetation index method is used to extract vegetation coverage in Wuhuan [4]. Among many vegetation indices proposed by scholars, the normalized vegetation index is the most widely used. Therefore, this paper selects the normalized vegetation index for calculation, and its expression is:

$$NDVI=(NIR-R)/(NIR+R) \quad (1)$$

In the Landsat 7 ETM satellite remote sensing image, NIR represents the brightness value of the TM4 band, and R represents the brightness value of the TM3 band.

Based on the normalized vegetation index, the vegetation coverage is calculated. When calculating the vegetation coverage, the pixel

[4]Niu Baoru, Liu Junrong, Wang Zhengwei. Establishing vegetation coverage extraction model in arid area[J]. Earth Information Science, 2005(01):84-86+97-131.

bisection model method is used and its expression is:

$$F_v=(NDVI-NDVI_{soil})/(NDVI_{veg}-NDVI_{soil}) \quad (2)$$

In the formula, NDVI represents the normalized vegetation index, $NDVI_{veg}$ represents the vegetation index for pure vegetation, and $NDVI_{soil}$ represents the vegetation index for pure soil. Where $NDVI_v$ is 0.7, $NDVI_s$ is 0. When the NDVI is greater than 0.7, the F_v value is 1; when NDVI is less than 0, the F_v value is 0.

3.2. Land surface temperature inversion

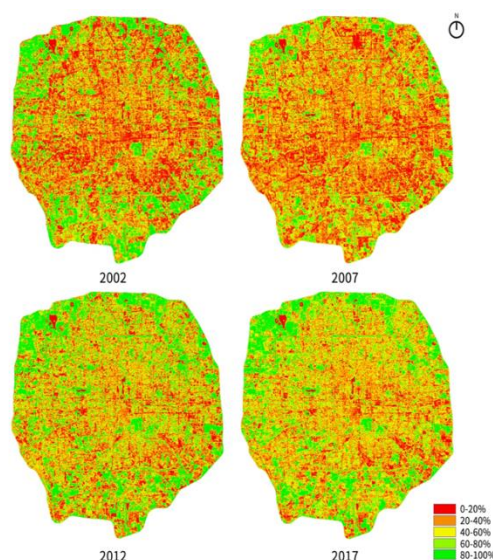


Fig. 2 Spatiotemporal evolution about vegetation coverage in Wuhuan, Beijing, 2002-2017

This paper selects the atmospheric correction method for land surface temperature inversion[5]. Before calculating the land surface temperature, it is necessary to calculate the land surface emissivity and blackbody radiation measurement. Among them, the specific emissivity of vegetation

[5]Zhai Zhihao, Zhang Minghua, Arnon Karnieli, et al. A single window algorithm for calculating surface temperature using terrestrial satellite TM6 data[J].Acta Geographica Sinica,2001,56(4):456-466.

and architecture is calculated and the specific emissivity of water is taken as 0.995. Its expression is [6]:

$$\epsilon_{\text{green}} = 0.9625 + 0.0614 F_v - 0.0461 F_v^2 \quad (3)$$

$$\epsilon_{\text{building}} = 0.9589 + 0.086 F_v - 0.0671 F_v^2 \quad (4)$$

In the above formula, ϵ_{green} represents the specific emissivity of the vegetation, $\epsilon_{\text{building}}$ represents the specific emissivity of the building, and F_v is the vegetation coverage calculated above. The land surface emissivity is obtained by inversion calculation.

Based on the land surface emissivity, the black body radiance in the thermal infrared band is calculated and its expression is:

$$B(T_s) = [L\lambda - L\uparrow - \tau \cdot (1 - \epsilon)L\downarrow] / \tau \cdot \epsilon \quad (5)$$

Where $B(T_s)$ is the thermal radiance, τ is the atmospheric transmittance in the thermal infrared band, and ϵ is the surface radiance.

After obtaining the black body radiance at the temperature T_s in the thermal infrared band, according to the inverse function of the Planck formula, the true land surface temperature T_s is obtained. The expression is:

$$T_s = K_2 / \ln(K_1 / B(T_s) + 1) \quad (6)$$

In the Landsat 7 ETM remote sensing image, K_1 is 666.09, K_2 is 1282.71. The calculated T_s is the true land surface temperature in Kelvin (K).

Name	2002	2007	2012	2017
Low vegetation coverage area/km ²	143.08	134.29	86.75	62.2
Medium-low vegetation coverage area/km ²	206.47	260.71	180.87	198.24
Medium vegetation coverage area/km ²	133.38	150.83	161.9	186.18
Medium-high vegetation coverage area/km ²	82.54	74.82	105.62	111.67
High vegetation coverage area/km ²	101.04	45.87	131.37	108.23
Average vegetation coverage	44.56%	39.33%	51.49%	50.85%

Table 1 Statistical results about vegetation coverage in Beijing Wuhuan, 2002-2017

emissivity in landsat TM6 band range[J]. Remote Sensing of Land and Resources, 2004(3):28-41.

4. Correlation between vegetation coverage and surface temperature

4.1. Vegetation coverage evolution characteristics

The vegetation coverage data for the study

Name	2002	2007	2012	2017
Mean surface temperature /° C	38.71	37.38	39.88	47.62
Standard surface temperature deviation/° C	3.08	2.23	3.64	3.53
The highest surface temperature/° C	57.04	49.92	58.36	68.42
The lowest surface temperature/° C	13.88	17.87	5.85	21.77
Low temperature area/km ²	12.58	11.5	22.82	8.02
Medium-low temperature area/km ²	89.14	34.82	48.74	51.71
Medium temperature area/km ²	252.56	182.31	217.28	203.72
Medium-high temperature area/km ²	214.81	285.44	266.74	268.43
High temperature area/km ²	86.42	128.82	100.75	114.63
Ultra high temperature area/km ²	11.05	23.66	10.23	20.04

Table 2 Statistical results on surface temperature in Wuhuan, Beijing, 2002-2017

area was imported into the ArcGIS10.2 platform for statistics (Figure 2). Dividing the vegetation coverage in the study area from low to high according to 0.2 as the difference and classify it into five categories (Table 1). Combined with the data analysis in Table 1, the low vegetation coverage area in the Wuhuan has decreased from 143.08km² to 62.20 km²; The medium-low vegetation coverage has dropped from 206.47km² to 198.24km²; The area covered by medium vegetation has increased from

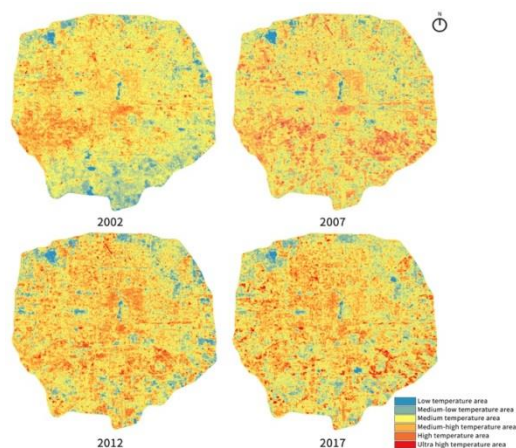


Fig. 3 Temporal and spatial evolution on surface temperature in Wuhuan, Beijing, 2002-2017

133.38km² to 186.18. Km²; The medium-high vegetation coverage increased from 82.54 km² to 111.67 km²; The high vegetation coverage increased from 101.04 km² to 108.23 km². The overall vegetation coverage showed a decreasing trend first and then increase, from 44.56% in 2002 to 39.33% in 2007, and then to 50.85% in 2017. Combining the development in recent years, the city continued to expand between 2002 and 2007. A large amount of farmland and forest land has transformed into construction land; From 2007 to 2017, a large number of international activities have been organized and carried out, and the vegetation coverage has picked up.

4.2. Surface temperature evolution characteristics

The land surface temperature inversion image was imported into ArcGIS10.2 platform for statistical calculation (Figure 3). The four images from 2002 to 2017 were re-classified according to the mean standard deviation method [7]. The temperature was divided into low temperature, medium-low temperature, and medium-high temperature, high temperature, and ultra-high temperature. relevant statistical data were obtained (Table 2). Combined with the data in Figure 3 and Table 2, it can be concluded that the thermal environment in the study area was warming up overall and peaked in 2007, and eased after 2007. In 2002, high-temperature and ultra-high temperature plaques were mainly concentrated in the central urban area and in the western part. Near the Wuhuan area, mainly medium temperature and low temperature parts; with the acceleration of urban construction, in

2007, the temperature change was more dramatic than that in 2002. There were more reductions in medium temperature and low temperature parts, and more high-temperature and ultra-high temperature plaques. After 2007, the proportion of medium-high temperature, high-temperature, and ultra-high temperature plaques was higher in the study area.

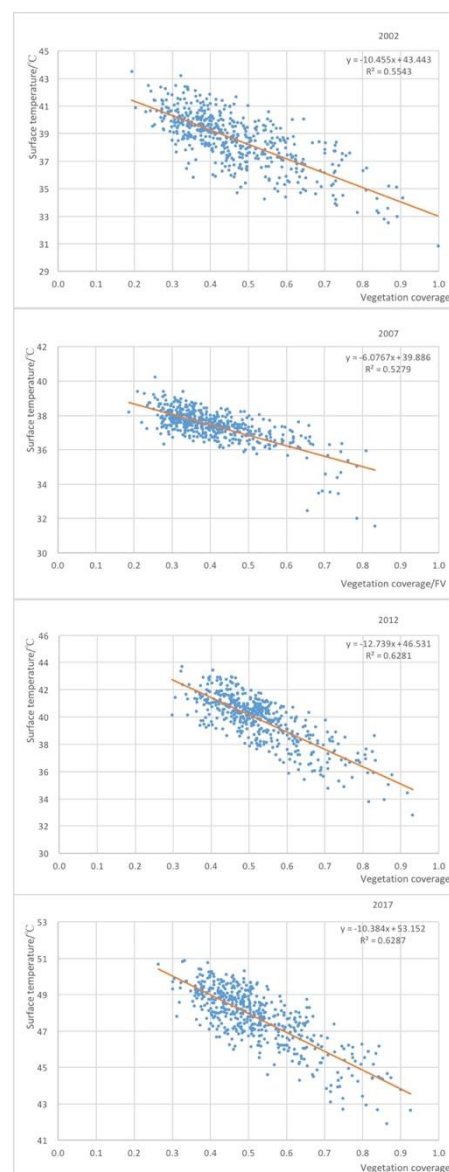


Figure 5 Regression analysis results of vegetation coverage and land surface temperature, 2002-2017

[7]Chi Teng-long, Zeng Jian, Wa Si-jun. Study on vegetation coverage and land surface temperature evolution in Zhengzhou based on RS and GIS[J]. Chinese Landscape Architecture, 2016, 32(10):78-83.

4.3. Correlation analysis on vegetation coverage and land surface temperature

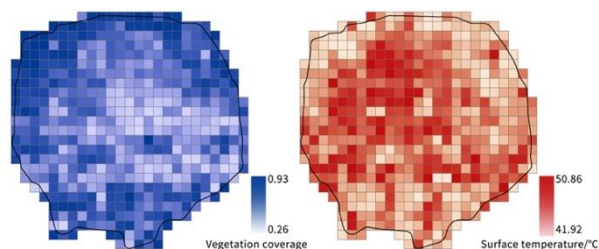


Fig.4 The grid vegetation coverage and surface temperature in Wuhuan, Beijing ,2017

In order to more accurately reflect the correlation between land surface temperature and vegetation coverage, the grid analysis method is used to calculate the correlation between the two. First, the grid is used to divide the study area, and the length of each grid is set to be 1200m*1200m. The study area is divided into 507 grids. The grid covers the data information for all land surface temperature and vegetation coverage in the study area. The spatial resolution of the vegetation coverage image is 30m*30m, so each grid in the image contains 1600 original raster data. The spatial resolution of the land surface temperature image is 60m*60m, so each grid in the image contains 400 raw raster data. The average value for the grid data is calculated by ArcGIS 10.2 software to represent the vegetation coverage and land surface temperature values in the grid, and the grid coverage image of the vegetation coverage and land surface temperature is obtained (Figure 4). Finally, the vegetation coverage data and land surface temperature data for all the grids are imported into Excel software, and the correlation between the two is studied, and the regression analysis results on the ground temperature and vegetation coverage between 2002, 2007, 2012 and 2017 are obtained. (Figure 5).

According to the regression analysis results, there is a significant negative correlation between vegetation coverage and land surface temperature. In 2002, 2007, and 2012, regression equation determination coefficient (R^2) is 0.55, 0.53, 0.63, and 0.62, respectively, and at the 5% significance level, the four models pass the test, indicating there is a strong correlation between them. From the slope for the regression equation, the slope is respectively -10.445, -6.0767, -12.739, and -10.384. This indicates that for each 0.1 unit increase in the vegetation coverage index within the Wuhuan in Beijing, the land surface temperature will be reduced by 0.61°C to 1.27°C.

5. Conclusion

Based on the above study, the following conclusions are obtained:

(1) During the period from 2002 to 2017, the vegetation coverage and land surface temperature in the Wuhuan have undergone major changes. The vegetation coverage generally shows a decreasing trend at first and then increase. The land surface temperature generally rises first and then maintains at a higher level.

(2) There is a negative correlation between vegetation coverage and land surface temperature in the study area. For every 10% increase in vegetation coverage within the study area, the average land surface temperature will be reduced by 0.61°C to 1.27°C; Conversely, when the vegetation coverage decreases, the average land surface temperature will increase to the same extent. This conclusion can also provide a quantitative assessment basis for urban forest construction results in Wuhuan.

The conclusions can provide reference and guidance for planning and constructing

urban forests to improve the thermal environment in large cities similar to the study area.

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The Embodiment of Cultural Connotation of the Black Bamboo Park Scenery Name in Plant Landscape and the Combination with Modern Park Design

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Abstract

Humanistic-natural landscape and garden has an inseparable relationship with the traditional Chinese culture. As the crystallization of wisdom of the Chinese nation, Chinese traditional culture has laid an important cultural foundation for the development of many traditional gardens. So the traditional Chinese Garden is honored as “poetic habitat”: many scenic spots are named from literature and landscape painting, and the planting also coordinates well with the entire aesthetics. The scenic spots names of traditional Chinese landscape garden can be said that with Chinese characteristics and cultural recreation, is the gardener's cultural wisdom. The article took the Black Bamboo Park as an example and chose the methodology of analyzing cultural connotation of the scenic spots names. It discussed the issue that how the planting landscape responses to the pursuit of “artistic conception” in their scenic names, in the aspect of characteristic space-making and creating landscape features. Also, the passage also explored whether to combine the modern landscape design with the cultural-oriented scenic spots names and its corresponding landscapes, and how to better reflect the cultural wisdom of gardeners. It aims to provide some references to planting and naming in the modern landscape designing process.

Keywords: Landscape Architecture; Scenery name; China traditional culture; Planting design; Modern park

1. Introduction

Landscape design and appreciation are often set forth from the four elements of mountain, water, plant and building, and the scenery name, the couplet, the plaque are often the crowning touch. The scenery name, as a kind of literary language of garden, is the conciseness of the cultural wisdom of

gardeners. While performing the idea of gardeners, it also has the function of associating and rendering artistic conception. With the development of social economy and the improvement of people's living standards, park has become an indispensable part of people's life. But with the advent of rapid urbanization, some modern parks that lack local cultural features emerge in endlessly.

As a modern park with traditional cultural features, the scenery name of the Black Bamboo Park is not only responsive to the plant landscape, but also full of poetic meaning, which fully embodies the garden cultural wisdom. Based on the analysis of the scenery name of the Black Bamboo Park and the fit of the plant landscape, it explores how to integrate the traditional cultural wisdom into the planning of the park and the feasibility of enriching the cultural characteristics of the modern park with the help of the cultural connotation and plant landscape.

2. Overview of the Black Bamboo Park

The Black Bamboo Park is located at the southern end of Baiyi road, Hdian district. The garden covers a total area of 45.73 hectares, and the water surface is about one third of the total area. The Nanchang River and the Shuangzi Canal pass through the park, and the rivers, lakes, embankments, islands, continents, and canals spread throughout the park.

The Black Bamboo Park has a long history. Since 1953, it has proposed the characteristics of creating parks with “bamboo landscapes, bamboo victories, and bamboo fame” and gradually built scenic spots with different scenery. There are many types of bamboo, tall and straight, with great charm, enjoying the reputation of “the first bamboo garden in north China”.

Bamboo, one of China's oldest plant species, existed on Chinese land hundreds of thousands of years ago and is an important part of Chinese traditional garden culture. At

the same time, bamboo culture is also an important part of Chinese culture, which contains distinctive national characteristics and interprets the rich connotations of traditional Chinese culture. The Black Bamboo Park has been holding bamboo festivals in the park since 1947 to show the meaning of bamboo culture to the public in a more intuitive way. The garden wisdom contained in bamboo culture has long been subconsciously entering people's material life and spiritual world.

From the beginning to the present day, The Black Bamboo Park has condensed the strong traditional culture atmosphere. The scenic spots are dominated by bamboo and stone landscape, and fully integrated with poetry, calligraphy and painting culture. In the process of landscape restoration and construction, the whole garden is themed with bamboo, which displays the inheritance and development of traditional cultural wisdom, and forms a unique landscape of natural.

3. General Layout of The Black Bamboo Park

Since the beginning of the planning and construction of the Black Bamboo Park in 1953, according to the location and the terrain at that time, the principle of building a park with the theme of mountain forests was proposed. In formulating the near-term planning plan in 1976, it was more clearly stated that “the park should be characterized by lush trees, natural water features and simple garden architecture.” The beauty of the landscape is even more valuable due to its natural features.

The overall landscape of the park is modeled on water and natural, showing the pattern of three lakes, two islands and one embankment. The lake is surrounded by mountains and five arch bridges connect the lake, island and shore. The pavilions and porches were scattered in the garden, and bamboo and flowers are distributed among them. The eastern lawn area is surrounded by trees. The grass spreads trees around the space to create a quiet and elegant atmosphere, fully displaying the individual beauty and group beauty of the plants. In the south of the park, there is a landscape of hills, streams, and trees. Through the change of the terrain, the combination of various trees forms a rich landscape level. Walking along the road, you will feel as if you are in the deep mountains and valleys, and get physical and mental pleasure. Lake area is a region where tourist activities are concentrated. The change of the lake and the planting of lotus have increased the contrast between the actual situation and the size of the entire scenic spot. The northeastern part of the park is flat on the ground and the plant landscape that focuses on changing seasons brings visitors a rich visual experience. The northern part of the river is a landscape unique to the Garden on the Yangtze Delta, and its own scenery echoes the overall environment of the park. The overall layout fully reflects the wisdom of traditional Chinese gardens. (Fig. 1)



Fig. 1. Plan of the Blank Bamboo Park.
 IFLA World Congress Singapore 2018

4. Scenic profile of the Black Bamboo Park

In each functional area of the park, there are scenic spots with buildings as the main scene or plants as the object of display. Such as “Yuanhuazhujun” scenic spot, “Yunshiyuan” scenic spot, etc. (Tab. 1)

Tab. 1. List of scenic spots

Function division	Scenic spots
Leisure and entertainment area	“Yuanhuazhujun” scenic spot
Children's play area	“Tongleyuan” scenic spot
Central Scenic area	“Chengbi” mountain house scenic spot Moon island scenic spot “Qinglian” island scenic spot “Kuahaidongzheng” scenic spot
Fishing area	“Black Bamboo fishing ” scenic spot
North viewing area	“Yunshiyuan” scenic spot

5. The Types of Scenery Names and Landscape Analysis of Main Scenic Spots

As the expression of ancient gardeners’ cultural wisdom, the scenery names come from allusions, fables, and poems, creates corresponding garden landscapes according to their origins. Through the changing terrain, rich plant configuration, thematic sculptural pieces and architectural collocations to create a variety of landscape effects. The cultural connotation contained in the scenery name is presented. This article selects important scenic spots related to plant landscapes in the Black Bamboo Park.

Based on the origin of the scenery names, the scenery names are divided into three categories: mythological allusions class, poetry and lyrics class, classic quintessence class. Different types of scenery names reflect different landscape styles. At the same time, the connotation of cultural wisdom contained in the name of the scenery also reflects the historical characteristics of garden culture in the process of social development.

5.1. *Mythological Allusions Class*

Such scenery names are often extracted from the mythological allusions to character characteristics or character stories as the prototype, taking plant landscape as the object of construction, using techniques such as comparison, symbolism, etc., abstract expression of gardeners' feelings of the character story.

5.1.1 " *Yuanhuazhujun* "

The scenic spot is located on the left side of the east gate of the park, and the overall environment is fresh and elegant. From the last year of the Shang Dynasty, Bo Yi and Shu Qi were rather hungry and did not eat food for the relief of the Zhou Dynasty. Therefore, they named the spot as the "Yuanhuazhujun". A scene depicting Bo Yi and Shu Qi's picking wild vegetables in Shouyang Mountain on a blue stone highlights the theme. With the upright and beautiful *Phyllostachys propinqua* McCL, *Phyllostachys aureosulcata* McCL to create the surrounding environment, lush, patchwork. At the same time, with the bamboo's integrity, tenacity, willingness to break and unwillingness to bend, and the

appearance that the appearance is straight, the middle is empty to metaphorize the determination of Bo Yi and Shu Qi who would rather starve to death and lose their integrity. Fully integrate traditional allusions with bamboo forestry, embodying the cultural wisdom of gardeners.

5.1.2 " *Banzhulu* "

Old pine and cypress trees are planted on the top of the mountain, and the foothills are flourishing. Ehuang and Nuying's sculpture is standing beside the shore and reflecting in the lake. It is relatively weeping and full of affection. (Fig. 2) The entrance to the scenic spot is further visited by the Yanmen descendants for their legends and carved on the stone.

"Banzhulu" is where the two mountains meet each other, and the valleys are winding and quiet. 'Tanakae' are planted on both sides of the hill and rocks, these are the backgrounds for Ehuang and Nuying sculptures. The spots on the leaves metaphorized the tears of Ehuang and Nuying.

5.2. *Poetry and Lyrics Class*

This type of scenery name starts from the artistic beauty depicted in the poetry and lyrics and fully applies the plant material to the landscape. Make visitors fully feel the beauty depicted in the poetry and lyrics. Or directly plant the plant species involved in poetry and lyrics, reproduce the scenes, and more intuitively express the mood of poetry.

5.2.1. " *Chengbi* " mountain house



Fig. 2. “Banzhulu”

The name comes from the poem written by Xie Lingyun, a poet of the Wei and Jin Dynasties, the meaning of the poem is the sky and the colored clouds complement each other, the sky and water are so fresh. Taking the “Chengbi” mountain house, “Chengxiang” Gallery, and “Liuyin” Pavilion as the main buildings to create a landscape, the sun sets, and the poetry of “melting sunset and melting clouds together” creates the artistic beauty of the sunset bathing. Surrounded by mountains and rocks, the willows brush the branches, the lake shimmering, the horizon is open, and the landscape in the poem is in line with the landscape. (Fig. 3)



Fig. 3. “Chengbi” mountain house

In the northwest of “Chengbi” mountain house, there is a small pavilion with a peaked roof called “Liuyin” pavilion. There is no complex engraving or painted decoration, simple painting with brown oil, simple and natural. There are three willow trees and three poplar trees planted next to the pavilion, and even if you stay in the pavilion during summer in June, you will not feel hot. Lush bamboo grows in the southwest, accompanied by a gentle breeze, the branches make sounds. The branches of the willows are old and prosperous, and the thick shade of trees is blocking the sun. Fully reflects the meaning of “Liuyinyiqing”, which means the thick willow shade makes people feel refreshed.

5.2.2. “Xiaoshengzuiyue”

“Xiaoshengzuiyue”, Which means the moon was intoxicated by the sound of a vertical bamboo flute. “Xiaoshengzuiyue” is the theme of Moon Island. The island's mountain path twists and turns, flowers and trees are beautiful, green bamboo grows luxuriantly. It presents the wonderful artistic conception of Li Bai's poem, the meaning of the poem is walking into the bamboo forest through the secluded path, the green leaves gently brush the pedestrian clothes. In the patio, there is a sculpture of “the girl blowing a vertical bamboo flute”, point to the theme of the scenic spot. The *Lagerstroemia indica* L blooming in the mountains are graceful and gorgeous. Under the shadow of a thick bamboo forest, the blooming flowers are particularly dazzling. Scattered terraces, followed by planting crape myrtle, combined with the terrain to form a slope.

5.2.3. “Bayi” pavilion

The scenic spot is located in “Qinglian” island scenic spot, connected to the surrounding environment by three bridges called “Mei”, “Lian” and “Hong”. The island's flowers and trees are thriving, the pine and bamboo are full of life, and the blooming lotus flowers surround the island.

The poem appreciate the bamboo is more verdant under the blow of the wind and snow, and appreciate the painting, recite the verse, and enjoy the beautiful scenery. “Bayi” pavilion fully integrates the ancient bamboo culture into the landscape construction. The interior walls are carved with poems praising bamboo, on the column of the porch is a plaque called “Bayi”. “Bamboo Rhythm Stone” is engraved with wind bamboo, rain bamboo, frost bamboo, snow bamboo pattern and poetry. It integrates the scenes of the bamboo's four seasons scene in the habitat, and the bamboo planting beside the stone. This building has Garden on the Yangtze Delta is located in the luxuriant bamboo forest, face to the lotus pond, back against bamboo forest.

5.3. Classic Quintessence Class

This type of scenery name refines the Chinese classic culture, or integrates the classics of other cultural fields into the garden landscape through plant configuration. Or refines the traditional garden culture and present it in a more refined way.

5.3.1. “Kuahaidongzheng”

The scenery name is one name of the eight famous pieces of Chinese chess. The scenic spot skillfully combines garden art, sculpture art and chess culture. In order to foil the situation of the dangerous situation in the chess board, the overall environment also coincides with it. The plants and sculptures of the high and low levels echo each other, with high bamboo planting to show the manager to hold up the chest, and the momentum of the victory. With the low shrub as the background of the soldier, show the soldiers to fight bravely, waiting for the command to start at any time. The chessboard is surrounded by mountains on three sides, with *Ginkgo biloba* L towering in the mountains, enclosing the scenes of the "two armies" in a small environment. Visitors can look at the whole situation and try to marshal their ancestors. They can also participate in confrontation and enjoy the "battlefield" battle.

5.3.2. “Jiangnanzhuyun”

The scenic spot is located in “Yunshiyuan” scenic spot, “Yunshiyuan” scenic spot is a garden in the Black Bamboo Park, covers an area of about 7 hectares. The main landscape is constructed of mountains, rivers, water and bamboo, and the landscape architecture is correspondingly landscaped. The scenery is elegant, delicate, quiet, chic and full of poetic charm. With bamboo as the theme, ten scenic spots have been set up to form a landscape garden with the style of Garden on the Yangtze Delta.

“Jiangnanzhuyun” is a sunken garden to make landscape with bamboo and stone, which is a masterpiece of “Yunshiyuan” scenic spot. The entrance is set with a green

marble carved Su Shi word – “Jiangnanzhuyun”. (Fig. 4)



Fig. 4. “Jiangnanzhuyun”

With bamboo and wall as the background, more prominent the style of Garden on the Yangtze Delta. The area is planted with *Phyllostachys edulis*, *Phyllostachys propinqua*, ‘Tanakae’, *Arundinaria fargesii*, *Arundinaria graminea*, *Sinarundinaria nitida* and so on. With bamboo as the main plant configuration, it fully displays the connotation of bamboo culture, to win with fewer forces, to win by novelty, to return to simplicity, to pursue the principle of nature, and to cultivate the famous bamboo in “JiangNan” region to reflect the theme.

6. The combination of scenery name culture and modern park design

With the improvement of living standards, people's demand for urban gardens has gradually shifted from the pursuit of beautiful scenery to the spiritual level. The garden culture is rooted in the traditional culture, and the culture in the garden means preserving the cultural heritage of the

forefathers and creating the culture that is valuable today. ^[1] In addition to a beautiful garden landscape, a park that is popular among the people must have its own unique garden culture. ^[2]

As a carrier of traditional cultural wisdom, scenery name also exists as an important garden language. The so-called “scene is written by the text, culture as the point of the landscape”, the culture integrates with the landscape to show its charm, and the landscape is more elegant because of the cultural wisdom. Rich cultural wisdom of the scenery name, only need to use a few isolated words and phrases to arouse the association of visitors, to outline the mood of the landscape in the mind of visitors, it will not only guide the tourists to appreciate the landscape, appreciate the historical culture, but also expand the charm of the landscape garden, and use this unique art form to add color to the landscape garden. No matter what kind of cultural wisdom features to carry out the park planning layout, artistic conception creation, the creation of the artistic conception, the landscape treatment or the plant landscape, the scenery name is a most intuitive way of expression. Summarized the scenery names of Chinese classical imperial gardens and private gardens with plants as the main landscape, and found that there were 198 landscape names related to plants in about 65 gardens. ^[3] In the modern park, the name of the scene also serves as a communication medium to convey the historical context of the city, showing poetry, painting, and artistic conception. When on the way of landscape in modern park to express the excellent traditional

culture, and with the aid of scenery name to highlight the theme, with moisture things silently penetration method to make people feel the wisdom of traditional culture in the process of leisure and entertainment, it's also an important way to realize regeneration of traditional culture.

7. Conclusion

The themes of many scenic spots in Black Bamboo Park come from the artistic conception of landscape in historical allusions or poems and paintings, from the architectural style, the couplet plaque and the plant landscape, the expression method fully responds to the cultural wisdom connotation of scenery name. To create a good landscape effect while conveying historical and cultural wisdom, embodies the concern and protection of traditional cultural wisdom, inheritance and development.

The design of modern park is still inseparable from the expression of traditional cultural wisdom, and the traditional theme of culture is used to consolidate the landscape theme. Plant landscape configuration is a kind of a carrier of traditional culture. Under the premise of ensuring its functionality, it combines traditional culture to create the landscape effect of poetic painting and extracts the name from the traditional cultural wisdom. To create a natural plant community and landscape, highlight China's natural landscape culture, and finally achieve the pursuit of "artistic conception" in the scenery names.

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The Post Occupancy Evaluation Of Urban Parks Based On Social Media Data——A Case Study of Parks Within the Second Ring Road In Beijing

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Abstract

There are 409 parks of different sizes and types in Beijing. The rates of people's visit to these parks vary widely. Due to the subjectivity of people's practices in urban planning, the actual usage of parks often differs from the designer's original intentions. Several problems emerged such as overuse, misuse and lack of use. Post occupancy evaluation (POE) is a evaluation method which takes the average trend of people's subjective feelings as the standard of evaluation after the environment is built. POE can reflect how the environment supports and meets people's needs after the construction of parks, and also can help landscape architects to understand the users' spatial distribution preference, and thus a feedback mechanism is formed to improve the quality of parks. With the rise of Internet and social medias, a vast volume of new data provides us with real-time distribution of tourists in green spaces, and along with their ratings or evaluations of parks they visited. Taking parks within the second ring road area in Beijing as the research object, this paper evaluates the use of parks from three aspects——the usage counts of users online, the satisfaction and the interest points of the visitors. Researchers pick up visitors' subjective reviews and their check-in position information as basic data from social media platforms such as "dianping" and "weibo". Through the data analysis, several charts will be drawn to reflect the users' topic hotness of different parks and their functional areas. Meanwhile, researchers use Natural Language Processing platform to do word segmentation, POS tagging and other operations to filter tourists' comments. High frequency key words about emotional expression, Atmosphere description and interest points will be extracted and grouped. Based on the above data, we concluded the focuses of visitors in different group.

Keywords: social media, post occupancy evaluation, topic hotness of parks,

1. The Use Status of Beijing Urban Parks

Urban parks provide convenient places for residents to return to nature. According to the statistics of the official website of the Beijing City Greening Bureau, by the end of 2017, there are 409 registered parks in Beijing, which cover comprehensive parks,

community parks, country parks, wetland parks, Forest Parks etc.

There are spatial and temporal variations in the use of parks with different types and area. The variation may lead to some problems of visiting experience. For example, some parks are overcrowded during holidays, causing visitors to experience a crowded and noisy tour, while other parks are lacking of attraction, making people feel cheerless.

The frequency of use in different areas of the same park is also very different. Due to the subjectivity in design practice, current usage of parks are sometimes inconsistent with designers' intentions and resulting in problems such as overuse, misuse, and insufficient utilization.

2. Related Concepts

2.1. Post occupancy evaluation

The specific meaning of POE method refers to: After the construction of the evaluated project for a period of time, the evaluator collect the users' evaluation data and analyze these data scientifically to understand the users' satisfaction level and find suggestions of subjects. The post-occupancy evaluation of built parks can reflect how the park environment supports and meets people's needs, help the landscape architects find the users' spatial distribution preferences. Additionally, it form a feedback mechanism in the design, expand the traditional design process which has been transformed into a cyclical process of "design--evaluating -- re-planning".

The data collection methods of POE are mainly questionnaires, interviews and document analysis. Semantic Differential, Likert Scale are data collation method that be used usually. However, during the evaluation process, most of the questionnaires and interviews presuppose the scope of the answer. The respondents are often under pressure from the investigators, and it is difficult to find some deep-seated problems. Moreover, the errors caused by the questionnaire's recovery rate and efficiency also require a lot of energy to correct. These limitations have affected the overall accuracy and efficiency of the POE evaluation.

2.2. The advantages and applications of social media data.

With the rise of the Internet, the application of new data has begun to penetrate into various research fields. This type of data is often called "big data." New types of data are characterized by a large number, variety of types, and high processing speed. These data are generated in terminals such as mobile phones, mobile phone signaling, public traffic card records, and bank consumption records. They cover location information, digital information, text information, and trajectory information, and are collected and stored by major online operating platforms. These data require new processing models to have greater decision-making power, insights, and process optimization capabilities.

For landscape architects, information from social media and professional review websites can provide us with information about the real-time distribution of tourists in green spaces, the trajectory of visitors in parks and the satisfaction level after visitor's' use. Moreover, these online comments come from the initiative post of the appraisers. Because these appraisal comments are not guided and interfered by the interlocutors, they are more supportive of the research. These new data can be used as the substitute for traditional questionnaires and be basis for the evaluation of built environments.

3. The evaluation case of parks within the Second Ring road in Beijing

2.3. Data Collection

The sources of data for this study are 3 social media websites which respectively called "Weibo", "Dianping.com" and "Mafengwo.cn". "Weibo" is the name of

Chinese microblog. Similar to Twitter, Weibo is one of the most popular social networking platforms in China with the highest penetration rate and the highest number of users. "Dianping.com" is a leading living information and trading platform in China. It is the first independent third-party consumer review website established in the world, covering approximately 200 million monthly active users. "Mafengwo.cn" is a travel information website popular among young Chinese generation. The website's reviews on attractions, restaurants, hotels, etc. all come from the true sharing of hundreds of millions of users, helping hundreds of millions of travelers make free-flowing plans. Reviews on the three platforms introduced above respectively represent the subjective evaluation of objects by comprehensive community, citizens, and tourists.

This study takes parks within the Second Ring Road of Beijing as the research objects. There are 21 parks within the second ring, ranging from 1.8 hectares to 273 hectares. The main types are urban comprehensive parks, linear parks and roadside green spaces. As Second Ring Road is also the dividing line of the urban edge of Chinese ancient capital, many traditional blocks and ancient ruins are preserved in this area. A part of these comprehensive parks are built around important cultural heritage sites such as the Tiantan Park and Beihai Park, attracting a large number of tourists from all over the world. Researchers have classified these parks as comprehensive parks (class A) which is distinguished from other modern comprehensive parks (class B) with various functions and facilities. Moreover, most of linear parks are built around the ancient city walls, the ruins of the gatehouse or the moat, which are mostly distributed on the edge of the Second Ring Road or the central axis of

the city. Roadside green spaces are located in densely populated blocks with good residents' accessibility. Of course, because of the extensive traffic system coverage within the Second Ring Road, all these parks are highly accessible.

By extracting key information from web page source code. The study captures the position information and sign-in text contents of the "Weibo check-in" website pages, the satisfaction rating and text contents of parks in "dianping.com", and user's recommended ratings and subjective evaluation contents for parks in "mafengwo.cn" A total of 208,008 evaluations were collected for this data collection. The number of comments for each park and parks' related information are shown in the table below.

PARK NAME	CLASSIFICATION	WEIBO SIGN-IN	DIANPIN G.COM	MAFENG WO.CN	AREA
BEIHAI PARK	<i>comprehensive park class A</i>	43687	6660	3651	71HA
JINSHAN PARK	<i>comprehensive park class A</i>	35562	3618	3505	22.5HA
SHICHAHAI PARK	<i>comprehensive park class A</i>	7988	2441	4336	146HA
TIANTAN PARK	<i>comprehensive park class A</i>	12465	6061	4634	273HA
TAORANTING PARK	<i>comprehensive park class B</i>	20145	3045	397	56.6HA
ZHONGSHAN PARK	<i>comprehensive park class B</i>	10612	1716	645	23HA
DAGUAN GARDEN	<i>comprehensive park class B</i>	10047	1744	740	12.5HA
NANGUAN PARK	<i>road side green space</i>	1072	117	5	2.6HA
MINGCHENGQIANG HERITAGE PARK	<i>linear park</i>	6064	483	104	15.5HA
CHANGPU RIVER PARK	<i>linear park</i>	2826	297	56	3.8HA
BEIERHUAN CITY PARK	<i>linear park</i>	1633	44	-	5.4HA
LONGTAN PARK	<i>comprehensive park class B</i>	559	1444	254	49.2HA
HUANGCHENGGEN HERITAGE PARK	<i>linear park</i>	1212	216	140	7.5HA
GUANYUAN PARK	<i>road side green space</i>	553	87	-	1.8HA
XIBIANMEN PARK	<i>linear park</i>	3093	5	10	3HA
WANSHOU PARK	<i>road side green space</i>	840	192	-	5.1HA
JINZHONGDU PARK	<i>linear park</i>	69	86	5	4.8HA
YONGDINGMEN PARK	<i>linear park</i>	140	170	46	28.5HA
YUTING PARK	<i>road side green space</i>	392	45	-	3.3HA
DONGDAN PARK	<i>road side green space</i>	122	398	115	4.7HA
DESHENG PARK	<i>linear park</i>	204	15	-	5HA

Table 1 Table 1 The number of reviews and related information of parks on the three media platforms

2.4. Data Analysis

2.4.1. Topic Hotness of Parks

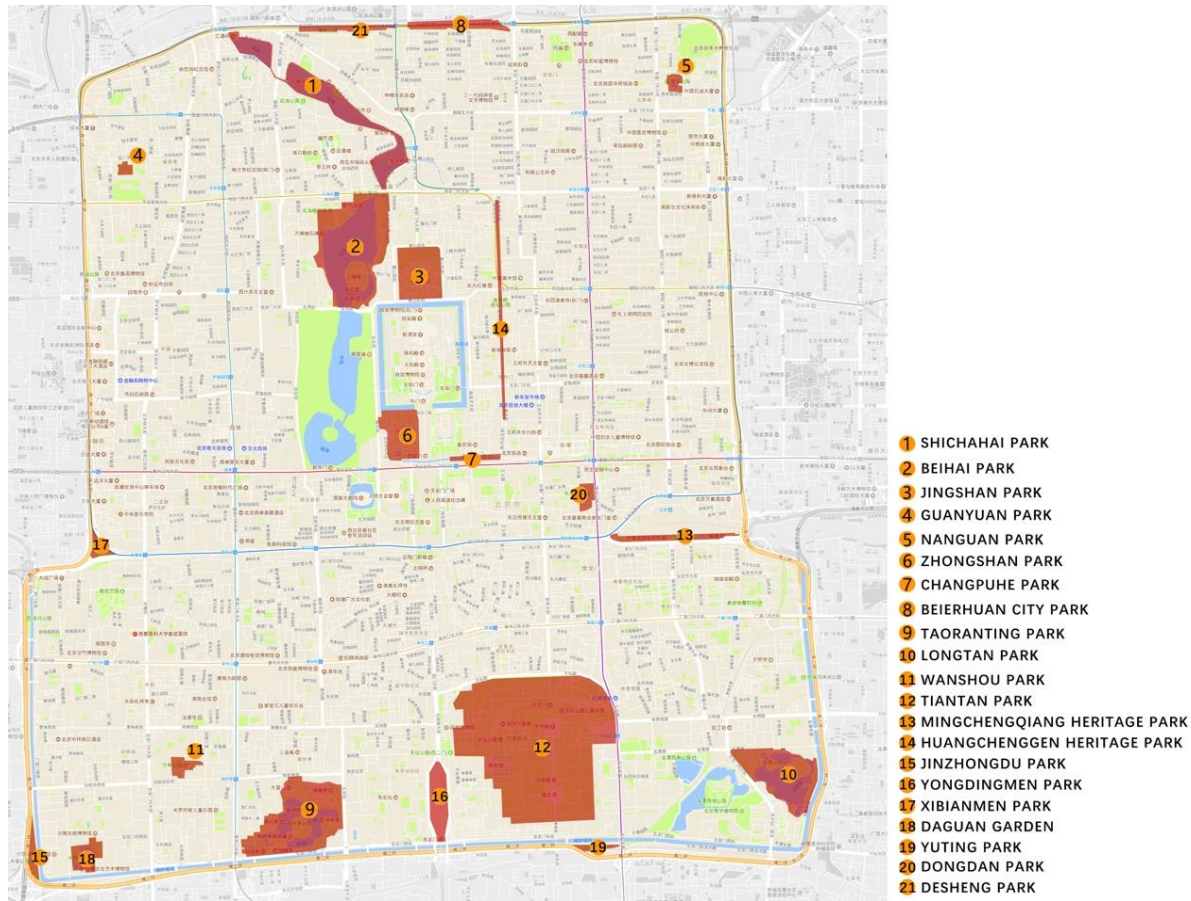


Fig. 1 Distribution of sample Parks

From the check-in and comment data volume of the three media platforms, it can be seen that there is a great difference in user popularity among 21 sample parks which are not far apart. The user popularity, usage, and visitor density of parks (comprehensive park class A) far exceed other types of parks. The number of comments accounted for 58 percent of the total number of comments. Among these parks, Beihai Park has the highest topic hotness, with 53,998 reviews, and the volume of data in “weibo” and “dianping.com” are all ranked first in all sample parks. But according to the statistics of “mafengwo.cn”, Tiantan Park has the highest topic hotness, which may be caused

by the different among user groups of the three websites. Tiantan Park is an important tourist attraction in Beijing. It is a place where ancient emperors worshiped heaven. There are many magnificent architectures and a spectacular central axis in the park, with solemn and orderly layout. Beihai Park is built on the site of the ancient imperial garden. There are a large area of water surface, mountains and flexible park roads. Although Beihai Park is not the most popular scenic spot in Beijing, it meets the diverse needs of the general public for leisure fitness and daily visiting. The popularity of modern parks (comprehensive park B) ranked second, and the number of reviews accounted for 21% of the total comments. Most of these parks with

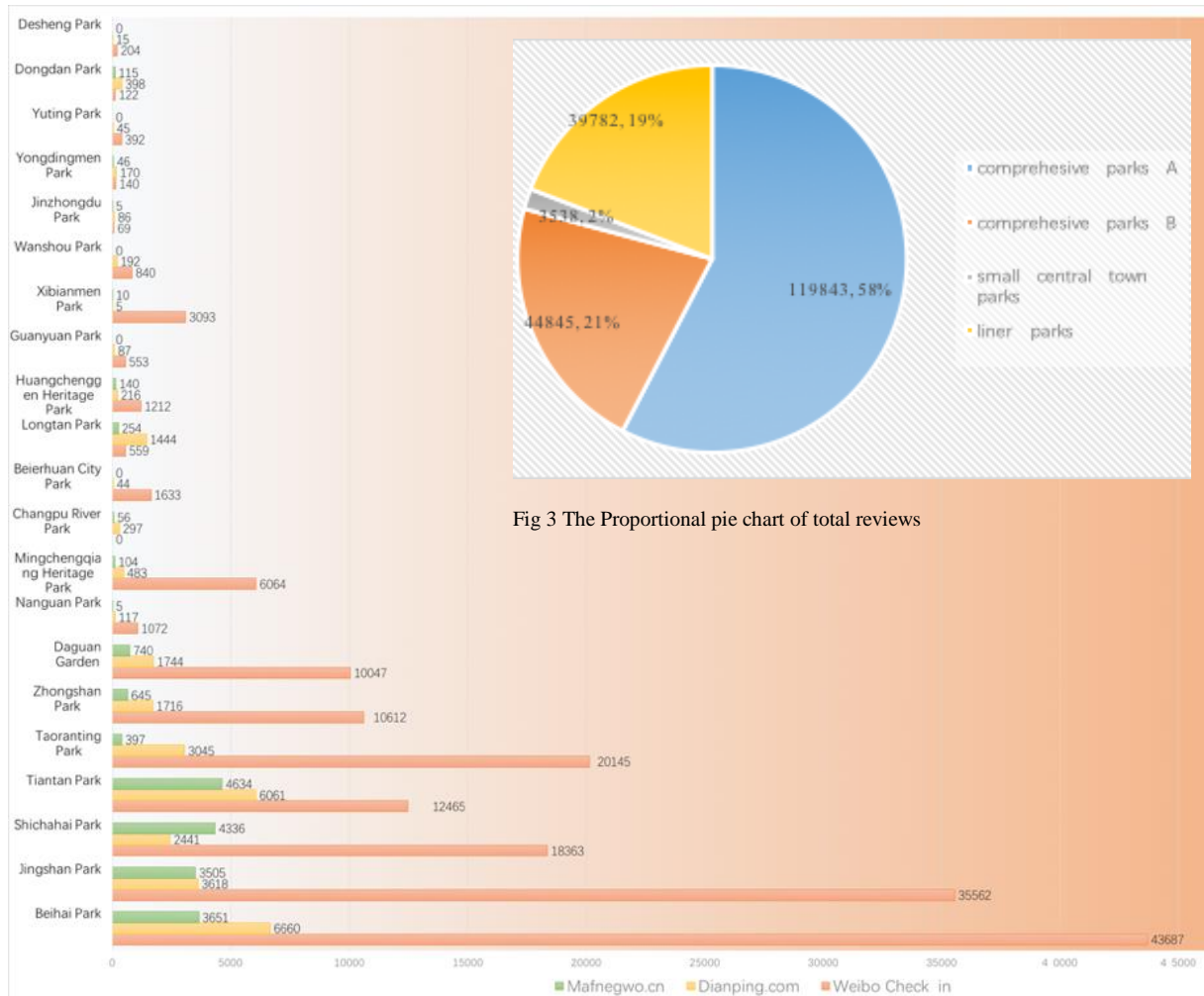


Fig 2 The park comments statistics bar chart

Fig 3 The Proportional pie chart of total reviews

relatively large areas have completed functional zone, various facilities, beautiful lakes and abundant plants, which can provide citizens with a good place to relax and meet the needs of various groups of people. Although they are not very prominent on travel websites, they also have a high degree of popularity in “Dianping.com”. linear parks and roadside green spaces did not attract much attention. Due to the large number of linear parks in sample area, comments of this type of park accounted for 19%. These two types of green space are in a small number of comments on “Mafengwo” travel network. Part of the type of park such as the Nanguan

Park are no user reviews recorded which can reflect that foreign tourists rarely pay attention to this type of green space. As can be seen from the scatter gram in Figure 3, there is a clear positive correlation between the area of the park and tourists’ enthusiasm of comment posting. That is to say, larger parks can attract more tourists. However, in parks of relatively similar size, the visitors' topic hotness does not vary with a clear linear relationship, indicating that the area does not affect the enthusiasm of tourists in parks with area varying in small spans.

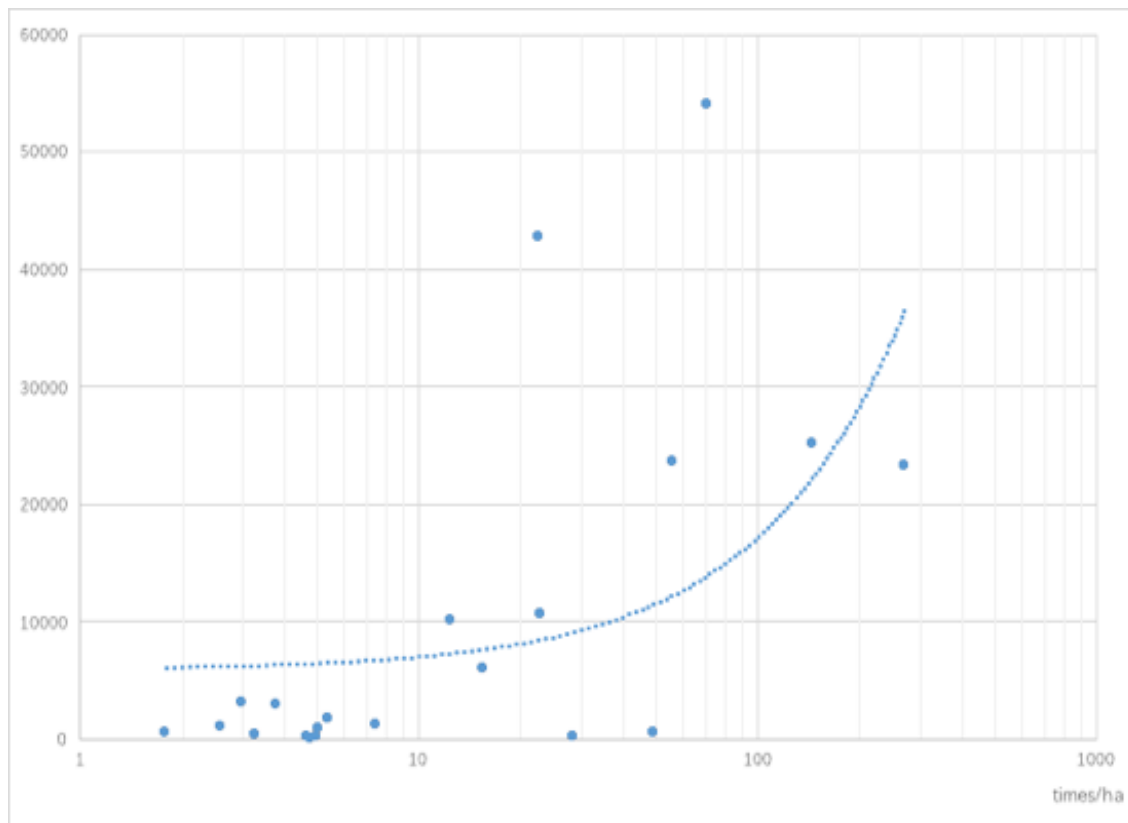


Fig 4 The Scatter chart of the relationship between the park area and the comment volume

2.4.2. *The satisfaction evaluation of park use*

Social media platforms give their users the right to rate the star rating of the evaluation object. This is similar to setting a semantic gradient in the traditional questionnaire to measure the satisfaction level of visitors to the built environment of the park. But the difference is that this star rating is more direct and accurate, and the result is more comprehensive. However, it is regrettable that parks can not be evaluated according to the designer's needs in a certain content. "Weibo" has a large amount of data and a relatively comprehensive user group. The total score of the evaluation is 10 points, starting from 0 points and increasing by 2 points. According to statistical results, the comprehensive park with a high degree of

concern has the highest satisfaction among tourists. It is not only A -class comprehensive parks represented by Beihai Park and Jingshan Park, but also modern parks in the group of B -class comprehensive parks represented by Taoranting Park and Longtan Parks also scored 8 points. In contrast, the score of linear parks are very low except for the Xibianmen park, which scored 8 points. Most of others scores are about 4 points.

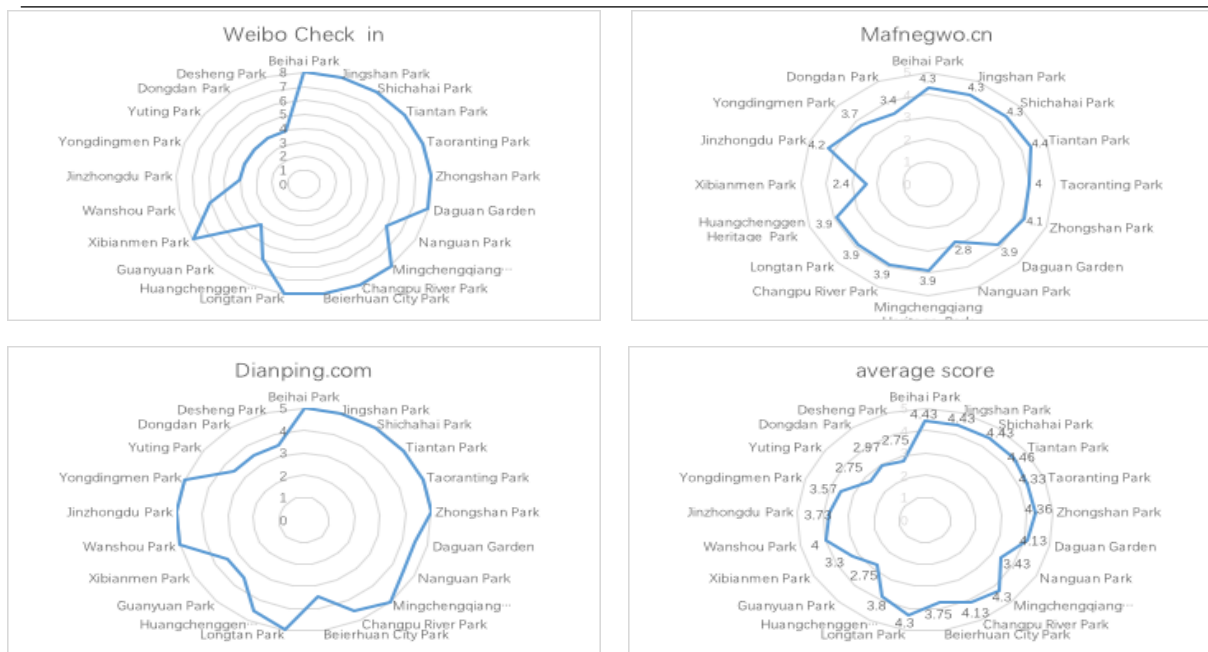


Fig 5-8 User Satisfaction Rating of Parks on Platforms

The full score of “Mafengwo.cn” is 5 points, and there is no obvious increasing gradient. The result of Figure 6 showed that the satisfaction degree of each park varies little, but the accuracy is higher. The general trend is still that comprehensive parks got a higher degree of satisfaction. In particular, the A-type parks all scored more than 4.3 points. The ratings of linear parks and the roadside green spaces were all low as indicated above. The value distribution of park satisfaction is also different with the Weibo data. For example, Xibianmen Park, which scored highest in the Weibo evaluation, has got the lowest score that was only 2.4 in the result on Mafengwo.cn. This may be due to the contingency and error caused by the small sample size of linear parks on Mafengwo.cn to a certain content. Many unknown small parks, such as Desheng Park, have not even received any feedback from tourists.

In the data analysis results of dianping.com, all parks are highly satisfied. The full score of the website is also five points, and the

increasing gradient is 0.5. Different from the previous two platforms, 11 parks in samples scored 5 out of the full rating on the website. Most of these full-score samples are A-type comprehensive parks, but there are also other three types of parks. Low segment Park samples are still distributed in smaller strip green spaces and roadside gardens, with a minimum score of around 3.5. Summing up the data from three platforms above, the park with the highest satisfaction level within the second-ring road is the Tiantan Park. The park is built around the Temple of Heaven, where the ancient emperor worshiped the heavens. It is the site of famous world cultural heritage. Tiantan park has the largest floor area compared to other samples. There are not only has magnificent buildings, spectacular central axes and thousand-year-old trees, it also seeks to arrange larger public square to meet the needs of the surrounding residents' daily leisure activities. Several other A-class comprehensive parks, such as Beihai Park and Jingshan Park, scored immediately behind. The scores of the B-type

comprehensive parks are also high, with more than 4.2 points. These parks provide improved infrastructures and landscape view that satisfied diverse demand of different visitors. The parks with the lowest scores are Guanyuan Park and Desheng Park, both of which are located in the northwestern part of Second Ring Road. Guanyuan park is a small roadside park. It is the smallest one of 21 sample parks which covered only 1.8 ha.

2.4.3. The analysis of visitors' interests

Through the statistics of high-frequency vocabulary in social media user reviews, it is possible to find out what content in the park has caused visitors' interest and left a deep impression on visitors. Since the evaluation content is all completed by the evaluation subject spontaneously, these interest points cover various aspects such as the planning and design of the park, operation and management, and the experience of trips, which are of great significance to the construction of the park.

Language Technology Platform (Hereinafter referred to as LTP) is an open Chinese natural language processing system that provides users with efficient and accurate language processing cloud services. The service content includes word segmentation, part-of-speech tagging, named entity recognition, dependency syntax analysis, semantic role tagging, and so on. Through the LTP platform, text comment data of social media users will be processed by word segmentation and named entity recognition programs. This process uses words such as “park” and “garden” as keywords to filter out comments that are not related to the study object. After preliminary filtering, it was found that some users prefer to feedback their emotional state of life in

the weibo check-in data, and the connection between the check-in location and micro-blog content is so weak that the use of the park is less reflected. Therefore, reviews from the dianping.com and mafengwo.cn are used as the main data sources for the word frequency statistics. According to the statistics, high-frequency vocabularies of 21 sample parks are shown in Table 2.

	DIANPING.COM	MAFENGWO.CN
BEIHAI PARK	Let's the paddles(A Chinese song), White pagodas, Royal gardens, Mandarin ducks, and Qiong Hua island.	Let's row the paddles, Nine Dragon Walls, summer, boating.
JINSHAN PARK	The Forbidden City, Central axis, High point, Wan Chun Pavilion, Emperor Chongzhen, Pine tree	The central axis, The panoramic view of the Forbidden City, The suicide of Emperor Chongzhen, The tree of emperor suicide
SHICHAHAI PARK	Water, bridge, rowing, bar, snack	Bar street, winter skating, lively, good place.
TIANTAN PARK	Qinian Temple, the round hill, the couplet, the orchid, a big park	Qinian Temple, the place to worship the heaven, the tickets for the park, majestic
TAORANTING PARK	The culture festival of Malus spectabilis culture festival, Taoran Pavilion, boating, amusement facilities, dancing;	One of the four most famous pavilions in Chinese history, A small park, the Mercy Temple, good place, the cheap ticket.
ZHONGSHAN PARK	Tulips, Tiananmen Gate, Sun Zhongshan, The altar of the state , wintersweet	The west side of Tiananmen, The altar of the dynasty Qing and Ming, five-colours soil, Sun Zhongshan ,Tulip Festival.
DAGUAN GARDEN	Dream of Red Mansions(a classical novel), temple fairs, The Scenic areas of Red Mansions, the show, snacks	Dream of Red Mansions, Yihong Yard, Xiaoxiang building, Nancai garden, Daoxiang Village
NANGUAN PARK	Russian Embassy, fitness, lake, water saving	Low carbon life, reclaimed water landscaping, Russian Embassy, environmental education, modern gardens
MINGCHENGQIANG HERITAGE PARK	Plum, city wall, free, history, quiet	Ancient city wall, vicissitudes of life, southeast corner tower, east gate, the largest city corner.
CHANGPU RIVER PARK	Tiananmen, willows, pavilions, the Acorus River, the city wall	The east side of Tiananmen, a small park, the Nanchizi street, a good place to go.
BEIERHUAN CITY PARK	Greening, narrow, Lama Temple, subway, noise	-
LONGTAN PARK	Temple fair, ice and snow carnival, flower appreciation, fitness, parking	Tickets are cheap, temple fairs, The Second-ring Road, good places,large parks.
HUANGCHENGGEN HERITAGE PARK	Street park, ruins, Chinese medicine hospital, city wall, planning and design	The biggest Street Park, city wall, Donghua gate, photography enthusiasts.
GUANYUAN PARK	Playing cards, walking, a small park, judicial bureau, clock	-
XIBIANMEN PARK	City walls, free, clean, small parks, ruins	Pocket park, The city wall of dynasty
WANSHOU PARK	Free, fitness, Guan Yu Temple, flowers, fitness equipment	-
JINZHONGDU PARK	The ruins of the capital of dynasty Jin, street park, walking, river ,corridor bridge.	museum, moat, walking, fitness
YONGDINGMEN PARK	The starting point of the city axis, tower, the demolition event, a big square, fitness.	The southernmost end of the central axis, the city tower, the city gate, 1553

YUTING PARK	Clean, free, walking, tidy, quiet	-
DONGDAN PARK	Quinquagenarian activities, walking, fitness, The Tongren Hospital, homosexual gathering place	Dongdan intersection, gay, Dongdan gymnasium, Quinquagenarian, air raid shelter
DESHENG PARK	Watching fishes, relaxing in a cool place, Playing chess, Fitness, Walking a dog	-

Table 2 The Statistical table of High-Frequency Commensts Words of Parks

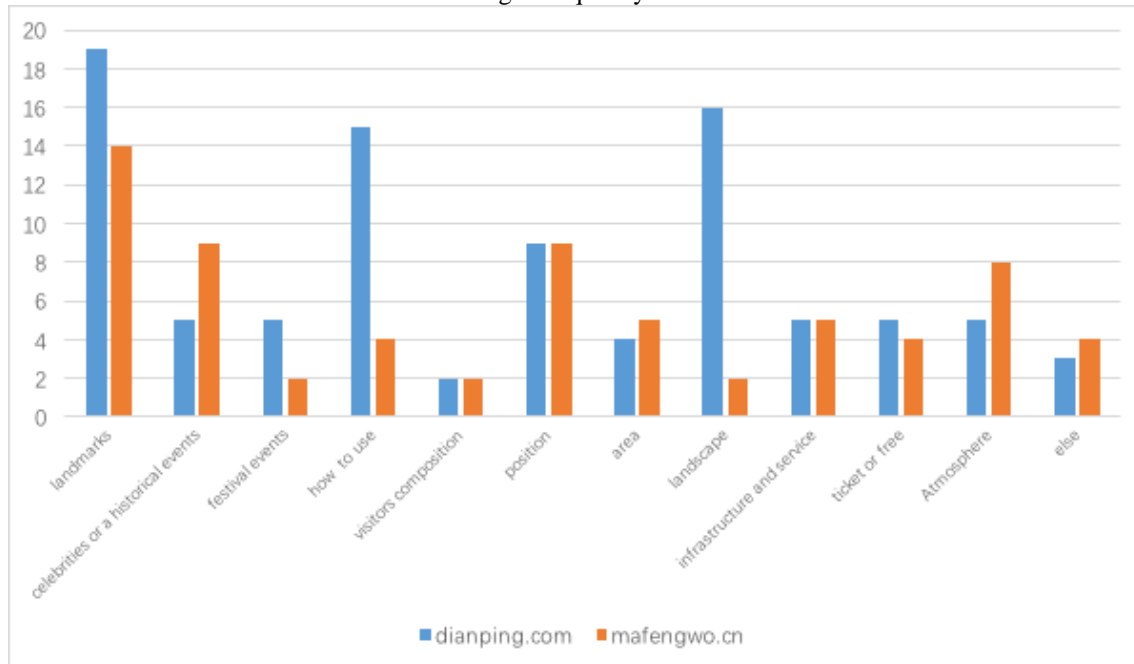


Fig. 9 The statistics bar chart of the types of keyword occurrences

High-frequency vocabularies to be counted can be mainly divided into several groups: landmarks, celebrities or historical events, large-scale events, usage patterns, composition of visitors, location information, park landscape, facilities and services, park area, ticket or free and trip atmosphere.

On the website of dianping.com, landmarks are the most popular labels, including famous buildings, historical heritages, or the landmark of park. Compared to roadside parks, such vocabularies appear more frequently in the comments of comprehensive parks. Additionally, use patterns and related vocabularies of landscape have also been mentioned more frequently, indicating that citizens pay more

attention to the everyday use and landscape view of parks. The high-frequency vocabulary of use is mainly for fitness, walking, dancing, playing cards, etc., and it is more frequently seen in the evaluation of street gardens. In terms of landscape vocabulary, plant landscapes are mentioned by many citizens, such as eucalyptus, tulips, and wax blooms, and the proportion of flowering plants is large. These plant landscape vocabularies often appear together with seasonal flower viewing activities, indicating that citizens have great enthusiasm for ornamental flowers. In the user evaluation of Mafengwo.cn, the type of landmark vocabulary also occupies the largest proportion, and related vocabularies of celebrities and historical

events also appear frequently. Compared with the data of “dianping.com”, the tourist group has more attention to the historical value, while the visual landscape effect is not very concerned. Moreover, key words about the location are also been highly concerned, such as surrounding important urban nodes (the Russian Embassy, Tongren Hospital, etc.). Location information and the surrounding environment can easily help tourists form a new cognitive maps. Similarly, the flow of people in the surrounding urban functional areas is likely to be part of the user of the park. However, unlike the Mafnegwo.cn, such vocabulary often appears in descriptions of roadside gardens and banded green spaces, rather than comprehensive parks. Besides the most frequently occurring types of vocabulary, other types of vocabulary are also recorded by users in two network platforms to describe parks. For example, because tourists visit many parks in a short time, they are more sensitive to the park area and more inclined to describe the atmosphere of the open space, such as quiet, clean, noise, etc. Residents is more concerned about the content and function of the park, such as festival performances and fitness venues. As for the infrastructure services provided by the park, the two groups have the same level of concern. These keywords include food, snacks, parking, amusement facilities and fitness equipment. Moreover, whether the park is free or whether the tickets are cheap are also a hot issue for all users. Except for these categories of words, there are other high-frequency vocabulary like summer, low-carbon life, water landscape, five-color soil and a famous song related to Beihai park. All these labels show that the design concept, landscaping techniques, seasonal landscape are concerned by the users too.

3. Summary and Prospect

3.1. conclusion

From the analysis above, it can be concluded that the satisfaction level of visitors has the same trend as parks’ topic hotness. Within the area of Second Ring Road, Parks that receive more evaluations also tend to have higher satisfaction level with social media evaluations. These parks are mainly comprehensive parks built to protect important cultural heritage. Other comprehensive parks with relatively large scale have received high satisfaction too due to the rich and convenient facilities and services. On the contrary, smaller parks like linear parks and roadside green space have performed slightly worse in terms of topic hotness and satisfaction.

There are similarities and differences between tourists and ordinary citizens in their concerns about the park environment. The landmarks and the location of parks are greatly concerned by both groups. For tourist, The location of parks has an important impact on accessibility and landmarks bring their journey commemorative significance and historical knowledge. For ordinary citizens, the site of landmarks provides a place to meet friends or a Object of reference. In other respects, ordinary citizens pay more attention to the use pattern and landscape, while tourists tend to feel the trip atmosphere, understand the historical events and related celebrities of parks.

3.2. Advantages and Limitations

Social media data have the following advantages. 1. It avoids the pressure of the questionnaire collector on the evaluator and ensures that all information is the true

feelings of the user, instead of checking the answer in the questionnaire designer's regulations. 2 the social media platform provides huge amount of data, avoiding errors caused by the limited questionnaire samples. 3 The computer's rapid processing capabilities allow researchers to quickly and easily obtain statistical results. 4 The data update speed of the platform is so fast that enable the long-term stable research can be conducted. All These characteristics introduced above make the POE evaluation more accurate.

But at the same time, the limitations of this method are also obvious. Due to the complete spontaneity of the user, the text content contains excessive information irrelevant to the evaluation. Filtering out this interference information and grouping these massive data according to the specific content that we want to evaluate requires strong language processing platform support. For instance, during the process of

trying to analyze the composition of visitors, it is found that in these reviews, it is difficult to identify the user's age group and occupational characteristics. In this regard, social media data is far less convenient than questionnaires. Therefore, combining the traditional questionnaire with the modern web platform is a development direction that can better improve the POE evaluation.

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The Construction of Chinese Smart Campus from the Perspective of Landscape Architecture

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Abstract

China has formally introduced the concept of Green Campus (GC) from 1996, and with gradual strengthening of education, GC construction documents have been gradually introduced. Especially in 2013 China Green Building Council developed 'Evaluation Standard for GC', and in 2016 China GC Design Alliance established, promoting active ways to create GC, thus creating a harmonious coexistence between human and nature. After more than 20 years' practice, China's campus environment is constantly optimized. Based on the GC construction, we explore the way of building Smart Campus (SC) from the perspective of landscape architecture, so as to provide reference for current campus construction.

The SC construction in China can be divided into three levels, planning, designing and constructing, respectively. In planning stage, composite index system, including Greening Rate (GR), Living Vegetation Volume (LVV) and Green Looking Ratio (GLR), is gradually established. According to practice, better campus environment can be achieved when GR is up to 35%. Moreover, with focus on ecological benefits, researchers have proposed the concept of LVV, and put forward that green space structure can be basically controlled when LLV average value is in $0.3-0.5\text{m}^3/\text{m}^2$. In addition, based on full consideration of campus environment and ecological benefits, green space's landscape effect is also important. Experiments show that when GLR is in the range of 25%-50%, it will bring better feeling to users. The above three indexes constitute a composite index system to control the overall green space construction, which becomes the SC construction foundation.

In designing stage, environment function, concentrating on landscape beautifying, education-teaching and cultural commemoration, guides campus construction. Landscape beautifying is embodied in different functional partition, such as identifier landscape in entrance area, participatory landscape in living area and recreational landscape in teaching area. Education-teaching creates characteristic green space pattern, such as the integration of campus and botanical garden of Zhejiang Agriculture and Forestry University, the combination of LID facilities and green space by Tsinghua University. Cultural commemoration shows campus tradition, for example, Nanjing and Beijing Forestry University as two important green

universities, opened a memorial space, showing people's respect for the famous forest scientist, Liang Xi. The function oriented campus construction is the key content of SC construction.

In constructing stage, the applied plant materials, such as native plants combined with ancient trees and cultivated species, formed rich campus green background and created characteristic plant landscape. Taking the *Ginkgo biloba* road in Beijing Forestry University, the *Platanus acerifolia* road in Tsinghua University and the Sakura road in Wuhan University as representative, road plant landscape is closely related to campus structure and often chooses native plants. Giving full consideration to plant materials and landscape is the wonderful part of SC construction.

To sum up, the three aspects of Chinese SC construction complement each other, providing a complete framework for current campus construction and a reference for further exploration of SC construction.

Keywords: landscape architecture; smart campus; China; construction

1. Introduction

The construction of Chinese smart campus (SC) contains many aspects. The study of SC construction mainly concentrates on the information technology in colleges and universities, aiming to enhance the quality of campus information service and application, thus creating an open, innovative, collaborative, and intelligent information service platform [1]. The construction of SC is not only limited to the simple exploration of digital campus. This study focuses on the campus environment which is closely related to the users of the campus. In recent years, the concept of Green Campus (GC) has provided a good guidance for the construction of Chinese campus, and becomes an important reference for exploring the construction of SC in China from the perspective of landscape architecture.

China has formally introduced the concept of GC from 1996 [2], aiming to create a healthy, applicable and efficient teaching and living environment for students and teachers [3]. With gradual strengthening of education, GC construction documents have been gradually introduced [4-5].

Especially in 2013 China Green Building Council developed "Evaluation Standard for GC", and in 2016 China GC Design Alliance established, and in 2017, the second Chinese Green Campus Development Symposium has held, thus promoting colleges and universities to respond actively to the call for GC construction, and the positive discussion of the way to construct GC, aiming to create harmonious learning and living environment for teachers and students.

2. The smart campus construction frame from the perspective of landscape architecture

From the perspective of landscape architecture, Chinese SC construction concentrates on campus landscape creation which takes the green space as the carrier, aiming to search for the harmonious relationship between people and campus. This includes three aspects, namely the establishment of a composite index system in the planning stage, the multiple types of campus construction in the designing stage, and the diversified application of plant materials in the constructing stage. Base on the existing condition of Chinese campus

construction, taking the existing research on the construction of SC as the basis and combining with the actual cases, the way of construction of SC has been explored. Through concluding and analyzing, the construction framework of SC from the perspective of landscape architecture is gradually formed. (Fig. 1)

3. The composite index system in the planning stage

From the perspective of landscape architecture, the construction of SC first concerns the index control of campus green space (CGS). As there are differences in the level of CGS construction in China, it is very important to build composite index system to guide the construction of GC. Based on the experience accumulated in construction practice, in planning stage, composite index system, including Greening Rate (GR), Living Vegetation Volume (LVV) and Green Looking Ratio (GLR), is gradually established, that controls the overall construction of CGS in the planning stage and becomes the basic of SC construction.

3.1. The decisive index—Greening Rate

GR presents the proportion of green space in a certain area of construction. It is a key index that regulates and restricts the construction and development capacity of the site, and ensures the basic environmental quality of the site. It has strong operability and is widely used. At present, the CGS planning in China is basically based on the index of GR. The research shows that the GR in colleges and universities is basically controlled at 30-50%, and some of them are below 20% [6]. According to the practice of Chinese campus project planning, a good

spatial environmental effect can be achieved when the GR is up to 35% [3].

Attention should be paid to the following problems in cognition of the index of GR. First of all, although the construction process of campus is based on meeting the requirement of GR, it is necessary to further balance the relationship between green space and other lands. Secondly, the builders should correctly understand the connotation of GR and strictly observe the provisions of the index, and could not confuse the two indexes of greening rate and greening coverage rate. At the same time, as the decisive index of CGS construction, GR is the basis of standardizing the campus green line, but this index cannot fully control green space construction and be regarded as the only indicator of CGS planning.

3.2. The ecological index—Living Vegetation Volume

With the concern of plant ecological benefits, it is difficult using GR to evaluate the green space function level of different plant species and different greening structures. In the early 1990s, the concept of Living Vegetation Volume (LVV) was put forward. It refers to the volume occupied by all stems and leaves of all growing plants, which can more accurately describe the rationality of the spatial structure of green space and quantitatively study the correlation between greening and environment. The LVV can be analyzed by measuring the tree factor or the remote sensing image and laser scanning point cloud data, and then measured according to formula.

Study for campus LVV in China is relatively small, for the measurement of city LVV relatively can be used as a reference: Li [7] of Jiamusi University estimates the campus $0.46\text{m}^3/\text{m}^2$, Liu [8] estimates

Shenyang city $0.35\text{m}^3/\text{m}^2$, Tang [9] and Li [10] estimates Beijing six districts $0.29\text{m}^3/\text{m}^2$, the largest of which is Shijingshan district $0.74\text{m}^3/\text{m}^2$, the smallest Chaoyang district $0.14\text{m}^3/\text{m}^2$, Zhou [11] estimates for $0.33\text{m}^3/\text{m}^2$ in Ningbo, Jiangbei district for large $0.37\text{m}^3/\text{m}^2$, Haishu district for small $0.29\text{m}^3/\text{m}^2$. It can be seen that the average value of LVV in the area of campus construction in $0.3\text{-}0.5\text{m}^3/\text{m}^2$ can basically control the space structure of green space.

The following questions should be paid attention to the cognition of the LVV. First of all, the influence factors of LVV are relatively complex, ensuring tree size and quantity, reasonably controlling the proportion of Joe, irrigation and grass and the proportion of coniferous and broad-leaved forest helps to improve the unit area's LVV. Secondly, the CGS structure of different functional areas is different, and the corresponding values of greening are different. Strengthening the requirement of LVV of different green spaces can control the use of large area of lawn, avoiding to appear single structure and high cost of the campus landscape. At the same time, considering that the CGS is generally used as open space, according to the LVV of unit area of urban forest which is less than $0.8\text{m}^3/\text{m}^2$ are forest types with smaller canopy density [12], we can see that the LVV of CGS should not be too high.

3.3. The comfort index—Green Looking Ratio

Based on the full consideration of green line and ecological value, we should also pay more attention to the green space effect. Some studies have shown that the GLR has a great influence on landscape preference and landscape perception [13]. GLR refers to the proportion of green plants that people see in the eyes. Scholars at home and abroad

have carried out a number of studies since twentieth Century. At present, camera fixed-point photography is often used to obtain the image of human eye field, and then the GLR is calculated by image analysis. Experiments have shown that a linear relationship between GLR and green sensation is similar. When the GLR is in the range of 25%-50%, it will bring users a better feeling [14-15].

At present, there is less research on the GLR measurement of CGS, Li [13] estimates the GLR of three colleges of Harbin, results have shown that the main entrance is to 35-40%, the main road is to 40-70%, the sports field is to 10-20%, the main teaching building is to 25-30%, and the leisure space is to 50-80%. It can be seen that GLR of different functional areas of the campus is different, the GLR of the leisure area is high with the sports field is low, and the other areas are basically controlled within the range of 25-50%.

The following questions should be paid attention to the cognition of the GLR. First of all, according to the characteristics of the campus and regional functions, we should formulate different levels of GLR. Secondly, by adjusting the collocation of the shrub layer and the vertical planting of the wall, there will have a significant influence to the GLR. At the same time, GLR can effectively regulate the comfort degree and construction effect of CGS, which is one of the indicators that cannot be ignored in the planning stage of CGS.

4. The multiple types of campus construction in the designing stage

Landscape is the place where people and nature depict a picture of mutual reflection, overlap, separation and even opposition, and it includes material, space, individual perception and group culture psychology

[16]. Campus landscape is the picture which reflects the symbiotic relationship between teachers and students. From the perspective of landscape architecture, the construction of SC is not only to embody the form beauty of landscape, but also to explore and pursue the deep value of landscape. In the designing stage, the function of campus environment mainly concentrates on three aspects of landscape beautifying, education-teaching and cultural commemoration. The construction of multiple types of campus environment is beneficial to the performance of the characteristics of campus and is an important aspect of the construction of the SC.

Landscape beautifying is embodied in different functional partition, such as identifier landscape in entrance area, participatory landscape in living area and recreational landscape in teaching area. The tree hole garden near the dormitory of Beijing Forestry University was originally used as sports space, which was then transformed into a bicycle parking shed, but with the shed was demolished, leaving a space covered with moss. Designers would like to depict a picture that people look at each other no matter time goes by, and aims to create a quiet rest and whisper space for teachers and students. Through the organization of space, landscape will create different possibility of looking and cause different stories [17] (Fig. 2). In order to ensure the unity of architectural language and the environment around Beijing Forestry University Teaching and Research Center building, designers translated the management philosophy of Beijing Forestry University into the core of landscape, which can be classified as 'Xi Shan Xing Lv' that means travelling around nature. The east, south and the north side of the building is created as the green space which gradually becomes the city interface. The spindle

square is defined as the landscape growth of building language. The sunken garden further analyzes the meaning of the subject of 'Xi Shan Xing Lv' [16]. The PM2.5 air quality sensor glass art device is placed in the sunken garden, which can real-time monitor the PM2.5 particle concentration in the air, and convert it to digital signal, and dynamically control the color of LED light. As there are some plant patterns in the laser-micro-engraving glass, the device not only echoes the surrounding environment, but only makes the garden have multiple meaning of art and ecology [18].

The abundant plant resources make the campus to be a place of natural class. Education-teaching creates characteristic green space pattern, such as the integration of campus and botanical garden of Zhejiang Agriculture and Forestry University. The botanical garden has a rich collection of 2500 kinds of plant materials as well as the national key protected plants and other rare plants. Through the four major projects of the implementation of plant resources, plant landscape, plant culture and plant information, the botanical garden has become the domestic first-class university botanical garden with landscape appearance, scientific connotation, ecological characteristics, humanistic qualities and scientific education [19] (Fig. 3). Tsinghua University Sheng Yin garden used to be the teacher housing area, but with the change of campus environment and the limitations of the site itself, it gradually becomes a low-lying and environmental crumbling place. Site transformation has balanced historical protection, functional renewal, storm water management, revitalization and revitalization, and has explored the inherent logical mechanism of landscape design and storm water management [20].

On the aspect of cultural commemoration, the campus memorial space is the place where the characteristics and culture of the campus are directly displayed. Nanjing Forestry University and Beijing Forestry University are two important green universities in North and South China, in memory of our famous forest scientist, Mr. Liang Xi, the two universities has opened memorial spaces in the campus. In Nanjing Forestry University, the bust of Mr. Liang Xi stands in the curved square in front of the library. Around the statue, some plants, such as *Ginkgo biloba*, *Cercis gigantea*, *Buxus megistophylla* and *Sabina chinensis* hedges have been planted. In Beijing Forestry University, the bust of Mr. Liang Xi stands in the west side of the main building, in the background of *Acer truncatum*, on both sides of *Sophora japonica*, surrounded by *Buxus megistophylla* and *Buxus sinica* hedges. The regular plant landscape is lined with figure statues, forming a solemn memorial space that integrates with the overall campus environment (Fig. 4).

5. The diversified application of plant materials in the constructing stage

In constructing stage, the applied plant material is important. As one of the elements of landscape architecture design, plants play an important role in the construction of CGS. Enriching the application of native plants and balancing plant species diversity is an important way to achieve sustainable development of CGS in the construction of SC. Plant landscape is the direct embodiment of the application of plant materials, and is also one of the important ways to express the campus landscape. Giving full consideration to plant materials and landscape is the wonderful part of SC construction.

Plant species, based on native plants, old and famous trees, and combined with cultivated plants, formed a rich green background for the campus. Study on application of native plants in campus at this stage can be listed as followed. Chu [21] estimates 6 universities in Harbin, the native woody plants application accounted for 62.5% of the total, Wang [22] estimates 10 universities in Beijing, accounted for 33.7% of total, and more than 60% of the native woody pants are the commonly used species in the greening of Beijing. Mao [23] estimates 8 universities of Hangzhou, accounted for 35.64% of total, Liu [24] estimates 56 universities and 54 middle school in Chongqing, accounted for 40.3% of total, Yang [25] estimates 9 universities of Kunming statistics, accounted for more than 45% of the total, Huang [26] estimates the South China Agricultural University, accounted 57.4% of the total. To sum up, the proportion of native plants applied in the campus is only 30-50%, and the introduction and application of native plant resources should continue to develop.

Study on the statistics of campus plants application shows that the number of plant species in Chinese campus remained at around 100-200, and geographical distribution showing an increasing trend from north to south. This is consistent with the condition in urban landscape, such as 100 species in Beijing, 200 species in Hangzhou and Shanghai, 300 species in Guangzhou [27]. Secondly, according to the general life style of plants, the number of trees and shrubs in the campus is higher than that of vines and herbs. Mao [23] and Shen [28] found that the diversity index and evenness of tree and shrub layer is higher than that of vine and herb layer, and evenness has been in an imbalance state.

Plant landscape is closely related to campus structure and often chooses native

plants, taking the *Ginkgo biloba* road in Beijing Forestry University, the *Platanus acerifolia* road in Tsinghua University and the Sakura road in Wuhan University as representative. The Sakura road in Wuhan University mainly plant Japanese cherry trees, with total length of about 600 meters, passing through the old college building, the Sakura house, the History museum, the Kunpeng square, the Valentine slope, and the Song Qing stadium [29]. The Sakura road not only attracts many teachers and visitors, but also carries the historical memory during the war of resistance against Japan, which is a witness of Sino Japanese friendly relations after the establishment of diplomatic relations between China and Japan in 1972 (Fig. 5).

In order to protect and utilize rationally, the plant resources condition should be understood clearly and accurately. The teachers and students from the school of landscape architecture, forestry and biology took three years to complete the Beijing Forestry University campus plant guidebook, which records the historical changes of nearly 400 kinds of plants in the campus, and is a creative work fusing plant cognition, photography, drawing, color measurement, planting plan and other multi-disciplinary. This is the unique green wealth of the campus that creates a new way to display and popularize the university's own plant resources. It is not only a valuable textbook for teachers and students to popularize campus plant resources, but also becomes cornerstone of the construction of campus green culture.

6. Conclusion

The construction of SC is an important aspect to speed up the reform of ecological civilization, build a beautiful China and

promote green development. Landscape architecture plays an important role in the construction of GC. From the perspective of landscape architecture, the construction of campus environment with green space as the carrier is more concerned with the construction of SC. This paper puts forward the suggestion of SC construction from three levels, including composite index system in planning stage, multiple types of campus construction in designing stage, and diversified application of plant materials in constructing stage. The three aspects complement each other, providing a complete framework for current campus construction and a reference for further exploration of SC construction.

Acknowledgments

Figure 3 is cited from <http://hangzhou.3dkezhan.com/lvyougonglu/e/18675.html>. Figure 4 is cited from http://blog.sina.com.cn/s/blog_77a4b08a0100s8qj.html. Figure 5 is cited from <http://www.phone3g.cn/caoyuvr/32285.html>.

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Appendix

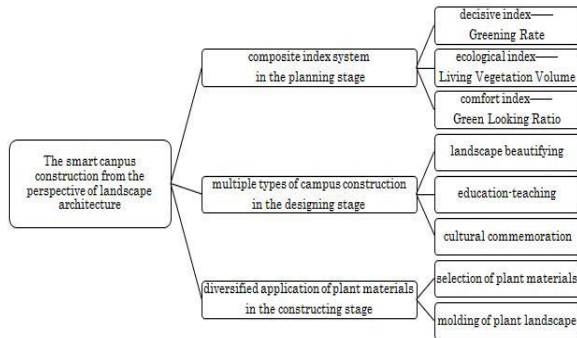


Fig. 1. The smart campus construction frame from the perspective of landscape architecture



Fig. 2. The tree hole garden in Beijing Forestry University



Fig. 3. The Zhejiang A&F University botanical garden



Fig. 4. The Liangxi statue square in Nanjing and Beijing Forestry University



Fig. 5. The Sakura road in Wuhan University

Research on the Mitigating Effect of “Greening Blanks” on the Heat Island Effect——A Case Study of Baoding City

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Abstract

The urban heat island effect has gradually become one of the most significant problems in urban climate with the development of urbanization in China. As the important component of urban ecosystem, the urban green space can effectively alleviate urban heat island effect^[1]. By adopting the method of remote sensing data inversion and comprehensive application of GIS and RS technology, this paper got the spatial and temporal evolution map of surface temperature and vegetation coverage of different periods in Baoding city center, and analyzed spatial and temporal evolution law of the last ten years. Through using the grid method to study the coupling relationship between vegetation coverage and surface temperature, this paper found that the average temperature of the surface could be reduced by 0.9 -1.3 degrees when the vegetation coverage in the study area was increased by 10%, thus made quantitative suggestions for the ‘leaving white and adding green’ in the study area.

Keywords: Vegetation fraction; land surface temperature; Urban heat island effect; “greening blanks”

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In 2017, Beijing put forward the policy of ‘greening blanks’ and ‘building urban forest’. The policy of ‘greening blanks’ aims at the other types of land outside the planned green space, or the space of improving the living environment of the city and reserving space for the long-term construction through greening in the context of unclear use of urban planning and unidentified or unimplemented permanent plan after demolition in a short term^[2]. This policy is not only implemented in Beijing, but also focus on the Beijing-Tianjin-Hebei region, aiming at forming a continuous ecological security pattern in this region.

In recent years, the urbanization of Baoding has been accelerated with a large number of green space be replaced by grey infrastructure and the increasing urban built-up area, thus brought about declining vegetation coverage of Baoding year by year, the weakened landscape and ecological function and the intensified urban heat island effect. Taking the Baoding city center as the research object, this paper carried out correlation study of the vegetation coverage and the surface temperature between 2007 and 2017, aiming at quantitatively studying the alleviating effect of ‘leaving white and adding green’ on urban heat island effect and making suggestions for the relationship between urban development and ecological green space construction of Baoding.

1. Overview of study area

The study scope is the Baoding city center (Fig. 1), including the Jingxiu District and the Lianchi District. The regional geographic coordinates are 113°40′~116°20′ of the east longitude and 38°10′~40° of the north

latitude. The north of the center is 140 kilometers away from Beijing. Characterized by the warm temperate zone continental monsoon climate, Baoding has four distinct seasons and an average annual temperature of 13.4°C.

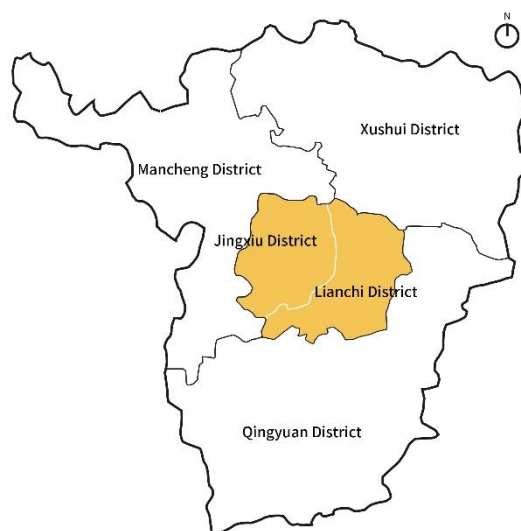


Fig. 1 The scope of the study area

2. Data sources and preprocessing

The study selected three remote sensing images of Landsat 7 ETM satellite of America as the basic remote sensing data, of which the imaging time was September 3, 2007, August 16, 2012, and September 7, 2017. And the satellite track number of them were p124/r44, including 8 universal bands, of which the third and fourth band were used to extract the NDVI and the vegetation coverage information of the study area, and the sixth band is the thermal infrared band image, which is used to study the surface temperature of the study area. The spatial resolution of satellite images is 30m*30m, except for the sixth bands of 60m*60m. The time of the satellite over Baoding is about 8:50 in the morning. The imaging time of the three periods is basically the same, and the

[2] Haidian District Landscaping without artificial plants and flowers[N]. Beijing daily.2017.05.05((04) Focus News·Beijing)

quality of the remote sensing images are good with precision meets the calculation requirement.

In dealing with these data, the radiometric calibration and atmospheric correction processing of the three period image data are first used to eliminate the radiation error caused by the atmospheric scattering, and then the image data of the Baoding city center is cut through the vector boundary layer. Furthermore, the remote sensing images of the corresponding bands were selected for the NDVI calculation and the surface temperature inversion. Finally, the ArcGIS10.2 software was used to process the relevant data in order to compare and calculate the correlation between surface temperature and vegetation coverage.

3. Calculation method

3.1. Vegetation coverage calculation

The method extracting vegetation coverage using remote sensing data mainly includes empirical model method, vegetation index method and mixed pixel decomposition method. In this paper, vegetation index method is used to extract vegetation coverage in Wuhuan^[3]. Among many vegetation indices proposed by scholars, the normalized vegetation index is the most widely used. Therefore, this paper selects the normalized vegetation index for calculation, and its expression is:

$$NDVI=(NIR-R)/(NIR+R) \quad (1)$$

In the Landsat 7 ETM satellite remote sensing image, NIR represents the brightness value of the TM4 band, and R represents the brightness value of the TM3 band.

[3]LIANG B.-P.,ZHAI L.-X. A Research on Spatial-temporal Changes and Correlation between Vegetation Fraction and Land Surface Temperature in Guilin during 1991—2006[J]. Chinese Landscape Architecture,2014, (7): 77-81.

Based on the normalized vegetation index, the vegetation coverage is calculated. When calculating the vegetation coverage, the pixel bisection model method is used and its expression is:

$$FV = (NDVI - NDVI_{soil}) / (NDVI_{veg} - NDVI_{soil}) \quad (2)$$

In the formula, NDVI represents the normalized vegetation index, $NDVI_{veg}$ represents the vegetation index for pure vegetation, and $NDVI_{soil}$ represents the vegetation index for pure soil. Where $NDVI_{veg}$ is 0.7, $NDVI_{soil}$ is 0. When the NDVI is greater than 0.7, the FV value is 1; when NDVI is less than 0, the FV value is 0.



Fig. 2 Spatial and temporal evolution of vegetation coverage in 2007~2017

3.2. Surface temperature inversion

This paper selects the atmospheric correction method for land surface temperature inversion^[4]. Before calculating the land surface temperature, it is necessary to calculate the land surface emissivity and blackbody radiation measurement. Among them, the specific emissivity of vegetation and architecture is calculated and the specific emissivity of water is taken as 0.995. Its expression is^[5]:

$$\varepsilon_{green}=0.9625 + 0.0614 Fv - 0.0461 Fv^2 \quad (3)$$

[4] YANG D.-F.,WANG F.-Y. The Application and Research of Mathematical Model in Ecology 33[M]. Beijing: Ocean Press.2015.
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$$\varepsilon_{\text{building}} = 0.9589 + 0.086 F_v - 0.0671 F_v^2 \quad (4)$$

In the above formula, $\varepsilon_{\text{green}}$ represents the specific emissivity of the vegetation, $\varepsilon_{\text{building}}$ represents the specific emissivity of the building, and F_v is the vegetation coverage calculated above. The land surface emissivity is obtained by inversion calculation.

Based on the land surface emissivity, the black body radiance in the thermal infrared band is calculated and its expression is:

$$B(T_s) = [L\lambda - L\uparrow - \tau \cdot (1 - \varepsilon) L\downarrow] / \tau \cdot \varepsilon \quad (5)$$

Where $B(T_s)$ is the thermal radiance, τ is the atmospheric transmittance in the thermal infrared band, and ε is the surface radiance.

After obtaining the black body radiance at the temperature T_s in the thermal infrared band, according to the inverse function of the Planck formula, the true land surface temperature T_s is obtained. The expression is:

$$T_s = K_2 / \ln(K_1 / B(T_s) + 1) \quad (6)$$

In the Landsat 7 ETM remote sensing image, K_1 is 666.09, K_2 is 1282.71. The calculated T_s is the true surface temperature in Kelvin (K).

4. Results and analysis

4.1. Evolution characteristics of vegetation coverage

Vegetation coverage refers to the percentage of vertical projection area of the vegetation's growth area in the study counting area, including the trees, shrubs, grass and crops^[6]. The image resolution of the third and fourth bands in the Landsat 7 satellite images is 30m, which means the

[6] QIN W., ZHU Q.-K., ZHANG X.-Review of vegetation covering and its measuring and calculating method[J]. Journal of Northwest Agriculture and Forestry University (Natural Science Edition), 2006(09):163-170.

individual pixel in the image represents the vegetation coverage within the range of 30m. The degree of vegetation coverage is indicated by the depth of color, of which the deeper the color is, the higher the vegetation coverage is, while, the shallower the lower. Calculated the vegetation coverage image of Baoding city center by ENVI5.1 software and introduced the result into ArcGIS10.2 software for statistical processing, and finally got four vegetation coverage images in 2007, 2012 and 2017 in the study area.

As can be seen from Fig.2, the vegetation coverage in the Baoding city center was declining between 2007 and 2017. In the urbanization of Baoding, its construction land has increased rapidly with its city central gradually expanded to the suburb and the city gradually occupied some farmland and woodland, thus resulting in the obvious decrease of the vegetation coverage in 2017 than in 2007 in the study area.

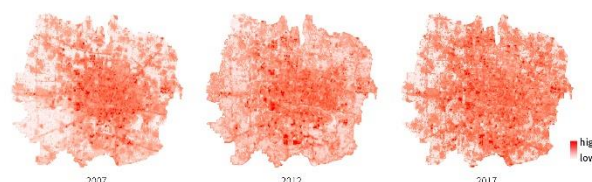


Fig. 3 Spatial and temporal evolution of land surface temperature in 2007~2017

4.2. Surface temperature evolution characteristics

The image resolution of the thermal infrared band (sixth band) in the Landsat 7 satellite images is 60m*60m, which means the individual pixel in the image represents the vegetation coverage within the range of 60m*60m. The degree of vegetation coverage is indicated by the depth of color, of which the deeper the color is, the higher the vegetation coverage is, while, the shallower the lower. Calculated the

vegetation coverage image of Baoding city center by ENVI5.1 software and introduced the result into ArcGIS10.2 software for statistical processing, and finally got four vegetation coverage images in 2007, 2012 and 2017 in the study area. (Fig. 3)

It can be seen from Figure 3 that the surface temperature of the Baoding city center was on the rise, as the rising urban heat island effect gradually spreading from the central city between 2007 and 2017. In 2007, the heat island effect of the central region was more obvious, of which the types of land use in the suburbs were mainly farmland and a small number of villages, thus the heat island effect was not so obvious. In 2017, with the rapid development of the city, the influence range of the heat island effect has been spread rapidly from the central area to the suburb. The area of the built-up area of Baoding is gradually expanding, with a large number of land use types in the suburb been gradually transformed from farmland to construction land and the underlying surface properties of the suburban areas been changed, therefore the urban heat island effect's coverage has been changed.

4.3. Correlation analysis of surface temperature and vegetation coverage at different periods

Through processing the data of vegetation coverage images and surface temperature images in the research area and taking the average value by the grid method to make an detailed analysis of the study area, this paper extracted data information in an all-round way.

The research area is meshed first with the

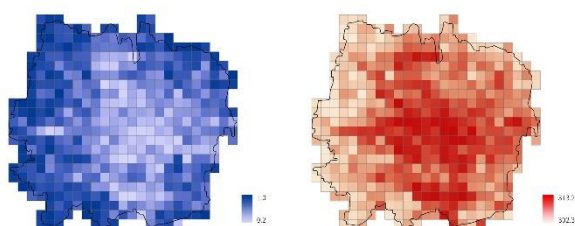


Fig.4 Grid plot of vegetation coverage and land surface temperature in 2017

border length of each grid is 900m*900m and 565 grids were presented and the coverage of all the data of surface temperature and vegetation coverage in the study area. Each grid contains 900 original grid data due to the spatial resolution of the vegetation coverage image is 30m*30m, and each grid of the images contains 225 original grid data due to the spatial resolution of the surface temperature image is 60m*60m, Then, the average value of the grids are calculated by ArcGIS10.2 software to get the partition grid image of vegetation coverage and land surface temperature (Fig. 4). Finally, the vegetation coverage and surface temperature data of all grids were introduced into Excel software to study the correlation between them, bringing out regression analysis results between surface temperature and vegetation coverage in 2007, 2012 and 2017 (Fig. 5).

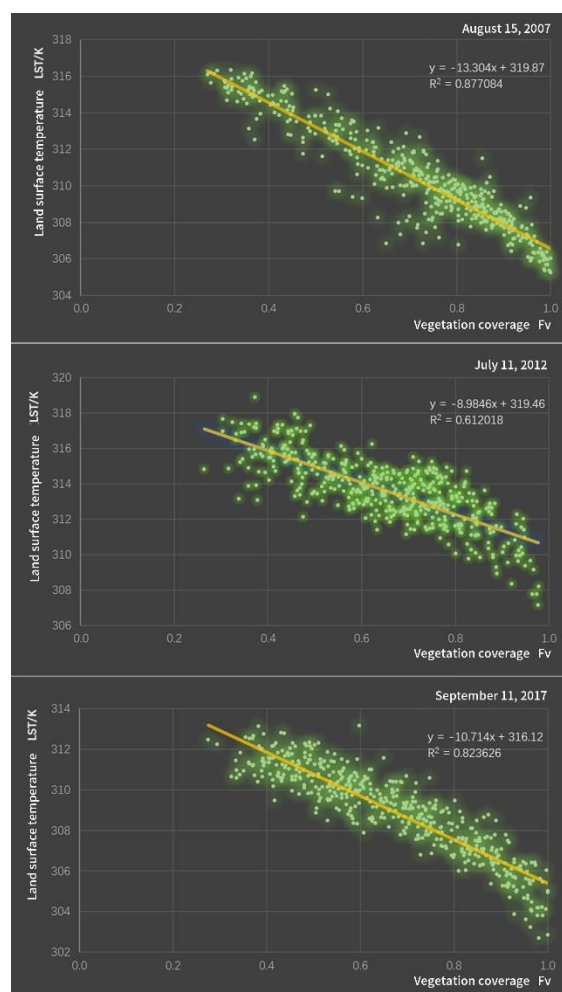


Fig. 5 Regression relation analysis of vegetation coverage and land surface temperature in 2007~2017

There is an obvious negative correlation between surface temperature and vegetation coverage in the study area as can be seen from Figure 5, of which the higher the vegetation coverage is, the lower the surface temperature in the corresponding sites is. The determinant coefficients (R^2) of the regression equations of 2007, 2012 and 2017 are 0.877084, 0.612018 and 0.823626 respectively as can be seen from Figure 5, indicating a strong correlation between them. While, the slope of the regression equation in 2007, 2012 and 2017 is -13.304, -8.9846 and -10.714 respectively with the absolute value ranges from 8.9846 to 13.304. What can be concluded from these data is the increase of vegetation coverage of the region can effectively change the surface temperature, indicating that when the vegetation coverage index of the Baoding city center is increased by 0.1, the surface temperature will be reduced by 0.9°C -1.3°C.

5. Conclusions and suggestions

The results showed that the vegetation coverage and the surface temperature changed greatly in the Baoding city center between 2007 and 2017. It is caused by the continuous expansion of urban and rural construction land in Baoding, the decreasing area of urban vegetation coverage and the strengthening urban heat island effect. In addition, there is a significant negative correlation between surface temperature and vegetation coverage in the study area, which means that the average surface temperature of the study area can be reduced by 0.9°C - 1.3°C when the vegetation coverage in the study area increases by 10%.

The relationship between urban heat island and urban development should be balanced in the development of Baoding's future cities. In 2017, the existing vegetation

coverage in the Baoding city center was 40%. If the urban expansion was uncontrolled in the future construction, the surface temperature would rise by 1°C when the vegetation coverage in the study area increases by 10%, which means that the temperature of local area may rise above 5°C. Therefore, it is necessary of 'leaving white and adding green' in urban development, and contribute to the ecological environment in Baoding. In 'adding green', on the one hand, rational planning and utilization of land, strictly keeping the 'red line' of land and ecological protection, controlling the development boundary of the city, overlying the wasteland or the unplanned land after demolition at a short term, increasing the green coverage of the city is needed. On the other hand, what should be done is to use the method of vertical and roof greening to increase urban greening coverage in the built-up area of the city.

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Research on Structural Optimization of Landscape Structure Based on karamba3D

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Abstract

The organic unity of structure and form has always been the goal of the construction industry. However, because designers habitually neglect the structural problems of small-scale landscape structures and lack of professional structural knowledge, design works are often not ideal. With the arrival of the digital age, more and more scholars are trying to improve this situation with new finite element analysis tools and have achieved some research results. Through case studies, this paper introduces how to quantitatively analyse a structural system by using Karamba3D, a finite element analysis tool developed based on the Rhino/Grasshopper parametric platform, and optimize the analysis results with some algorithms and plug-ins to get a relatively optimal solution to the structural morphology. Finally, four methods for structural optimization by using this tool are summarized to help designers to take full advantage of finite element analysis tools in the design of landscape structures.

Keywords: karamba3D; Finite Element Analysis; Structure optimization; Landscape Structures

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1. Introduction

The difference in scale causes the structure stress of landscape structure being simpler than architecture, and therefore its structural problems are often ignored by designers. In addition, with the constant refinement of the division of disciplines, structural knowledge of architectural and landscape designers is becoming increasingly scarce. The above two reasons lead to the separation and contradiction between the appearance form and structural morphology in most of the design works. There is neither a pleasing form nor a light and efficient structure, resulting in high costs but little profit.

The greater freedom of form creation in the landscape structure design enables the designers to actively explore the most reasonable structure as far as possible and pursue the expressive force of the structure itself. Famous architect Nervi thinks that “the structure should have its own expressive force, and a reasonable structure itself is beautiful”.^[1] When the structure plays the modelling role and satisfies the use demand with the lowest cost and the best performance, this design work will certainly be praised. The Hannover Expo-dome, designed by Thomas Herzog, is a good example (Fig. 1). The structure not only has a response to the environmental tendency of circulation space but also correspond to the theme of World Expo technology and ecology. The design work achieves the perfect unity between structure and form by adopting various methods from the whole to the details and had excellent visual effects.^[2]

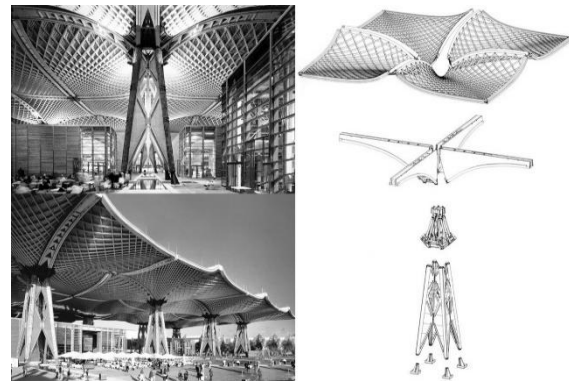


Fig. 1. Hannover Expo-dome designed by Thomas Herzog

The digital age gives designers some finite element analysis tools that are easy to learn and operate, such as the RhinoVault plug-in based on the Rhino platform, the finite element analysis plug-in Karamba3D and Millipede based on Rhino/Grasshopper platform and so on. Designers can use these tools to get accurate data on various mechanical properties of space structures and have a preliminary judgment on the structure rationality of the design works. Then these properties indexes can be optimized by using various algorithms or plugins. Many famous designers and architectural firms have used these new tools to create many great works. For example, the CIAB pavilion designed by Zaha Hadid in 2013. The designer extracted the primary and secondary stress lines by using Karamba3D and converted it into beautiful



Fig. 2. CIAB pavilion designed by Zaha Hadid Architects

force-flow pattern (Fig. 2). In addition, many architectural colleges and academic groups have done in-depth research on the teaching of finite element analysis, such as the "Shanghai digital future" summer camp planned by College of Architecture and Urban Planning, Tongji University which introduced the design method and teaching mode of structure performance into teaching practice. *Research on Digital Structural Performance Morphologies* published by professor Yuan Feng in 2014 explored the education on structural performance-oriented design based on this event. [3] In *Towards an Integration of Architecture and Structure Performance Design* published in 2017, he sifted through the pertinent research and practical projects on "structural performance-based aesthetics" and "structural performance-based tectonic culture", and predicted its prospective trend. [4] In the same year, Meng Xianchuan, professor of architecture and urban planning college in Nanjing university, published *Some Thinking on Tectonic Design with Finite Element Analysis: a Case Study on Karamba3D*. He revealed and reflected the new possibility brought by the new finite element analysis software for construction design. [5] In this context, this paper summarizes four structural optimization methods based on finite element analysis tool Karamba3D through some structural optimization cases study which can be used to help designers achieve the goal of organic unity between structure and form.

2. Structure optimization method

The tool used in this paper is Karamba3D, a finite element analysis plug-in developed under the Rhino/Grasshopper platform. It was jointly developed by Clemens Preisinger and Bollinger Grohmann Engineers to facilitate designers to use, which can achieve the structural performance-oriented landscape structure design combined with the Grasshopper parametric geometric model and a variety of optimization algorithms.

Karamba3D-based structural analysis and optimization process is usually divided into five steps (Fig. 3): 1) Create a parametric model 2) Define boundary conditions 3) Analysis results 4) Optimize processing 5) Visualization of results. In order to use a variety of algorithms or plug-in to iteratively optimize the structural system, firstly, a parameterized model needs to be created by

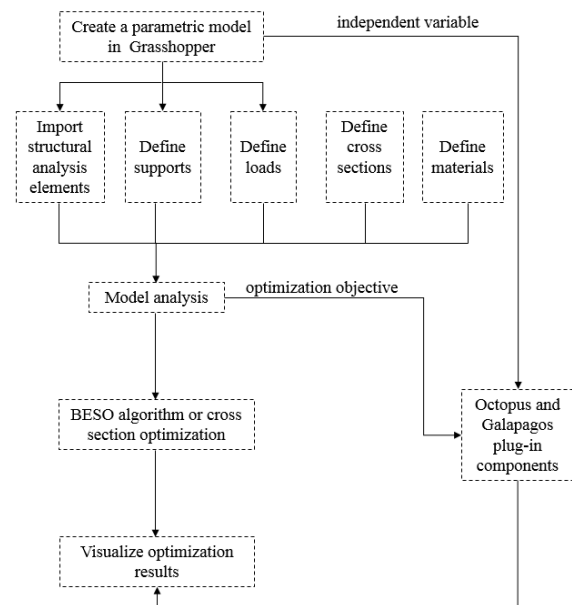


Fig. 3. Structure analysis and optimization flow chart based on Karamba3D

using Grasshopper, and then data association between the model data information and finite element analysis tools can be established. Secondly, defining boundary conditions including the structural elements, supports, loads, cross sections and materials, and selecting the optimization objectives from the analysis results of structural performance, such as strain energy, maximum displacement, the total mass of the structure and so on. Finally, optimizing the structure system by using the appropriate algorithm or plug-in, and visualizing the analysis results.

2.1. BESO algorithm

The Bi-directional ESO (BESO) is perfected on the basis of the Evolutionary Structural Optimization (ESO). It can not

only remove low-utilization materials in the structure, but also grow in the most needed part, so that the structural system evolves into an optimal form. [6] The pedestrian bridge designed by BKK Architects from Australia and Xie Yimin research team with a net span of 72m. In order to obtain the maximum structural stiffness, the BESO algorithm is used in the conceptual design. Under the same load condition, the algorithm generates the corresponding optimal forms according to the two support conditions. The first type of support condition is that one side is a fixed support and the other side is a sliding support. The second type of support condition is that both sides are fixed supports. In the end, the former produces a typical truss form, the latter forms an arched structure. (Fig. 4). [7]

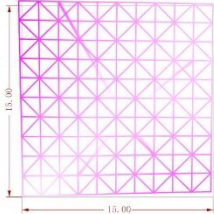
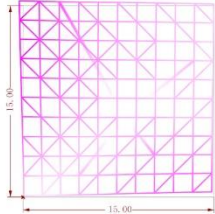
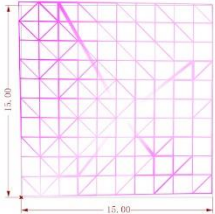
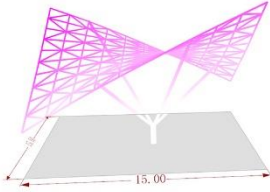
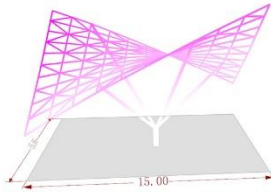
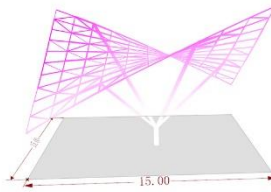
	No optimization	BESO for Beams	BESO for Beams and Optimize Cross Section
Top			
Perspective			
Maximum displacement	load case 1 274.86mm load case 2 208.01mm	load case 1 278.66mm load case 2 215.22mm	load case 1 258.36mm load case 2 115.74mm
Elastic energy	load case 1 2.622kNm load case 2 1.705kNm	load case 1 2.840kNm load case 2 1.625kNm	load case 1 2.929kNm load case 2 0.637kNm
Number of beam	324	284	281
Mass of structure	10918.99kg		6465.25kg

Table 1. The dendriform structure optimization results



Fig. 4. The pedestrian bridge designed by BKK Architects from Australia and Xie Yimin research team

The algorithm integrates successfully into Karamba3D, a finite element analysis tool, which set up two components for beams and shells: BESO for Beams and BESO for Shells. In the next case study, a simple dendriform structure is optimized with the help of the former component (Table 1). The structural analysis elements are composed of the top hyperbolic single-layer lattice shell and the dendriform structure, and displacement and three-axis rotation are constrained at column base. The load consists of the gravity of the structure itself and the uniform load at the top of the shell. All beams are circular hollow section, the cross-section diameter of the top single-layer lattice shell is 11.20cm, wall thickness is 0.56cm, and the diameter of the branch beam is 22.00 cm, the wall thickness is 1.32 cm, and the trunk beam diameter is 44.00 cm, the wall thickness is 2.40 cm. The BESO algorithm is applied to the oblique beams of the top single-layer lattice shell, and the optimization target of the structural mass ratio is set to 60%. After optimization, the number of oblique beams used to reinforce the structure in the top single-layer reticulated shell is reduced by 40, and the maximum displacement of the structure under the two load conditions is not significantly increased. BESO for Shells has a similar function and can distinguish

between the different utilization areas in shell structure.

2.2. Cross-section optimization

Karamba3D has an "Optimize Cross Section" component that can automatically select the optimal solution from the list of cross-sections set by the user based on the force state of the beam or shell. In the official case of the shell bridge cross-section optimization, it can be seen that under the condition of gravity load and external load on the bridge deck, the cross section of the

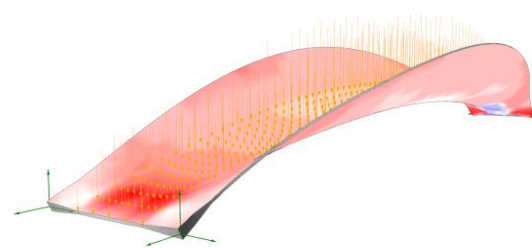


Fig. 5. The pedestrian bridge cross-section optimization case thin shell near the supports is significantly thickened (Fig. 5).

This method was used to further optimize the cross-section of the dendriform structure described above (Table 1). In order to ensure a certain structural reserve, the target value of the element utilization is set to 70%. The cross sections diameter are in the range of 4cm to 40 cm, and wall thickness of all the beams is 0.05 times the diameter. After BESO algorithm and cross-section optimization, it is found that the structure quality is reduced from the initial 10918.99kg to 6465.25kg, and the maximum displacement is significantly reduced. These data prove that the cross-section optimization effect is obvious.

2.3. Octopus and Galapagos plug-in components

Galapagos is a single-objective optimization component in grasshopper. It contains genetic algorithm and annealing algorithm, which is suitable for some simple single-objective optimization problems. Octopus is part of a range of tools developed by Robert Vierlinger at the University of Applied Arts Vienna, and Bollinger + Grohmann Engineers, which can be used for multi-objective optimization combined with the principle of Pareto Optimum and evolutionary algorithms.

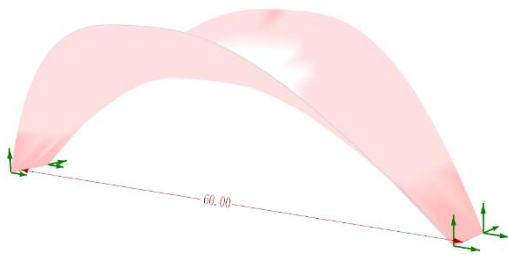


Fig. 6. The pedestrian bridge parametric model

In a case on the Karamba3D official website, the Octopus plug-in is used to optimize a concrete pedestrian bridge under the gravity load (Fig. 6). Firstly, establish a parametric model of the bridge in grasshopper. Then the independent variables are set to the width of supports, the arch highness, and width and height of the cross section at the middle of the pedestrian bridge. The optimization objective are the maximum value of the bridge highness, the maximum displacement of the structural system, and the minimum value of the structure mass. Since the optimization objective tends to the minimum value by default, the bridge highness value needs to be turned into a negative number to be inputted to the Octopus plug-in. The

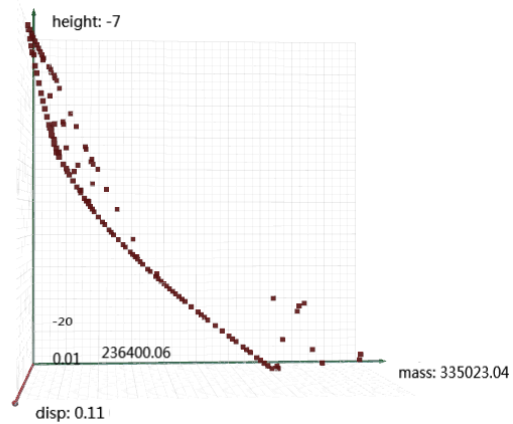


Fig. 7. The Pareto Front solution

optimization solution set is displayed in three-dimensional coordinate axes (Fig. 7), and each axis represents an optimization index. The scattered squares represent different solutions, and the lighter the colour is, the older the generation is. The solid square is the Pareto Front solution. Each square can be clicked to feed the solution back to grasshopper, or to be marked and deleted. Designers can choose the relative optimal solution in the solution set according to their needs.

In addition to using this plug-in to optimize Karamba3D's analysis results, designers can also set optimization objectives to non-structural performance indexes. For example, in the official case of inclined column position optimization (Fig. 8), it is necessary to use 10 inclined columns

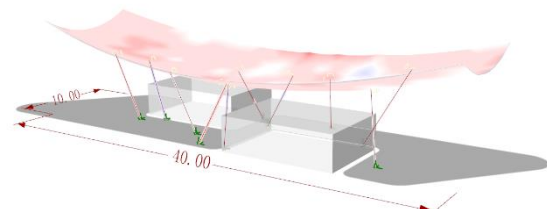


Fig. 8. The case of inclined column position optimization



Fig. 9. AA Summer DLAB 2015 design work InFlux

to support the surface roof, and not to collide with the two buildings below the roof. Therefore, the three optimization objectives are the minimum value of the structural mass, the maximum value of the minimum distance between the column bases, and the minimum number of the intersection between the columns and the two buildings. After inputting the model parameters of the column position as independent variables to the Octopus multi-objective optimization plug-in, ideal optimization results can be obtained.

2.4. Force Flow lines and Stress lines

The component of "Line Results on Shells" in Karamba3D can be used to extract the force flow lines or stress lines in shell structure, and then the efficient and Innovative structure can be obtained by removing the material between the force lines or transforming the stress lines into the structural skeleton. In the design work of AA Summer DLAB 2015, Elif Erdine and Alexandros Kalle-gias led the team to design a red concrete landscape wall with 2.2 meters height, 4 meters width, and a varying depth of 3 ~ 25 cm (Fig. 9). In the conceptual design stage, Karamba3D was used to analyse the structure of the surface wall, and then the force flow lines were extracted based on the analysis results. This

form was obtained by removing the material in the area between the force flow lines. Then the high-strength red concrete was poured into the CNC engraving template, the design result of organic unity between form and structure were obtained after the template was removed. Patrik Schumacher, a partner of Zaha Hadid Architects, has studied how to use Kammba3D to analyse the hyperboloids, and then extract the primary and secondary stress lines in different directions from the analysis result, and finally transform them into beautifully adapted rib-patterns (Fig. 10).^[8] The CIAB exhibition pavilion introduced above has also been designed and built by using the

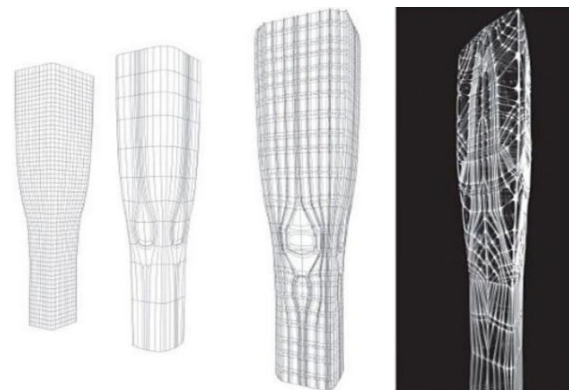


Fig. 10. Philipp Ostermaier uses Karamba to extract stress lines and transform it into support structures

same method. In addition, continuous changes in structural properties can also be correlated with material densities to generate innovative forms. The 15th International Architecture Exhibition in Venice showed a chair created by Zaha Hadid, Patrik Schumacher and Stratasys, a 3D printing company. The designer used finite element analysis tool to obtain the structural performance data of the chair when a person was sitting and adjusted the material density distribution according to the data to optimize

the structural performance, and the result also got a beautiful form. (Fig. 11).



Fig. 11. 3D printed chair designed by Zaha Hadid Architects

3. Conclusion

Karamba3D is a powerful finite element analysis tool that can combine the advantages of grasshopper parametric model. While changing a certain model parameter, it can carry on the real-time structural analysis to a series of models that produce quickly. In addition, a relatively optimal solution can be selected from these models by using some algorithms or plug-ins based on the analysis results. This paper summarizes four structural optimization methods based on finite element analysis tool Karamba3D through some structural optimization cases study of the dendriform structure, pedestrian bridge and so on. Designers can use BESO algorithm and cross-section optimization component to gather materials in the most needed area, and also can use Octopus or Galapagos plug-in to find the optimal form of structural

performance under some rule restrictions, for example, the mass of the structure is optimized under the restriction that the columns do not collide with the buildings in the case of inclined column position optimization. In addition, the force flow lines or stress lines of the structure can be extracted to create the “force form” by removing materials in the area between force flow lines or converting the stress lines into structural skeleton. The author hopes that the emergence of these new tools and methods will be an opportunity to break the barrier between the form design and the structure design of landscape structures, and to achieve the goal of cooperative development and organic unity between both sides.

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First of all, I am extremely grateful to my supervisor, Lu Shiliang, for his patient guidance and trust from the selection of the thesis topic to the successful completion. At the same time, I am much obliged to the IFLA organization for giving me the opportunity to participate in the 55th International Federation of Landscape Architects World Congress 2018. In addition, I would like to express my sincere gratitude to Karamba3D official website for providing these structural optimization cases. Last but not least, I would like to express thanks to my colleagues in the studio for their support and help in the writing process of this paper.

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Landscape elements and bloodsucking midge breeding sites

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Abstract

The purpose of this study is to analyse the relationship between landscape factors and the larval breeding sites of bloodsucking midge (*Forcipomyia taiwana*). The study intent is to establish the environmental management strategies that make the designed landscape *per se* the environment that is difficult for the larval breeding sites to form. Studies have indicated that unsuitable landscape designs can increase the population of the bloodsucking midge in green spaces. However, we have little further information about which kind of designed environmental factors that affect the formation of the larval breeding sites. As a result, the landscape professionals are in lack of information to establish effective strategies for midge prevention at the early stage of a site preparation. Therefore, in this study, we use spatial analyses, GIS technique, and field survey data, and statistical technique of logit regression to analyse how the surveyed landscape factors can influence the occurrence of larval breeding sites of bloodsucking midges. The results show smaller canopy width 1-3m promotes algae growth while other larger canopy widths relate with less algae growth, the medium tree height of 4-6m and half shaded presents suitability for algae growth while other heights and less than half shaded areas discourage algae generation. The results of ground materials indicate the covers that either have less ability to retain water ('sandy soil'), is covered by other strong competitors for water and sunlight (natural grass), have shorter installation history (new high-tension brick), or have sufficient sunlight isolation (thick leaves) present a better ability to prevent algae growth.

Keywords: *Forcipomyia taiwana*; bloodsucking midge; landscape; environmental control method

1. Introduction

Bloodsucking midge (*Forcipomyia taiwana*), also publicly called ‘little black mosquito’, is a substantial nuisance blood-sucking insect distributed in Taiwan and also in warm and humid areas in mainland China. Its female imagoes are human blood-feeding and bite on human skin especially the expose parts, such as hand, foot, face, and calf. The imagoes of *Forcipomyia taiwana* are active in the daytime and the size is approximately 1.4mm. Due to this small size, it is difficult for people to aware their stops on the skin. The reaction of the bites can be itching and swelling in various sizes for several days. Depending on the constitution of the individual, it can trigger allergies [1].

Studies have indicated that unsuitable landscape designs can increase the population of *Forcipomyia taiwana* (bloodsucking midge). However, we have little information about what kind of design or environmental factors that relates to this issue. As a result, the landscape professionals are in lack of information to establish effective strategies for midge prevention at the early stage of a site preparation. The purpose of this study is to analyze the relationship between landscape factors and the larval breeding sites of bloodsucking midge (*Forcipomyia taiwana*). The study intent is to establish the environmental management strategies that make the designed landscape per se the environment that is difficult for the larval breeding sites to form.

Because *Forcipomyia taiwana* is human blood-feeding, the human inhabitations and activities become an important factor to the

midges’ population. Due to the warm and humid weather conditions and dense human population in Taiwan, the distribution of *Forcipomyia taiwana* covers a wide range including the areas of eastern, central, and southern Taiwan especially in the county of Tauchun, Chumhaw, Yinlin, and Tainan [2-3].

The various types of green spaces not only provide ecological services to sustain our environmental quality, but also offer people the opportunities for contacting with nature, participating activities, relaxing psychologically, and energizing physical strength especially in the highly populated and urbanized environment of Taiwan. However, since the blood sucking midges’ active time and people’s major outdoor setting use in the daytime are overlapped, many cases have been reported that people have been densely bitten during their stays in the outdoors causing adverse reactions pertaining allergies and skin irritation. To mitigate this situation, although the use of insecticide can temperately reduce the population of blood sucking midges [3], the insecticide application causes the public’s concerns for health and can lead to the *Forcipomyia taiwana* population rebound after a temporary reduction. It is apparent that a more sustainable and healthy management means needs to be studied. Therefore, this research intends to explore a mitigation method from the angle of environmental prevention.

Forcipomyia taiwana is a diurnal insect and is often active at the areas less than 2 meters height. The blood-sucking activity is cycled starting approximately from 8:00 am, reaching its most active time between 12:00-15:00, and stopping around 18:00 [4-5].

The suitable temperature for *Forcipomyia taiwana* is ranged 18-27°C. The population fluctuates generally following the seasonal change. The largest population happens in summer and smallest population happens in winter. The population outbreak often appears during the spring rainy period [6]. Studies have found the population of *Forcipomyia taiwana* positively relates to temperature, rainfall, rainfall days, and monthly temperature [7]. A similar conclusion was drawn in a study in Hawlian, Taiwan, indicating the population is dynamic based on sunlight hours, rainfall, humidity, and temperature, and the *Forcipomyia taiwana* population decreases when the temperature is higher than 35°C, lower than 10 °C, or the moisture is excessive [8].

The distribution of *Forcipomyia taiwana* is mainly in hills and low altitude mountains in Taiwan and Mainland China. An earlier Mainland China study reported the case of the female *Forcipomyia taiwana* carried Japanese encephalitis virus [9]. However, there are not enough reports to support *Forcipomyia taiwana* is a disease vector. Recent studies have found an extended trend of its population, spreading to cover almost all counties especially in the eastern areas in Taiwan [6-7]. Comparing studies along time, the distributed elevation range of *Forcipomyia taiwana* has also extended from 150m in earlier records, to 200-400m, and to the recent records of 350-400m [3,6]. Lately, the estimation is that approximately 78% of the population is in the area under 250m and 15% is distributed in between 250-500m [3]. This spread has been seen a reflection to the overall temperature raise by global warming phenomenon.

Forcipomyia taiwana is a completely metamorphic insect. Its life cycle experiences the four stages of egg, larva, pupa, and imago. Most eggs hatch within 3 days, then go through 16-18 days larval stage, and 3-5 days pupal stage to reach the imago stage. The time before imago stage is in the range of 21-26 days. The imago can live for another 22-26 days [10]. The male *Forcipomyia taiwana* feeds on dew or nectar while the female feeds on human blood. The needed blood time for female is 4-6 minutes a day, the female lays eggs after 3-4 days feeding on blood, and the average number of eggs laid is nearly 30-40. *Forcipomyia taiwana* often lays eggs in a scattered manner at sites that are humid and provided with algae for its consumption. The eggs are in brown-black color with the length approximately 0.3mm. The larva is terrestrial and ingests algae as the main source of food. In the latest stage of lava, it climbs on to drier location to form pupa. The imago frequently inhabits in bushes or lower trees less than 2m and wait for hosts [11].

During the stages of egg, larva, and pupa, *Forcipomyia taiwana* inhabits in the environments that provides algae for food. Since the flying ability of the imago is inefficient, most imagoes stay close to its larva site. Study found that the imago population concentrates within 100m from their larva sites, and most population stay within the range of 300m. The observed population significantly decreases as the distances further from their larva sites.

The larva mainly feed on blue-green algae, green algae, and other algae in the breeding sites. Freshwater algae include various different species. Most of the species

visually appear as green color as most of them contain chlorophyll and carry out photosynthesis. Based on the growing environments, algae can be classified as floating or fixing algae. Because *Forcipomyia taiwana* larva is terrestrial, its breeding site is related to the growth of fixing algae. *Forcipomyia taiwana* inhabits in sites that aggregate algae [2,5]. *Forcipomyia taiwana* larva feeding on blue-green algae can shorten nearly half of its developing days to become an imago [12]. The locations with indirect sunlight and high moisture are suitable for algae growth. Studies also found the ditches, fencing walls, or shaded places within 20 meters from residences often breed *Forcipomyia taiwana* larva [13]. The moisture condition of the groundcover material is a factor for breeding sites. Ground covers with sands and dry soil relates to less larvae found [14] while the soil pH value does not show effect. In addition, the shady places close to structures and people can be candidates for breeding *Forcipomyia taiwana* larva.

Forcipomyia taiwana are observed to haunt about two land use types. One is the agriculture land use, such as bamboo farm and betel nut farm. Another is the landscaping green spaces, such as green settings at schools and parks [2,7]. In addition, the frequency of human activity significantly affects the population density of *Forcipomyia taiwana* [13]. The active range of *Forcipomyia taiwana* has been found limited to the place near their larva breeding sites as well as relating to distances from people's constant appearances [13]. The settings have sufficient blood sources from people's residences and activities, such as parks, recreation areas, schools,

agricultural communities, are potential locations for being rampant. Therefore, we understand environmental factors in landscaping designs, such as plant type, canopy coverage, plant height, and groundcover material that influence the population of *Forcipomyia taiwana*.

Forcipomyia taiwana often bites on human skin on the parts with no covers, such as face, neck, lower neck, foot, and hand. The spot bitten usually appears wheal and extreme itchy within an hour and may lead to a delayed type hypersensitivity appearing blisters, pustules, itchy eruptions, or sometimes allergies that need medical treatment [1]. We know that the green spaces infested by *Forcipomyia taiwana* often associate with frequent human activities [7] and in fact causes impacts on the visits to recreation areas, shops, and on quality of life. As many of those green places have an important role for various functions that support ecological values, aesthetic quality, social capital, psychological and physical health for the public. Therefore, this study intends to understand the effects of characteristics of landscape elements on the larva breeding site of *Forcipomyia taiwana*.

The larva of *Forcipomyia taiwana* is terrestrial, ingest mainly blue-green algae, green algae, and other algae, those algae usually grows on different ground covers, such as brick, concrete, or bare soil. The growth of algae needs suitable conditions of micro-climates and sun light. In green spaces, plants and landscaping produce nature beauty provide outdoor recreation, environmental education settings, and comfortable environments supporting activities for the public and children,

however, inappropriate designs of green spaces may also become the settings that provide the algae for the larva of *Forcipomyia taiwana*. Thus, the management of green spaces is proactively seeking the strategies that can give considerations to the two sides of the creation of green spaces and prevention of *Forcipomyia taiwana*, yet the supporting studies that can provide the basis for possible solutions have been under development.

Studies indicated that an inappropriate design of green spaces may grow *Forcipomyia taiwana* [7,15] but little research has been done regarding which design, configuration, or environment factors that affect the growth of *Forcipomyia taiwana*. As a result, the landscape and planning professionals are difficult to reflect this consideration into their practices. Therefore, this current study explores the relationship between landscaping factors and algae growth as the indication of larva breeding site, investigating the characteristics of landscaping element, including tree canopy, tree height, shade density, and ground cover types, and use the method of spatial analysis, and GIS to explore the prevention strategies in landscape design and planning, so the configurations of settings per se can avoid the formation of larva breeding site.

2. Method

2.1. Study site

The study site is located at Chingshui Yan Recreational Area, Shetou Township, Changhua County, Taiwan. Based on survey

reports, this region is an infested area of *Forcipomyia taiwana*. The site is at the fringe of Changhua City and the foot of Bagua Mountain. This study site is approximately 12 Ha (120,000 m²) and its elevation is 100m-125m. The slope of the site is prepared and generally smooth around 5-8%. The monthly average low and high temperatures are 19.4°C and 28.0°C. The yearly average rainfall is approximately 1,400mm and the relative humidity is 77%.

Chingshui Yan Recreational Area was originally developed for the use of scout camp and currently used as a recreational area for the public, offering facilities including prepared camp sites with different paving material, restrooms, lodges, auditorium, pavilions, and large shelters. The site offers green areas throughout. The vegetation types include the combinations of majorly trees, natural grown ecological areas, natural grass land, and open lawn.

2.2. Data collection and analyses

This study used empirical field survey as the data collection method. The researchers first prepared and organized the site plan drawings into GIS for later data entry. In the field surveys, the surveyor recorded the pre-identified features, including algae growth spots, tree height, projected canopy area, the leaf density levels, and the groundcover or pavement material. The variables are listed in Table 1 and 2. The collected raw data were entered into layers with the identified feature attributes as GIS vector data. Then, we assigned 1x1m grid on the data map to extract the types of tested variables in each grid. The total sample size is 57066. We used the statistic technique of binary logistic

regression to analyses which variables promote the algae formation.

Table1. Tree features

Vegetation type	Features
Tree	Projected canopy area
Tree	Height
Tree	Light penetration

Table2. Ground cover materials

Category	Type
RC	1. RC Ditch
	2. RC
High-tension brick/ close pebble	3. High-tension Brick
	4. New High-tension Brick
	5. Close Lightly Pebble
Soil mix	6. Pebble Gravel Sand Mix
	7. Gravel Sand Soil Mix
	8. Sand Soil Mix
	9. Bare Soil
Natural fallen leaves cover	10. Clay
	11. One-layer Leaves
	12. Multi-Layer Leaves
Grass	13. Thick Leaves
	14. Lawn
Asphalt	15. Natural Grass
	16. Asphalt

2.3. Results

In this section, we report the results of whether the tree canopy, height, light penetration condition, and ground material affect formation of algae for larva breeding sites of *Forcipomyia taiwana*. To answer these questions, we conducted field surveys to collect the data that include tree canopy width, height, light penetration conditions, ground material, and algae growth locations, and used ArcGIS and Binary Logit Regression for examination.

Table 3,4 shows the estimated results. First, the model fit and model coefficient Omnibus test, results of the likelihood ratio chi-square presents the model fit is significant at $\chi^2=5675.405$ and $p<0.001$. This result indicates the estimate model is better than the null model. The results shows that the coefficient canopy width, tree height, and ground material are positively significant indicating those environmental factors are influential to algae formation. Results of Omnibus test indicate the coefficients are significant in the model level.

Table3. Model summary

Cox & Snell R ²	Nagelkerke R ²
0.095	0.383

Table 4. Model coefficient Omnibus test

	χ^2	df	Sig.
model	5675.405	26	<0.001

The table 5 show the effects of the characteristics of tree canopy, tree, height, light penetration, and the ground cover on the algae formation for *Forcipomyia taiwana* breeding sites. The predicted odds ratios represent the probability of the algae formation when the condition of factor changes. In comparison with the no-tree condition, the areas under 1-3m width tree canopy increase 103% in odds to grow algae (OR=2.029) while the areas under 4-6m, 7-9m, and more than 10m canopy in width would receive less odds to grow algae by 47%, 64%, and 65%. For the areas under different tree heights, the areas under tree height 1-3m have 75% less chance to grow algae while the areas under 4-6 received an increase 344% in odds to grow algae. Tree

shade levels indicate the ability for sunlight penetration. The half shade areas receive 40.1% increase in chance to grow algae while little and some shade conditions have respectively 51% and 63% decrease in odds to form algae.

The ground materials show an overall positive significant influence compared with the main road feature. Based on OR value of materials, 'RC ditch' presents the most positive influence on algae formation by 6443.77 times in adds to grow algae. The 'high-tension brick' also shows its high effects. The areas constructed by 'high-tension brick' have 266.98 times in odds to generate algae. The ground material 'bare soil' presents 107.83 times in odds to grow algae than main road, followed by the ground material of 'clay'(66.6 times in odds), 'close lightly pebble (60.8 times), 'gravel sand soil mix' (34.75 times), 'pebble gravel sand mix' (34.29 times), 'multi-layer leaves' (33.18 times), 'one-layer leaves' (30.75 times), 'RC'(27.84 times), 'sand soil mix' (11.31 times) 'new high-tension brick' (9.62 times), 'natural grass' (6.23 times), and 'thick leaves' (0.99 times), while the 'lawn area' and areas made of 'asphalt' are not significantly different.

Table5. Effects of landscape characteristics on algae growth

Characteristics		B	Sig.	OR	Impact order
Canopy width	C. width		<0.001		
	1-3m	.708	0.015	2.029	1(+)
	4-6m	-.637	0.003	.529	2 (-)
	7-9m	-1.016	<0.001	.362	3 (-)
	>10m	-1.043	<0.001	.352	4 (-)
Tree height	Tree height		<0.001		
	4-6m	1.492	<0.001	4.447	1(+)

	1-3m	-1.361	<0.001	0.256	2 (-)
	7-9m	-0.310	0.109	0.733	Not sig.
Tree shade	Shade		<0.001		
	Half shade	0.338	0.011	1.401	1(+)
	Little shade	-0.718	0.001	0.487	2(-)
	Some shade	-0.983	<0.001	0.374	3(-)
Ground Material	Ground Material		<0.001		
	RC Ditch	8.77	<0.001	6444.77	1(+)
	High-tension Brick	5.59	<0.001	267.98	2(+)
	Bare Soil	4.69	<0.001	108.83	3(+)
	Clay	4.21	<0.001	67.60	4(+)
	Close				
	Lightly	4.12	<0.001	61.80	5(+)
	Pebble				
	Gravel				
	Sand Soil	3.58	<0.001	35.75	6(+)
	Mix				
	Pebble				
	Gravel	3.56	<0.001	35.29	7(+)
	Sand Mix				
	Multi-Layer	3.53	<0.001	34.18	8(+)
	Leaves				
	One-layer	3.46	<0.001	31.75	9(+)
	Leaves				
	RC	3.36	<0.001	28.84	10(+)
	Sand Soil	2.51	<0.001	12.31	11(+)
Mix					
New					
High-tension	2.36	<0.001	10.62	12(+)	
Brick					
Natural	1.98	<0.001	7.23	13(+)	
Grass					
Thick	0.69	0.04	1.99	14(+)	
Leaves					
Lawn	-14.63	0.98	0.00	Not sig.	
Asphalt	0.87	0.26	2.38	Not sig.	
Constant	-6.49	<0.001	.002		

Reference categories: Canopy width='no tree'; Tree height = 'no tree'; Tree shade = 'no shade'; Ground Material = 'main road'

2.4. Conclusion

Forcipomyia taiwana is human blood-feeding that bite on human skin to cause itching, swelling, and trigger allergies [1]. Because *Forcipomyia taiwana* often haunt in landscaping settings and bite people conducting outdoor activities, we intend to understand which characteristics of plants and ground conditions can compose the environments that generate algae for breeding larva of *Forcipomyia taiwana* so we can understand considerations in landscape planning and design to mitigate the population of *Forcipomyia taiwana*.

Based on the results, we learn that the tree canopy width, height, shady areas, and the types of ground material significantly affect the algae formation for breeding *Forcipomyia taiwana* larva. Smaller canopy width 1-3m promotes algae growth while other larger canopy widths relate with less algae growth. The medium tree height of 4-6m presents suitability for algae growth. The results show half shaded conditions under trees promotes algae growth and the less shady conditions discourage algae growth. These results indicate that sunlight condition under tree is one of the conditions for the larva breeding sites of *Forcipomyia taiwana*. Trees with these conditions need to adjust to their site maintenance and accompanied ground cover condition to reduce the forming of larva breeding sites. The ground materials show an overall influence on algae growth. Among the material types, the not-covered RC ditch structures provide preferred humidity and suitable sunlight for

algae growth and thus become the most preferred sites for algae.

The materials of 'high-tension brick', 'bare soil', 'clay', and 'close lightly pebble' are the first five ground materials in effectiveness order that promote breeding sites of *Forcipomyia taiwana* larva. Those materials are characterized having higher ability to retain water in the material or trap water to stay in the soils framed in the material, such as the framed-brick. The next group of materials in their effect order- 'gravel sand soil mix', 'pebble gravel sand mix', 'multi-layer leaves', 'one-layer leaves', and 'RC' present that particle sizes may provide surface for growing algae ('gravel sand soil mix', 'pebble gravel sand mix', and 'RC') and a combination of moisture retention and sunlight of fallen leaves are needed to be either accumulated to become thicker or changed ('multi-layer leaves', 'one-layer leaves').

In comparison among the mixes of pebble, gravel, and sand, we found the mixes with more proportion of bigger objects (pebble and gravel) have larger chance to growth algae than the ground that contains smaller particles (sand). When comparing the thickness levels of fall leaves, we found the thinner leafy cover relatively promotes algae growth than the thick leafy cover does. The least influential group of ground cover contains 'sand soil mix', 'new high-tension brick', 'natural grass, and 'thick leaves'. The materials in this group indicate the covers that either have less ability to retain water ('sandy soil'), is covered by other strong competitors for water and sunlight ('natural grass'), have shorter installation history ('new high-tension brick'), or have sufficient sunlight isolation ('thick leaves')

present a better ability to prevent algae growth.

In this study, the inclusion of tested environmental factors is limited due to the composition and material installed in the study site. Future studies should include more sample sites with diverse vegetation types, such as shrub condition, and installed ground material to understand the interactions between algae generation and the landscape compositions. Moreover, future studies should consider the effects based on the combination of variables to understand specific environmental condition composed by landscape elements.

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Populating large scale virtual city models with 3D trees

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Abstract

As cities begin adopting smart technologies, one common goal is creation a digital twin of the city. A virtual three dimensional (3D) representation of the city in question from which advances in urban planning, data analytics and logistical operations can be simulated. Unfortunately the representation of vegetation in virtual cities remains mostly unexplored or oversimplified owing to the complexities involved in modelling it in 3D.

Urban trees and parks are known to be vital in making cities more liveable by providing both a psychological as well as a physical relief. Few other cities in the world exemplify this idea as much as Singapore which positions itself as a “City in a Garden”. Likewise, the digital twin of Singapore (Virtual Singapore) would also need to find ways to accurately represent the sheer diversity and volume its tropical trees in this new 3D environment.

The aim of this interdisciplinary research is to develop efficient tools and techniques to model spatially, biologically and semantically representative 3D Trees for Virtual Singapore. This paper outlines the initial developments in which the team consolidates a multitude of data sources and develops a methodology to efficiently populate large-scale city models with representative simplified 3D trees that are based off the best available data.

The team adopts the CityGML standard, the framework for Virtual Singapore, within which the vegetation theme is delineated into solitary vegetation and plant cover. The team demonstrates the extraction of existing trees from airborne light detection and ranging (LiDAR) data and classifying them into these two broad categories. This is then further cross referenced against an existing 2D database of managed trees. The classified tree locations and extracted information are then used to parametrically generate CityGML tree models based on allometric equations derived from measurements from mobile LiDAR data.

The methodology developed was tested on a 25km² site in Singapore. It demonstrates an efficient means to dealing with the representative modelling of 3D trees over large-scale city models and provides insights into dealing with both trees pre-identified within as well as outside of an existing georeferenced database. The findings also shed light onto the problems and limitations of modelling vegetation at these scales but provide a viable solution to populating large scale city models with representative 3D tree models.

Keywords: Virtual city models; CityGML; 3D Trees

1. Introduction

In the face of rapid urbanisation, smart technologies offer a possible solution to better comprehend the constant state of spatial-temporal flux in which cities undergo. One of these smart technologies involves the creation of a digital twin of the city in question [1] - an example of this is Virtual Singapore [2]. A massive virtual three dimensional (3D) representation of the city from which landscape architects, architects, planners, engineers and researchers can make advances in urban planning, data analytics and logistical operations such as the calculation of the solar-power generating potential of a city [3] or the planning of railway infrastructure projects [4].

The idea of a digital twin in order to replicate and run simulations of complex systems is not unique to the building of virtual cities [5] and the potential of having such a platform to perform a multitude of virtualised simulations is understandable. However, ambiguity around terminologies and use cases exists [6] along with differences in the process of generating these 3D city representations—all of which are interrelated dependent on the type and the needs of the model in question. Regardless of these differences, it is commonly understood that a 3D city model comprises of geometric (roads, buildings, trees, terrain) and non-geometric data (semantics, information) which are generated through 3D reconstruction and data integration through various methods such as photogrammetry, laser scanning which are then cross referenced with traditional 2D GIS databases [7]. This typically revolves around the generation of models of buildings, roads and other hard structures, but the use of 3D vegetation

representations remains mostly unexplored—a common occurrence in the modelling of 3D cities [6].

Perhaps in no other city is the need to accurately represent virtual trees as pressing as it is in Singapore (Fig. 1) [8]. With over 50 years of foresight to continually green the island, Singapore now has more than an estimated 2 million trees which line our roads, shade our public spaces and provide shelter for animals in the nature reserves [9]—thus making them an essential component of our urban landscape both visually and biophysically. Urban trees and parks are known to be vital in making cities more livable by providing both a psychological as well as a physical relief from the otherwise urban landscape amongst other potential benefits [10]. Few other cities in the world have exemplified this idea as much as Singapore which positions itself as a “City in a Garden” [11,12]. Likewise, the digital twin of Singapore would also need to find ways to accurately represent the sheer number, density, variety and size of trees which differentiates us from other cities. However, this presents itself as a complex task to find efficient means to model all of them in this new 3D environment.



Fig. 1 – While building models are modeled and even textured, trees are missing from the city model.

In general, 3D tree models can be generated by either a non-procedural, interactive approach or a procedural approach. Some of the work using an interactive approach include image-based [13], light detection and ranging (LiDAR) based [14,15], graph-skeleton based [16,17] and sketch-based techniques [18–20]. An interactive approach which requires user's input is inherently not scalable despite producing realistic tree models but a procedural approach which generates trees automatically based on a set of predefined rules makes it more suitable for the large scale modelling of trees.

The potential uses of these 3D tree models goes beyond generating realistic visualisations as more knowledge can be derived from our digitised landscapes than a mere visual understanding [21,22]. This includes the possibility to move beyond the visually perceivable environment to link with numerical models which simulate real world dynamics and create scientific visualisations and projections that act as a means to communicate and analyse complex relationships between the inhabitants and their environment [23].

Examples of such studies include micro-climatic analysis can help to determine the species or layout of trees to reduce urban heat island effects [24,25]. Understanding the millennium old tradition of planting trees as a direct reaction to flooding [26] by leveraging off coupled simulations [27]. New directions in the design and planning of our parks, roadside greenery and nature areas can be derived to better understand their "Landscape Performance" - a measure of the efficiency with which landscape solutions fulfil their intended purposes and contribute towards sustainability [28]. Scientific rigor can be exercised by coupling

models with simulations for more credible visualisations [29]. Documentation of existing trees to provide permanent 3D digital records can be subsequently monitored using change detection algorithms [30,31]. Animated or even virtual reality tours [32,33] of heritage roads, parks as well as conservation areas can be used as a means of communication, community outreach or as an educational tool to non-destructively understand our landscapes.

2. The Adoption of CityGML

As part of Singapore's National 3D Standards effort to establish such a comprehensive 3D representation of the city, the CityGML 3D specification (version 2.0) was studied and used as a reference for the development. CityGML is an official OGC standard established since 2008 [34] and is seen as a cost-effective mean for a sustainable maintenance of 3D city models with well-defined themes and meaningful semantics being captured which would facilitate interoperability and offer a consistent digital representation of the city. It is made possible by its open data model and XML-based format for the storage and exchange of city model information.

The CityGML standard has defined nine city themes to classify various city features, of which vegetation is recognised as important enough of a feature in the city to be the focus of one of these themes. Within this, the theme is further classified into two types of vegetation classes - *Solitary Vegetation Objects* such as trees, and *Plant Cover* which represents vegetation areas such as forests (Fig. 2) [35].

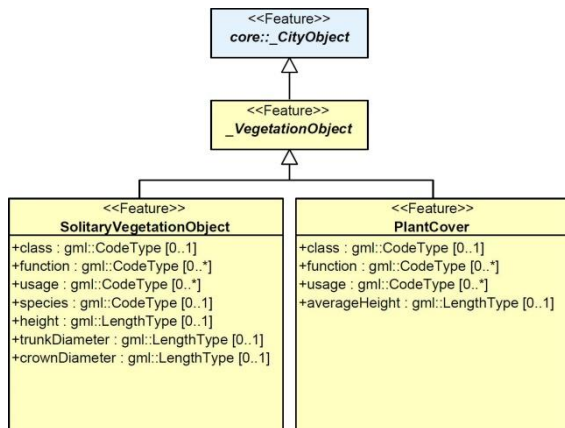


Fig. 2 – Within CityGML, the vegetation theme is pre-defined into two types, solitary vegetation representing trees or palms and plant cover representing forests or grasslands.

Another interesting concept that CityGML introduced was the notion of Level-of-Details (LoD), where objects of each city theme could be expressed in up to five variations of complexity; LoD0 being the coarsest representation, and LoD4 being the most detailed and sophisticated representation (Fig. 3) [35].

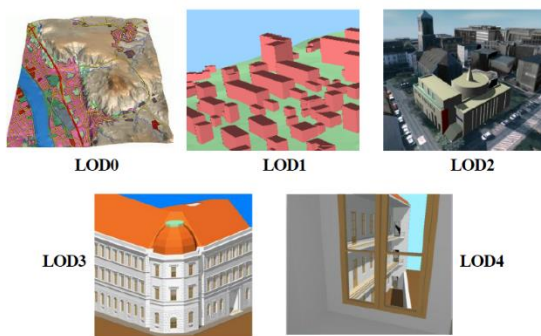


Fig. 3 – The levels of detail (LoD) defined by CityGML for buildings (source: IGG Uni Bonn)

At present, the Singapore CityGML standards for defining the LoD of solitary vegetation objects is still a work in progress but keeping aligned with the spirit of the existing LoD definitions, the generalised LoD solitary vegetation models follow a similar process of increasing in geometric complexity (Fig. 4). In this paper we deal

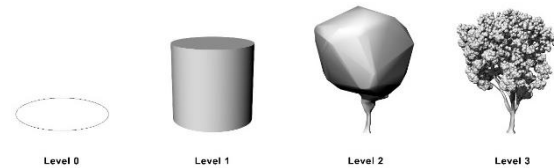


Fig. 4 – Our current delineation in the level of details for solitary vegetation stipulate that an LoD0 model is purely its 2D representation, LoD1 is an extrusion, LoD2 is represented by a trunk and its crown, while LoD3 consists of more detailed geometrical representation of the various components of a tree.

only with LoD2 models which are geometrically simpler and thus more computationally acceptable to mass populate Virtual Singapore. While the model is less complex, the semantic information within the tree would still allow for rapid simulation and analysis purposes alongside the other simplified elements such as buildings and roads.

While each solitary vegetation object is modelled as a single entity, the modelling of plant cover requires a few more considerations as a result of to the lack of data on the exact location and species of the multitude of trees within these natural areas. At the same time, it is important to work within computational budgets as 3D models with large polygon counts could affect the visualization performance and hence, the user experience. As such, several forms of representation are being tested using different techniques to evaluate their suitability and performance (Fig. 5). In this paper, we model plant cover as a group of

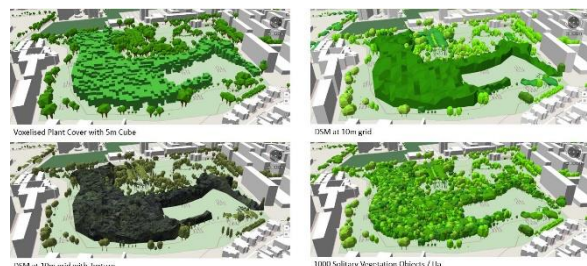


Fig. 5 – Several methods of modelling plant cover are being explored from the use of voxels, digital surface model (DSM) meshes or individually modelled trees but semantically grouped as plant cover.

individually modelled trees derived from remote sensing and allometric relationships as described in the later sections.

3. Data Sources

The team relies on data obtained from two main governmental agencies, the National Parks Board (NParks) which provides botanical information and geo-referenced tree data points as well as the Singapore Land Authority (SLA) which is the source for various spatial national level datasets listed below [36]. All data are geo-referenced to the SVY21 Coordinate system with orthometric height based on SLA's height datum. In this paper, the case study is a 25km² site centering on the Ang Mo Kio-Bishan Park in Singapore.

3.1. NParks Tree Database

The NParks tree database consists of over 500,000 geo-referenced data points in 2D GIS format indicating the identity, coordinate, species, girth, height ranges and other attributes (a web interface to this database was recently made public [37]). One important point to note is that while the extensive database covers the entire Singapore, it is limited to trees which are actively managed by the board. As such in the process of the research, it became clear that just attempting to populate Virtual Singapore based on the NParks database alone would be insufficient (Fig. 6).

3.2. Flora Fauna Web

The Flora and Fauna Web [38] is another online resource made available by NParks which serves as a user-friendly portal to search for species level information on both plants and animals within Singapore. In particular, the paper extracted the “*plant*

shape” attribute of the individual tree species where available in order to guide the eventual modelling process.



Fig. 6 – NParks tree database while extensive only georeferences trees which are actively managed by the board.

3.3. Airborne LiDAR & Imagery

Airborne LiDAR (ALS) data were collected in April 2014 using an Optech ALTM Pegasus with up to 4 range measurements, including 1st, 2nd, 3rd, and last returns. The data were then processed and saved in a LAS format to a vertical and planimetric accuracy of ±0.15m or better with a minimum of 5 points/m² and pre-classified (Fig. 7). Airborne imagery was obtained using a Leica RCD30 with a 60 megapixel resolution which produced an eventual orthophoto mosaic imagery in TIFF format with a resolution of 10cm with a spatial accuracy of ±0.5m RMSE or better.



Fig. 7 – ALS data is pre-classified, here vegetation is seen in yellow, buildings in orange and the ground in blue.

3.4. Mobile LiDAR

Mobile Airborne LiDAR (MLS) data were collected between Aug 2015 and June 2016 using a Riegl VMX-450 at approximately 40pts/m² at 70m range at a speed of 60km/hr with a measurement rate at minimum of 200,000 points/sec/head (Fig. 8).



Fig. 8 – MLS data of every road in Singapore is available and as a result every tree planted along the roadside has already been scanned.

3.5. CityGML Building Models

LoD1 building models were provided with a height error tolerance of ± 0.5 m and an absolute pointing accuracy of ± 0.5 m. While building footprints were extracted from LoD2 models and used in the data processing processes later.

4. Methodology – Data Preparation

4.1. Selecting Ten Representational Species

Out of the 1000+ species within the NParks database, ten species—representing approximately 34% of the trees in the database (Table 1)—were selected based on several factors including total population count, planting style or a representative species of a particular sub-type. For example, *Archontophoenix alexandrae* while not in the top ten in terms of population, was selected because it was the most widely planted solitary palm in the database.

Similarly, *Syzygium myrtifolium* was selected because it is usually planted as a continuous hedge and thus would allow us to explore a different planting style as opposed to the solitary planted tree.

Table 1 – Ten Selected Species and their relative proportion within the NParks tree database

Species	Type	% of Tree Database
<i>Samanea saman</i>	Tree	7.88
<i>Peltophorum pterocarpum</i>	Tree	5.61
<i>Swietenia macrophylla</i>	Tree	3.75
<i>Hopea odorata</i>	Tree	3.54
<i>Khaya senegalensis</i>	Tree	3.07
<i>Syzygium grande</i>	Tree	2.63
<i>Tabebuia rosea</i>	Tree	2.29
<i>Archontophoenix alexandrae</i>	Palm	2.04
<i>Syzygium myrtifolium</i>	Tree	1.74
<i>Sterculia parviflora</i>	Tree	1.44
Total		33.82

4.2. Measurement Data Extraction from MLS

MLS data was extracted for roads whereby the selected species were planted along the center divider because they were scanned from both sides and would form a more complete data capture as compared to trees on the side of roads. Identified trees were manually extracted from the MLS scan using PointCloudScene (version 20180314) [39] and then digitally measured using CloudCompare (version 2.10.alpha) [40] (Fig. 9).

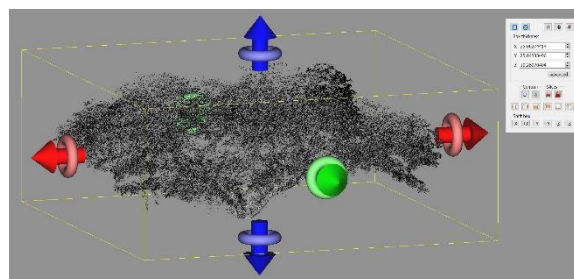


Fig. 9 – Trees were digitally measured using CloudCompare's Cross Section tool

These measurements include, total height of tree, height of crown (from main bifurcation, if visible, to top of crown),

Table 2 – Measurements carried out for the ten selected species. SD denotes standard deviation.

Species	n	Stats	Height	Trunk Height	Crown Height	Crown Diameter	Trunk Girth
<i>Acrhontophoenix alexandra</i>	66	Mean	8.92	5.85	3.48	4.11	0.72
		Median	9.68	5.89	3.63	4.31	0.72
		SD	2.67	2.32	0.87	0.89	0.29
<i>Hopea Odorata</i>	97	Mean	11.47	3.02	8.44	8.64	1.00
		Median	11.24	2.56	8.16	8.91	0.96
		SD	4.09	1.21	3.29	3.02	0.37
<i>Khaya senegalensis</i>	102	Mean	25.10	3.87	21.31	19.38	3.09
		Median	24.65	3.60	21.05	18.70	3.05
		SD	4.73	1.48	4.52	4.96	0.86
<i>Peltophorum pterocarpum</i>	178	Mean	12.39	2.85	9.55	12.43	1.48
		Median	12.28	2.72	9.41	12.27	1.45
		SD	1.84	1.02	1.95	2.16	0.38
<i>Samanea saman</i>	232	Mean	10.39	2.21	8.20	16.02	1.95
		Median	10.10	2.11	8.01	15.17	1.77
		SD	1.55	0.74	1.72	4.13	0.70
<i>Sterculia parviflora</i>	41	Mean	13.02	4.04	8.99	7.53	0.99
		Median	12.70	3.55	9.23	7.47	0.90
		SD	3.04	1.52	2.37	1.64	0.42
<i>Switenia macrophylla</i>	309	Mean	14.12	3.11	11.04	11.50	1.49
		Median	14.20	2.97	11.00	11.28	1.46
		SD	2.19	0.93	2.24	3.83	0.34
<i>Syzygium grande</i>	106	Mean	15.66	4.04	11.64	10.50	1.57
		Median	15.49	3.93	11.86	10.46	1.58
		SD	2.27	1.70	2.51	1.87	0.35
<i>Syzygium myrtifolium</i>	120	Mean	8.33	1.17	7.10	4.27	0.61
		Median	7.55	1.10	6.15	4.15	0.59
		SD	2.85	0.66	2.85	1.13	0.20
<i>Tabebuia rosea</i>	200	Mean	11.82	3.27	8.65	9.07	1.27
		Median	11.70	2.98	8.57	9.01	1.24
		SD	2.32	1.23	2.52	2.08	0.32
Total	1451						

North-South and East-West measured trunk and crown diameters which were then averaged into a single parameter. In total 1451 trees were measured digitally (Table 2) - with the exception of *Syzygium myrtifolium* which had to be measured in the field due to the proximity in planting with adjacent trees (See Limitations). It should be noted that this process of extracting such parameters from MLS data is currently being automated by other members of the team.

4.3. Derivation of Allometric Equation

We derived two sets of allometric equations using the power law model ($Y = aX^b$), which X and Y are tree attributes of

interest, while a and b are constants) to describe the statistical relationships between tree attributes [41,42]. One set predicts tree height, crown height, and average crown diameter using trunk girth as input for trees within the NParks database. These equations were fitted through the *nls* function of R package 'stats' (version 3.4.0) and were generated for each of the ten selected species (Table 3).

In addition, data from seven tree species were combined to derive a generalised allometric equation of tree attributes for Singapore's urban trees. The three excluded species are *Acrhontophoenix alexandra*, *Syzygium myrtifolium* and *Samanea saman*.

The first two was excluded because their forms are not comparable to the rest of the urban trees. The former is a palm, and the latter is usually pruned or maintained as hedges. *Samanea saman* was excluded to improve model fit of the power law allometric equations, especially for relationships between trunk girth with tree height and crown height. Another set of generalised equation uses tree height to predict other attributes for trees extracted from ALS data (Table 4).

Table 3 – a and b constants of the allometric equations for predicating tree attributes from trunk girth

Species	Tree Height		Crown Height		C. Avg. Dia.	
	a	b	a	b	a	b
<i>Generalised</i>	10.82	0.68	7.77	0.83	8.44	0.72
<i>Hopea odorata</i>	11.65	0.73	8.55	0.80	8.76	0.80
<i>Khaya senegalensis</i>	14.17	0.52	10.72	0.62	9.39	0.65
<i>Peltophorum pterocarpum</i>	10.91	0.34	8.00	0.47	10.36	0.48
<i>Samanea saman</i>	8.83	0.26	6.27	0.42	10.98	0.59
<i>Sterculia parviflora</i>	13.32	0.37	9.16	0.29	7.69	0.34
<i>Switenia macrophylla</i>	11.88	0.44	8.76	0.59	8.38	0.76
<i>Syzygium grande</i>	13.44	0.35	8.97	0.59	8.50	0.48
<i>Tabebuia rosea</i>	10.66	0.47	7.41	0.68	7.79	0.67
<i>Acrhontophoeni x alexandra</i>	13.09	1.01	4.31	0.54	5.29	0.65
<i>Syzygium myrtifolium</i>	9.05	0.37	7.73	0.48	5.51	0.32

Table 4 – a and b constants of the generalized allometric equation for predicating tree attributes from tree height

Species	Tree Height		Crown Height		C. Avg. Dia.	
	a	b	a	b	a	b
<i>Generalised</i>	0.07	1.18	0.5	1.16	1.05	0.9

4.4. Extracting Trees from ALS

As previously explained, NParks tree database does not reference every single tree in Singapore. As such to locate trees outside of the board’s purview as well as those within natural areas, one possible method is the identification and extraction of vegetative material from ALS data [43]. In

our paper, the pre-classified point cloud data was used to generate a canopy height model (CHM) of 0.5m resolution. However, the classification of the airborne LiDAR data exhibited errors which resulted in multiple points especially around building facades which were incorrectly classified (See Limitations) as well as vegetation points which were not classified correctly or gaps in the data resulting in pits in the data. As an intermediate solution, the LOD2 building footprints were buffered and used as a mask to remove errors along building facades, any points above 70m in height were removed (the tallest known tree in Singapore is reported to be 60m [44]) and pits were interpolated [45,46] in order to minimise errors (Fig. 10) during the detection process.

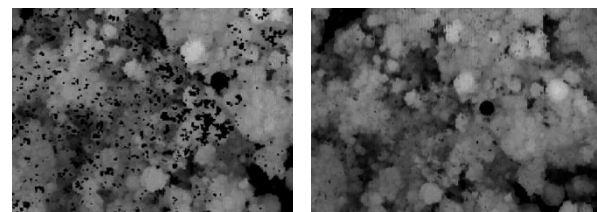


Fig. 10 – Several post processing steps were taken in an attempt to reduce the presence of pits within the extracted CHM

A tree detection algorithm was then applied to find individual trees of at least 5 m tall from the smoothed CHM by identifying local height maxima within a specific-sized fixed square window [47]. We used smoothing and tree-finding fixed square window size of 9 and 5 pixels respectively after a visual inspection of the output indicated a balance between not over-detecting multiple points in a single tree crown while not excluding the smaller-crowned trees. The algorithms were implemented through the *CHMsmoothing* and *FindTreesCHM* of the R package *rLiDAR* (version 0.1.1) [48]. It should be noted that the extraction methodology used is currently a temporary placeholder while other team members work on a better means of extraction.

4.5. Classifying Extracted Tree Points

From this initial extraction, a series of subtractions were made based by removing points which coincided with known trees within the NParks tree database as well as removing points manually which were found to be wrongly extracted (Fig. 11). This resulted in 2 sets of data, one of already referenced trees from the database, and another from unknown trees extracted purely from ALS data. These two are then further delineated into trees within the NParks database which fall within the 10 identified species and those that do not, as well as trees outside the NParks database which are then further classified as solitary vegetation and plant cover (Fig. 12).

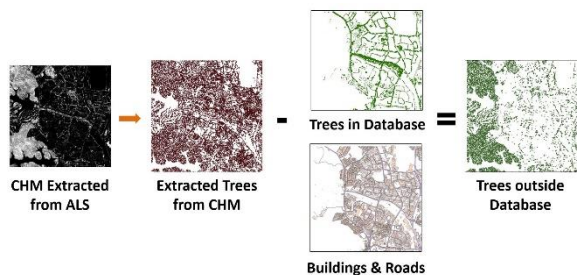


Fig. 11 – Extracted tree positions were cross referenced against those from the database as well as building and road outlines to produce a map of the remaining non-georeferenced trees.

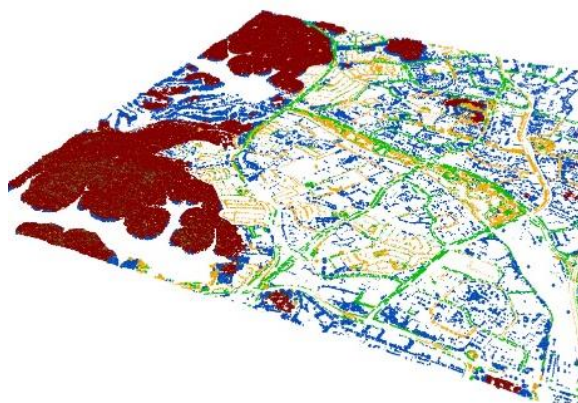


Fig. 12 – The eventual tree locations were classified into 4 categories – 10 identified species (green), other species within the NParks database (yellow), solitary trees outside the database (blue) and plant cover outside the database (red)

In this case, the Point Density tool in ArcGIS (version 10.3.1) was used to generate a 5m resolution raster from which points falling within cells of >4000 trees within a 100m radius were classified as plant cover. The purpose of this classification is to enable the parametric modelling process to be based on the best available data of that particular identified tree.

5. Methodology – Modelling Process

5.1. Seven Shape Typologies

Instead of using the same 3D tree model to represent all the trees in the city, we then categorised all of the species in the database into 7 main shape typologies based on extractions from the FFW data. 6 of these shapes are then modelled using an extruded pentagon whose vertices are manipulated to give the impression of the respective shape typology while keeping the polygon count as low as possible (Fig. 13).

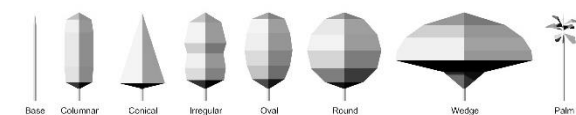


Fig. 13 – 6 Shape Typologies were modelled based off an extruded pentagon. The palm in this case had to be modelled differently with fronds at the top of the extruded pentagon.

5.2. Parametric Modelling

The script to generate the parametric models was created using Rhinoceros and Grasshopper [49,50] (Fig. 14). The script takes in a comma separated file (CSV) and generates a 3D Wavefront OBJ file along with a respective material file. In instances where by the trees fall within the NParks database, information such as the identity, coordinates, girth, species and shape

information were used as inputs and the model was parametrically generated based on the developed allometric equations. The identified ten species in particular were each allocated a unique equation which governs the form of these species based on their documented girths (Fig. 15). Other species were modelled using the generalized equation and adjusted for their respective shape typology.

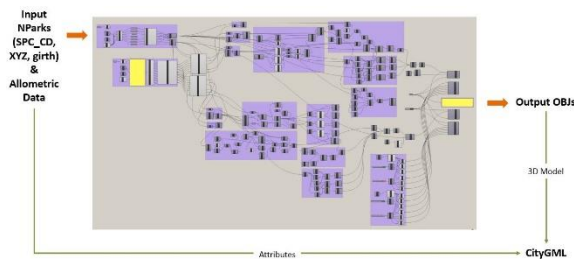


Fig. 14 – The Grasshopper script extracts identity, species, coordinate and girth information and parametrically models the trees with an OBJ as the eventual output. This OBJ file is then combined with the original attributes to form a CityGML model.

Tree locations which fell outside of the known tree database were put through the same script, but in this case the generalised allometric equation was reversed and a model of a random shape was generated based on tree height as opposed to girth. These were then segregated into plant cover and solitary vegetation classes based on the density filter described above. Randomisation in the algorithms ensures that no two trees would ever look exactly identical to improve the visualisation quality.

The resultant models are visually seamless in that there is no visual distinction between the different classifications (Fig. 16) although semantically this would be identifiable once we embed the respective information into the models by converting them into the CityGML format.

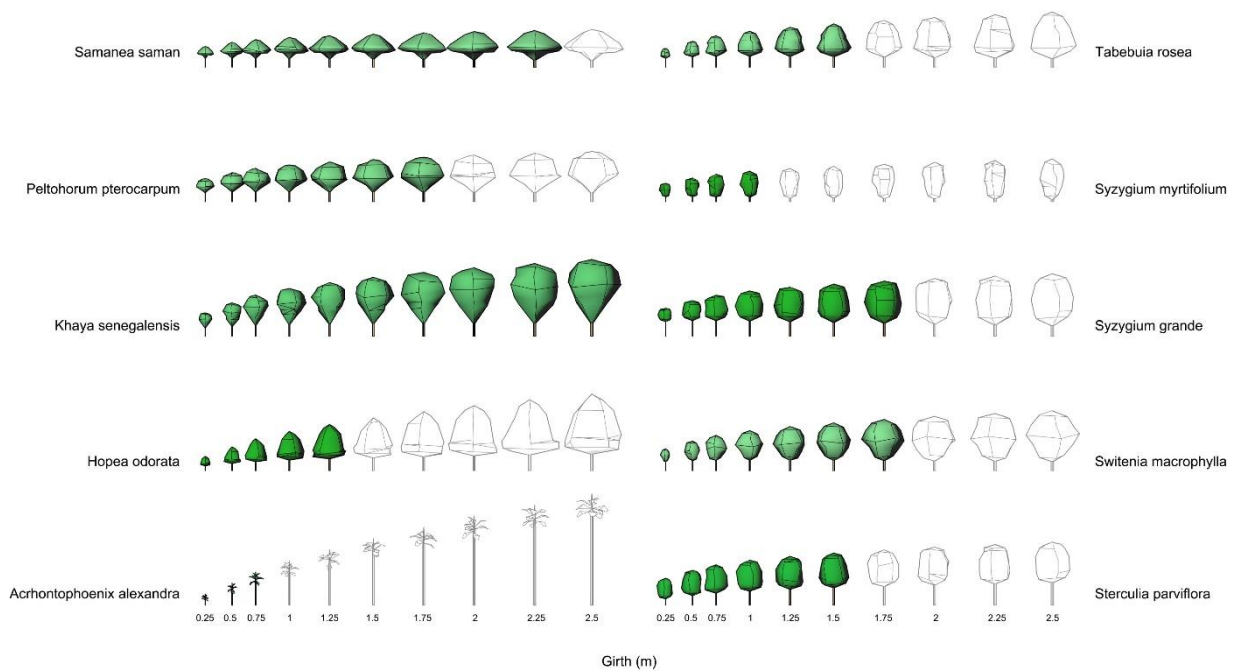


Fig. 15 – The 10 identified species each have their own allometric equations which govern their form based on a given girth size. Greyed out models indicate girth sizes which are larger than the average.



Fig. 16 – An overview of the 25km² test site including a total of more than 80,000 parametrically modeled trees.



Fig. 17 – The CityGML tree models developed have the potential to include useful semantic. Shown here are the creation date, species, trunk diameter and identity of the tree in question although more information can be included should it be readily available.

5.3. OBJ to CityGML Conversion

CityGML is required to store semantic information which the OBJ format does not allow for. Hence, a conversion tool was developed to combine the generated OBJ models with the respective semantic information from the NParks. The conversion tool was written on Python

(version 2.7), by extending libraries that had previously been developed but catered specifically for the vegetation theme. The eventual CityGML tree models will not only be geometrically representative but also be embedded with the semantic information (Fig. 17) allowing for the possibilities to include these models in city-scale analysis and simulations that require a semantically

rich 3D environment with models all of the essential elements of a city, including trees.

6. Limitations

6.1. Classification Errors in ALS Data

Classification errors and gaps in the scan lines from the ALS data result either in misidentified or overestimated tree positions. While some of these might be able to be corrected by reprocessing the data (Fig. 18) it is anticipated that manual corrections still need to be performed to single out anomalies within the extracted tree locations. Solutions to this issue is currently being explored by other members of the team who intend to use satellite imagery to supplement the extraction process.

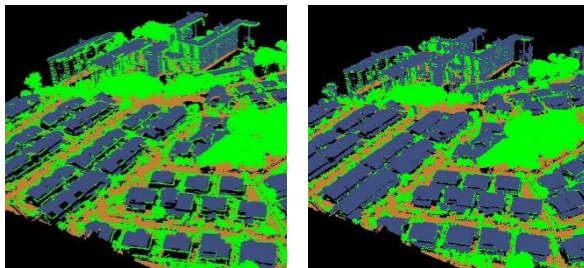


Fig. 18 – It is possible to reclassify the data in an attempt to resolve some of the errors especially around building facades and roofs, however this does not completely eliminate the problem.

6.2. Data Alignment Issues

As expected, there are alignment issues between the different data sources. One of which is positional errors when comparing NParks tree database locations with those extracted from ALS. The likely cause of this

error lies in the instrumental errors used in the geo-tagging of the trees during field operations. Again the team is working on ways to minimise these errors using MLS data to correct the roadside trees.

6.3. MLS Measurement Issues

While the initial intention of digitally measuring trees in the center divider was such that they would be scanned from both sides, problems arose when the scans were sometimes misaligned or noisy resulting in difficulties in deciding which scan line to take as reference. In addition, *Syzygium myrtifolium* had to be manually measured simply because the trees were planted too closely together making it impossible to measure them digitally (Fig. 19). This will likely be an issue moving ahead when we attempt to measure other species in similarly densely planted arrangements.

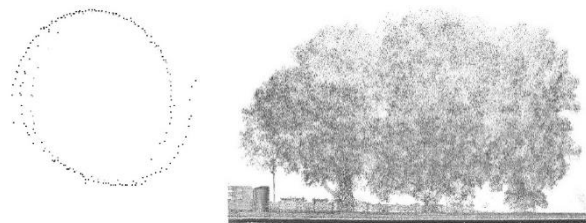


Fig. 19 – Scans from both sides of the road misaligned (left) while densely planted trees are impossible to differentiate between one another (right).

6.4. Only Ten Species Measured

Due to constraints of time, the project decided to focus on ten species only and models the rest using a generic allometric

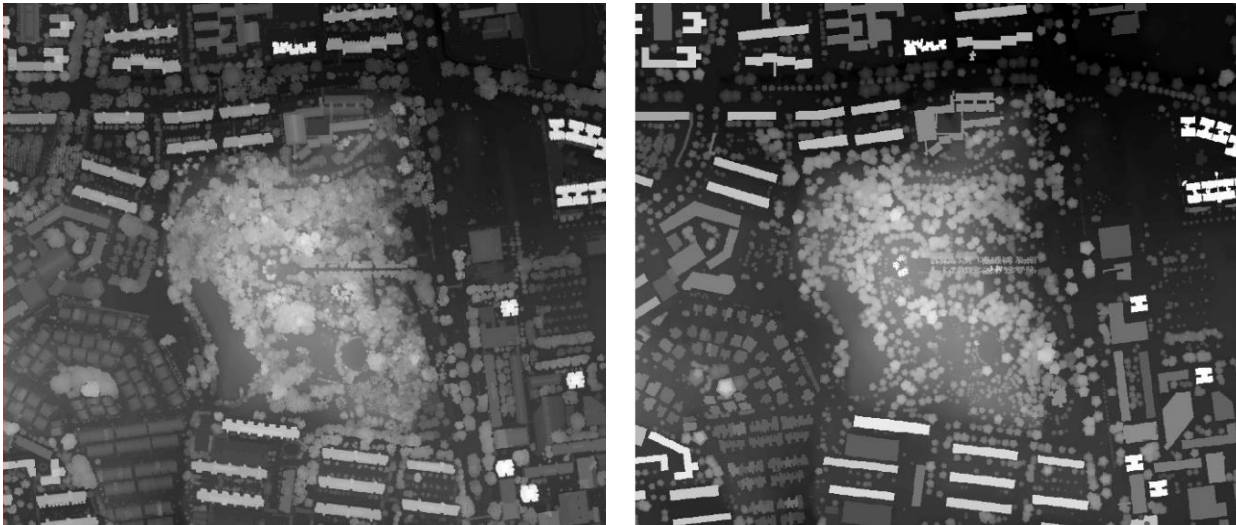


Fig. 21 – While generally similar, the crown sizes tend to be underestimated in the synthetic DSM (right) as opposed to the original extracted DSM from ALS data (left)

equation derived from data of these ten species. However, there are instances whereby this method fails, for example girths of *Ficus barteri* and *Ficus macrophylla* are recorded to be more than 10m. Using the generalised algorithms these result in trees with impossibly large crown (Fig. 20). While this is an exceptional case, the fact is that every species should have its own allometric equation in order to better model them. Likewise, trees within the forest are known to grow differently from their urban counterparts [51] which are particularly managed resulting in artificially governed growth rates.



Fig. 20 – Unusually large trees as a result of elevated girth measurements of certain species.

6.5. Synthetic versus Actual DSM

Finally, as a test of how accurate the generated models are, we generated synthetic digital surface models (DSM) of the virtual landscape using *Point Cloud Components* [52] in an attempt to compare them to the DSM derived from ALS data (Fig. 21). From visual inspection, it can be noted that the virtual trees typically have a smaller crown size than their real life cousins resulting in a smaller overall canopy coverage. We hypothesise that this might be due to measurement of samples which were planted in the road center divider as opposed to those along the sides of the roads or in parks. Trees along the center divider tend to be more heavily pruned resulting in artificially smaller crowns. If this difference in pruning is significant enough, the parametrically generated tree models would likely exhibit a similarly reduced crown size. More work will be needed to decide how to resolve this issue.





LoD0	LoD1	LoD2	LoD3	LoD4
 X (Top Down View)				NA
2D position of the tree (foot print not required)	Simplistic shape (cube or icosphere) for trees	Fan shaped representations, or volumetric shaped models for respective tree shapes	Modelling of trees to be similar shape to real life tree (useful for heritage trees)	Not meaningful to have more detailed representation for a city level

Fig. 23 – Decisions have to be made about the varying LoDs and how best to model them.

7. Conclusion

The paper has demonstrated a methodology and developed tools with the potential to populate large scale city models with virtual trees. There are no doubt limitations but it is impossible to obtain accurate data on every single species let alone every single tree in any city in the world, Singapore included. As such the approach of using the best available data for the different categories of virtual trees allows for the modelling work to proceed while leaving an avenue for improvement should more species be measured or if improved data sources could be obtained from future remote data acquisition campaigns.

8. Future Work

The project team as a whole will continue to improve on methodology and tools developed from areas of data extraction all the way to eventual semantics and models. This includes improved identification of tree crowns from combining CHM and satellite imagery, correction of known tree coordinates, improving the current LoD2 models (Fig. 22), automated extraction of tree parameters, the building of a more advanced tree library and the development of LoD3 trees amongst other things in order to generate biologically, spatially and

semantically representative 3D trees for Virtual Singapore at the various LoDs (Fig. 23).



Fig. 22 – To add even more realism, the same LoD2 models developed in this paper can be further textured.

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The Time-oriented Impact of Sunlight Shading on Landscape Design Elements in Atrium Buildings

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Abstract

Due to the difference in the shape of a building's structure proportion, the layout for a common atrium building affects the scope of the sun's shadow, sunshine duration all year round in the atrium space, and the design achievements of landscape elements from pavement and planting (trees, bushes, and grassland). Utilizing the atrium buildings at National Tsing Hua University as an example, this research discusses the effect of microclimate on landscape design element. First, simulate the position and height of the building structure. Second, numeric calculation software was applied to accumulate the scope of the sun's shadow and sunshine duration all year round. According to the research findings, the RSH (relative sunshine hours, %) values of each measuring point, it is found that the minimal and maximal RSH values on equinoxes are respectively 0% and 75%, the minimal and maximal RSH (%) values on summer solstice are respectively 0% and 81%, and the minimal and maximal RSH (%) values on winter solstice are respectively 0% and 86%. When considering what kinds of shade plants should be chosen, the conditions for the "crown layer" to receive sunshine are considered by the EVSH (equivalent vertical sunshine hours) curve distribution profile of seasons. It is therefore suggested if apply a symmetric and geometric pattern landscape design to an atrium building and conduct an appropriate planting layout plan should after sun shadow analysis to meet the plant's growth demand. So as to create an ecological multi-layered green environment where plants and people can achieve mutualism.

Keywords: building shadow ;RSH (relative sunshine hours, %);EVSH(equivalent vertical sunshine hours) curve; planting design

1. Introduction

The lack of sufficient sun exposure slows the rate of photosynthesis and the production of chlorophyll in ground plants. Long-term deprivation of sufficient light exposure will result in unhealthy plants and unfavorable conditions for the differentiation of flower buds and the development of fruit that influence ornamental quality and the greening effect, but few studies have addressed the location and growth condition

of trees subject to the shading effect from nearby buildings. The intensity and duration of sunlight varies significantly under different conditions, such as latitude, season, region, and even the geographic location. In response to the above characteristics of sunlight, plants control their internode length, leaf size, count, and the density of their chloroplasts. Plants also determine the optimum timing for flowering and other physiological processes (Levitt, 1980; Boardman, 1977) from those characteristics of sunlight.

By taking the open space enclosed by Buildings on the campus of Tsinghua University as the example (see Figure 1.), uses computer simulation technology to analyse the changes of sunshine shade of surrounding buildings in different seasons, in order to discuss the effect of microclimate on landscape design elements. This research uses RSH (%) value and profile EVSH distribution of seasons to consider the conditions of trees, shrubs, and grasslands at different heights receiving sunshine, which can help landscape designers to create abundant and various ecological environments through visual intuitive judgment.

2. Research Method

2.1. Definition of terms

1. RSH (%): RSH refers to the ratio of the sunshine hours of one measuring point being shaded by the building in the research scope and the duration of possible sunshine hours not being shaded by the building in the open space.

$RSH (\%) = \text{sunshine hours} / \text{duration of possible sunshine}$

The duration of possible sunshine for equinoxes, summer solstice, and winter solstice in Hsinchu, Taiwan (120°59'E, 24°47'N), which is used to respectively calculate RSH, as below:

- (1) duration of possible sunshine for equinoxes = 12hr
- (2) duration of possible sunshine for summer solstice = 13.6hr

- (3) duration of possible sunshine for winter solstice = 10.5hr
2. The equivalent vertical sunshine hours (EVSH) curve: according to the definition of this research, EVSH refers to the curve drawn by gradually gaining the sunshine hours of the building at different heights, and then, connecting the points with the same RSH in order.

2.2. Research scope and subject

This research is conducted on the campus of Tsinghua University. The atrium in the east is defined by the Auditorium (2F) and General Building I (3F); the atrium in the west is enclosed by General Building II (8F) and General Building III (8F); the street trees are planted in rows between the 2 areas. The 5 green areas of A, B, C, D, and E are divided within the scope of the site (see Figure 2.) to calculate and compare the RSH of the plants and review the afforested areas to be used as the principle of the measuring points.

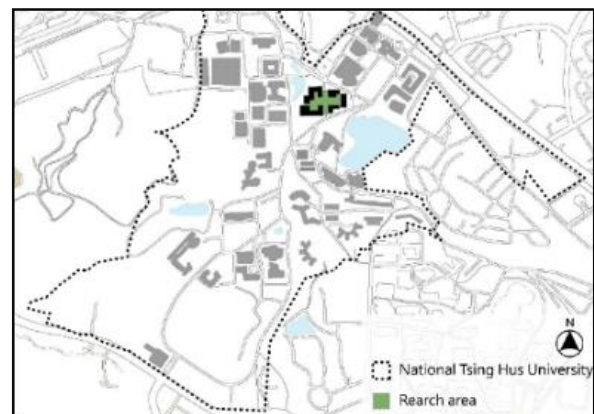


Figure 1. Site environment in the research scope

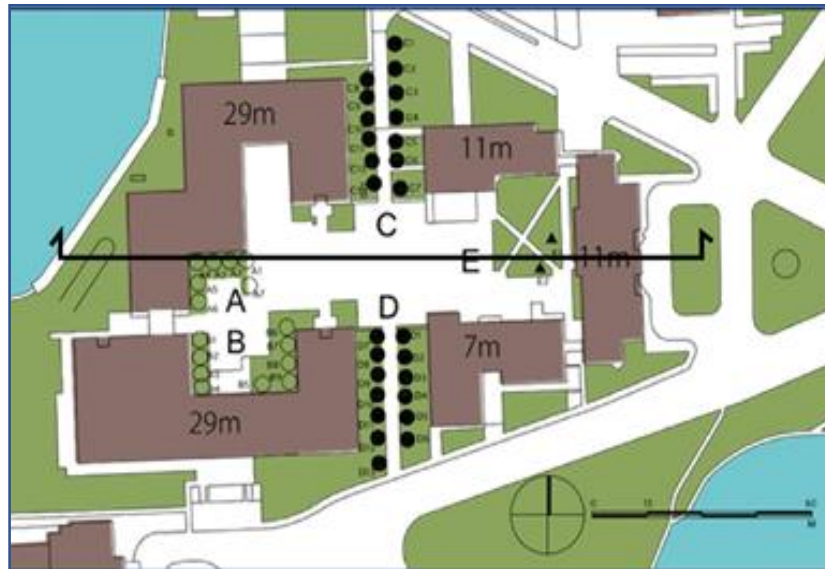


Figure2. Diagram for area division and position of measuring points

● : *Melaleuca leucadendra* Linn. ○ : *Terminalia mantalyi* H. Perrier. ▲ : *Araucaria excelsa* (Lamb) R. Br.

2.3. Simulation and analysis

1. Simulation shadow maps are overlapped to calculate SH (hr)

First, software is used to make a 3D model of building volume, the time period is from sunrise to sunset, and the time interval is hours, in order to simulate the shadow maps of equinoxes, summer solstice, and winter solstice. Then, 13, 15, and 11 shadow maps for equinoxes, summer solstice, and winter solstice are generated, respectively. Finally, software is applied to overlap the shadow maps to calculate SH (hr).

2. RSH (%) is calculated and drawn in the plane graph

Secondly, SH (hr) is simulated for each season, which is used to gain the

RSH (%) and 5 numerical intervals of 0~20%, 20~40%, 40~60%, 60~80%, and 80~100%, which are used to draw the RSH distribution diagram.

3. EVSH (Equivalent Vertical Sunshine Duration Curve) curve was drawn in a profile map of the atrium

The RSH at different heights is gained gradually, and the points with the same sunshine hours on the profile map are connected to draw EVSH for the convenience of judgment and analyzing the shading condition of plants in different seasons (spring, summer, autumn, and winter), as well as reviewing the suitability of plant (trees, shrubs, and grasslands) growth at different heights.

3. RSH (%) distribution in the whole area all year round

3.1. RSH (%) distribution of each area on the ground floor

1. Equinoxes: according to the RSH (%) distribution diagram for equinoxes in Figure 3, it can be known that building shading in Area B is the most serious, thus, the trees in this area may have the phenomenon of excessive growth, while the shrubs and grasslands may have the phenomenon of poor growth or withering; followed by Areas A, C and D; in Area E, the surrounding area is lower, thus, its RSH is relatively higher and the plants grow well.
2. Summer solstice: according to the RSH (%) distribution diagram for summer solstice in Figure 4, Area B remains the area where the RSH value is lower (0%~40%), the plants in Area A have the opportunity to gain appropriate sunshine, and some plants in Areas C and D are shaded by the building, thus, the plants planted in rows easily have the situation of uneven growth and

poor growth. On the whole, the shading status in the area close to Area B is more serious than Areas A and E.

3. Winter solstice: according to the RSH (%) distribution diagram for winter solstice in Figure 5, the RSH value is seriously insufficient in Areas A and B (less than 20%), which is mainly caused by the northbound courtyard space enclosed by building 8F, thus, the plants in this area grow poorly. On the whole, more than 50% of the area throughout the whole area in winter has insufficient RSH (RSH is less than 40%).

As shown in the 3 RSH distribution diagrams, the RSH values in many blocks on the site do not experience progressive increases or decreases with the change of seasons due to the effect of the shade of high-rise buildings, meaning the RSH values in some areas are insufficient all year round. Thus, in terms of the growth status of plants in this area, the trees have the phenomenon of excessive growth, while the shrubs and grasslands have the phenomenon of poor growth or withering.

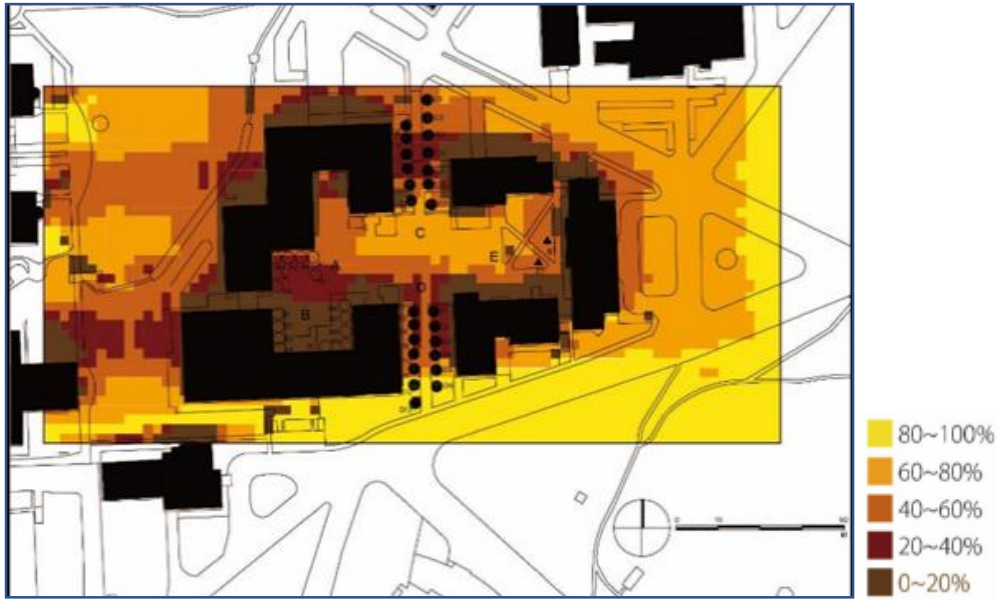


Figure 3. RSH (%) distribution diagram for equinoxes

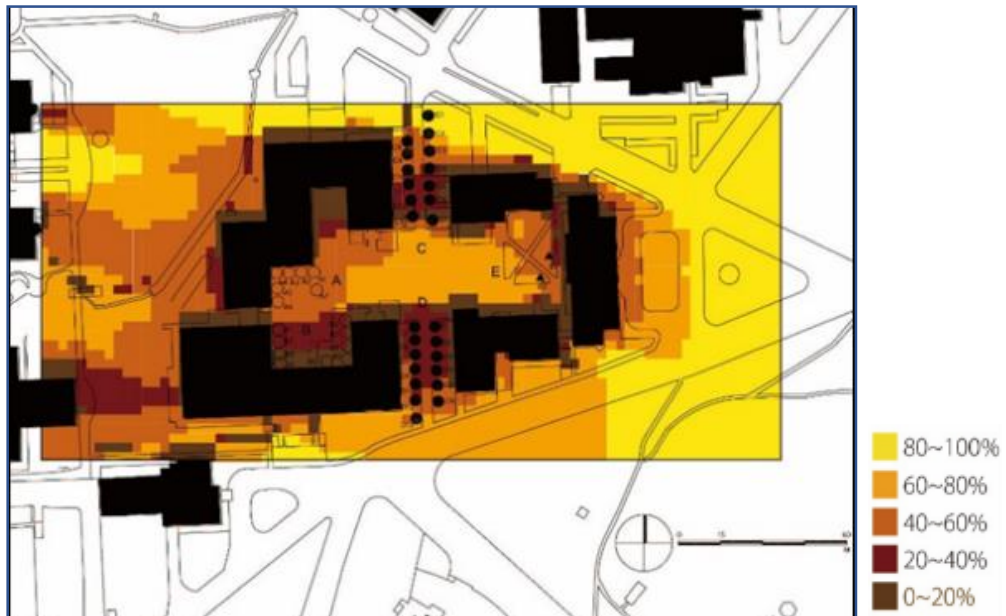


Figure 4. RSH (%) distribution diagram for summer solstice



Figure 5. RSH (%) distribution diagram for winter solstice

3.2. RSH (%) distribution of each measuring point on the ground floor

1. Area A: as shown in Table 1; the RSH (%) values of all the measuring points in the area during winter solstice are 0, and there is almost no direct sunshine reaching the ground floor. On equinoxes, in addition to measuring point A1 having the maximal RSH (42%), the RSH of other measuring points is 20~40%. On summer solstice, the RSH values of all the measuring points have average distribution in the interval of 40~60%.
2. Area B: as shown in Table 2; the RSH (%) values of all the measuring points on winter solstice is 0, and there is almost no direct sunshine. On equinoxes, the RSH

(%) value of all measuring points is also 0. On summer solstice, in addition to measuring point B6, the RSH (%) values of other measuring points are 0~22%. On the whole, the shading of high-rise building causes a serious shortage of sunshine in the whole area, thus, the growth status of plants in this area is not ideal.

3. Area C: as shown in Table 3; the RSH (%) value on winter solstice is 38%~47%. On equinoxes, the RSH (%) values have significant change in luminous environment, ranging from the minimal RSH (25%) of measuring point C5 to the maximal RSH (75%) of measuring point C7. On summer solstice, there is also a significant change in RSH (%), ranging from minimal RSH (22%) of measuring point C6 to maximal RSH (85%) of measuring point C1. On the whole, there is a great gap in the luminous

environment of *Melaleuca leucadendra* “planted in rows” in the area. While the effect of luminous environment on winter solstice is even, there is a great difference in luminous environments on equinoxes and summer solstice in the whole area.

4. Area D: as shown in Table 4; the RSH (%) on winter solstice is 38%~86%, which shows significant difference in RSH. On equinoxes, the RSH (%) value has a significant change in luminous environment, ranging from the minimal RSH (25%) of measuring point D5 to the maximal RSH (75%) of measuring point D7. The RSH (%) on summer solstice is

37%~66%. On the whole, there is a great gap in the luminous environment of *Melaleuca leucadendra* “planted in rows” in the area; however, as its luminous environment is similar on summer solstice due to the layout, there is great difference in luminous environments on equinoxes and winter solstice.

5. Area E: as shown in Table 5; the RSH (%) values on winter solstice, equinoxes, and summer solstice are 47%, 50%, and 44%~59%, respectively. On the whole, as the surrounding buildings in this area are lower, its sunshine duration is even.

Table 1. The RSH of measuring point simulating *Terminaliamantalyi* (H. Perrier.) in Area A

zone A		RSH (%)						
Cord.	A1	A2	A3	A4	A5	A6	A7	
Vernal/ autumnal	42	33	33	33	25	25	25	
summer	51	51	44	44	44	44	58	
winter	0	0	0	0	0	0	0	

Table 2. The RSH of measuring point simulating *Terminaliamantalyi* (H. Perrier.) in Area B

zone B		RSH (%)								
Cord.	B1	B2	B3	B4	B5	B6	B7	B8	B9	
Vernal/ autumnal	0	0	0	0	0	0	0	0	0	
summer	22	22	14	0	0	66	22	22	0	
winter	0	0	0	0	0	0	0	0	0	

Table 3. The RSH of measuring point simulating *Melaleuca leucadendra* (Linn.) in Area C

zone C		RSH (%)											
Cord.	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13
Vernal/ autumnal	58	50	33	33	25	50	75	58	33	33	33	41	50
summer	81	73	73	44	36	22	59	59	59	58	44	36	36
winter	38	38	38	38	47	47	47	38	38	38	47	47	47

Table 4. The RSH of measuring point simulating *Melaleuca leucadendra* (Linn.) in Area D

zone D		RSH (%)											
Cord.	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13
Vernal/ autumnal	58	50	25	25	25	42	75	42	25	25	25	42	67
summer	37	37	37	37	37	59	37	37	37	37	37	51	66
winter	38	38	47	67	86	86	38	38	47	47	76	86	86

Table 5. The RSH of measuring point simulating *Araucaria excelsa* ((Lamb) R. Br.) in Area E

zone E		RSH (%)	
Cord.	E1	E2	
Vernal/ autumnal	50	50	
summer	44	59	
winter	47	47	

4. East-west profile EVSH distribution of the seasons

After the sunshine hours and RSH of each measuring point in each area are calculated, the transverse courtyard space between General Building I and General Building III in the research scope is used to draw the profile map to discuss the difference in RSH at different heights all year round, in order to gain the effect of the distance of the adjacent

buildings on sunshine for plants; the sunshine distribution diagrams on equinoxes, summer solstice, and winter solstice are used to review the differences in the luminous environments of each measuring point, as well as the suitability of plant (trees, shrubs, and grasslands) growth at different heights. They are further analyzed, as below:

1. Equinoxes: as shown in Figure 6; the RSH values of the areas with a height of below 15m in Area A is 20~40%, and the RSH of some areas with a height of below 5m is 0~20%. As seen, the growth conditions for shrubs and grasslands is not ideal.
2. Summer solstice: as shown in Figure 7; the RSH value of some areas in Area A is 80~100%; however, the RSH of some areas with a height of below 20m remains at 0~40%.
3. Winter solstice: as shown in Figure 8; it can be seen from the profile map that the RSH value in Area A is relatively low, as it is affected by the shade of 8F buildings: the RSH value of the areas with a height of below 10m is 0~20%, and the RSH value of the areas with a height of below 20m is 20~40%, thus, it is detrimental to the growth of trees.

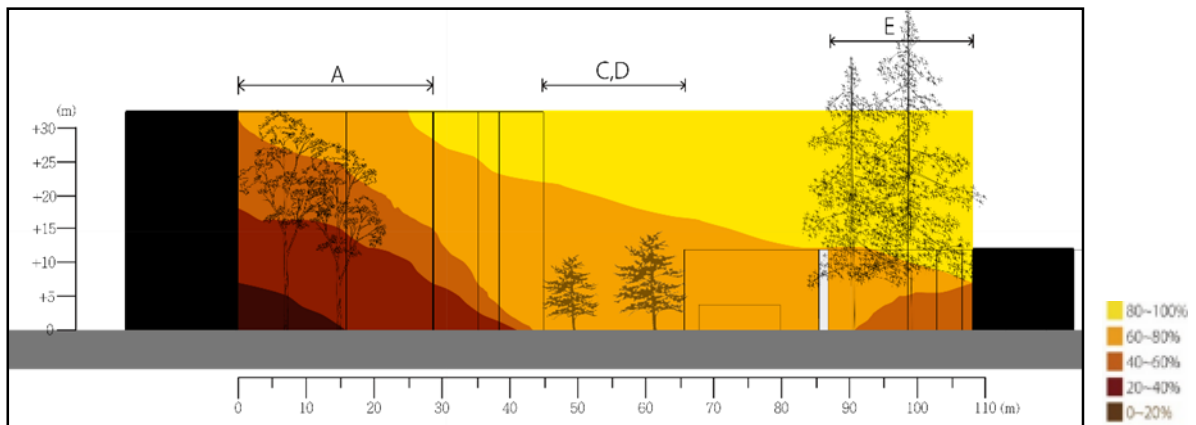


Figure 6. RSH (%) distribution diagram of east-west profile on equinoxes

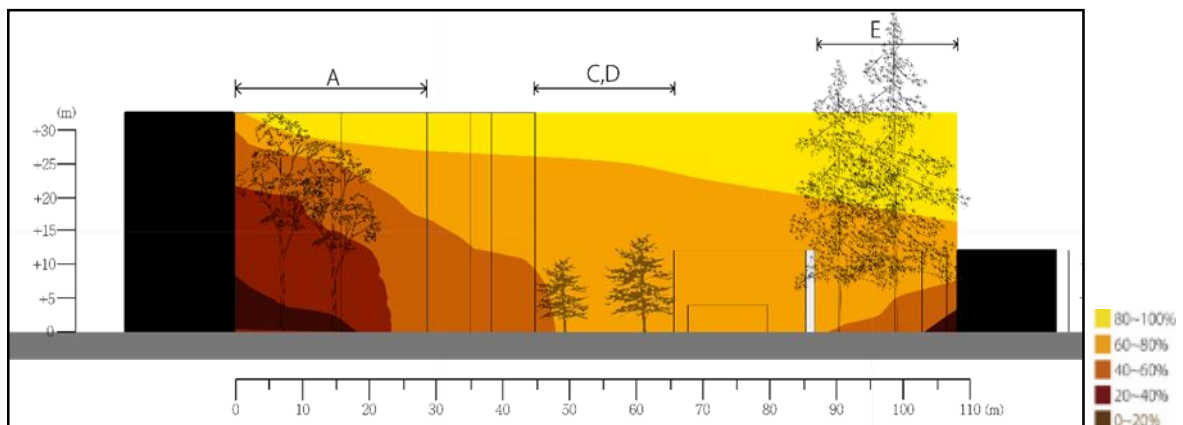


Figure 7. RSH (%) distribution diagram of east-west profile on summer solstice

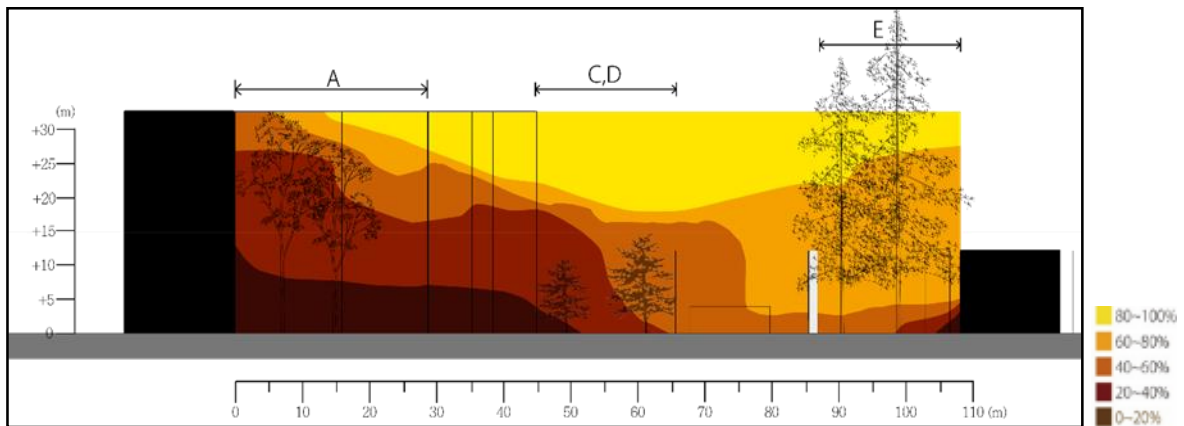


Figure 8. RSH (%) distribution diagram of east-west profile on winter solstice

5. Conclusion and Suggestions

this research has reached the following conclusions:

5.1. There is great difference in RSH (%) values for the same tree variety in different measuring points all year round.

According to the RSH (%) value of each measuring point, it is found that the minimal and maximal RSH (%) values on equinoxes are respectively 0% and 75%, the minimal and maximal RSH (%) values on summer solstice are respectively 0% and 81%, and the minimal and maximal RSH (%) values on winter solstice are respectively 0% and 86%. Therefore, the luminous environments for the same tree variety are significantly different in this site.

5.2. People should consider suitable planting distances near adjacent building in the atrium.

There is a great difference in RSH (%) values in the measuring points of *Terminaliamantalyi* for Area A and Area B. Thus, the plants in these areas have the phenomena of the poor growth and “excessive growth”. When considering what kinds of shade plants should be chosen, the conditions for the “crown layer” to receive sunshine are considered by the EVSH distribution profile of seasons (equinoxes is less than 40%), meaning the RSH (%) values of trees that have a height of 15m and are within 15m from the adjacent 8F building.

5.3. People should consider plants suitable for luminous environments at different heights to realize the layout of multi-layer plants (trees, shrubs, and grasslands).

According to the greening index of a green building, the main aim is to realize multi-layer planting. The profile EVSH distribution of seasons is used to consider the conditions of trees, shrubs and grasslands, and their ability to receive sunshine at different heights, which can help landscape designers to create abundant and various ecological

environments through visual intuitive judgment.

5.4. People should consider the differences in luminous environments in the atrium from different directions to lay out landscape design elements.

The shade distributions of atrium buildings from different directions are quite different. The symmetric or geometric design is obviously not suitable for living plants, thus, it is suggested to refer to sunshine conditions to design soft and hard pavement areas, in order to reduce maintenance and management costs. Moreover, the visual intuitive judgment of the EVSH distribution of seasons can briefly present which areas have the phenomena of being too hot in summer (RSH80% or above) or shading time is too long in winter (RSH 20% or below). This method can address plants in atrium buildings with insufficient sunshine, meaning their poor growth can be improved. In addition, the seating layout and people's degree of comfort can be further reviewed, in order to provide a more comfortable environment for activities in the courtyard space and create a landscape environment where mutualism between humans and plants can be achieved.

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Urban Informatics on Thermal Imaging and Urban Landscape with Next Generation Vigilantes

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Abstract

Growing trend of urbanisation imposes challenges on the foundation of sustainability in the urban landscape. As a monitoring or surveillance mechanism, integration of urban informatics or big data mining into functions of a smart city is an essential, predominant tool for successful continuous enforcement of sustainability. Since traditional manual and automatic monitoring mechanisms are respectively lethargic and accelerated capital cost is required, a smartphone app which extracts and analyses such information shared by the urban population as a participatory tool is proposed in this research. The app will be sanctioned for big data mining of unsustainable development, malpractices and inefficiencies, and monitoring Urban Heat Island effect (UHI). Survey research was conducted to understand the perception of urban population on the importance of sustainability and to understand their intention to participate in information sharing via smartphone application and social media. Majority of the Gen Y respondents were in favour of subscribing to smartphone application as a method for them to actively participate in smart city mechanism to further enforce sustainability in their environment.

Keywords: Urbanisation; Gen Y; Surveillance; Urban Heat Island; Urban Informatics; Big Data Mining; Social Media

1. Introduction

Since the dawn of industrial revolution in late nineteenth and early twentieth century, rural population of MEDCs (more economically developed countries) migrated to urban areas on a quest to secure occupation in industrialised service economies^[1]. However, by early 1950's trend of rural-to-urban migration was shifted to LEDCs (less economically developed countries) where rural population migrated to urban areas with the intention of occupation (80 percent of

global GDP was generated in urban areas^[2]), better quality of life and education. Although urbanisation in MEDCs has declined since mid-twentieth century, with rapid urbanisation and growth of economies in LEDCs (Asia and Africa), 30 percent of the urban population by 1950s is expected to increase at a rapid growth to 60 percent by 2050^[3].

It is further evident from figure 1 (*appendix I*) that between 1950 to 2014, twenty eight megacities have emerged with an overwhelming population of 10 million

concentrated in each confined urban landscape while the majority of urban developments around the world have a population concentration of 1-5 million. However, providing necessary facilities for increasing urban population including dwellings, transportation, educational institutes, recreational spaces etc. results in the inevitable egregious use of urban landscape.

Thus, to meet increasing demand for urban spaces due to the exponential growth of urban population, a rapid decline in sustainable development was often observed which resulted in dire environmental repercussions, especially in the case of LEDCs where policies on sustainable development were not enforced due to miscommunication and corruption^{[4][5]}. To state few examples; (1) modern buildings constructed without adequate approvals in the capital city of Sri Lanka - Colombo collapsed resulting in property damage, and a number of fatalities^[6], and (2) a partially constructed apartment complex which had been already occupied without obtaining occupancy certificate collapsed resulting in over seventy-four fatalities^[7].

The current growth of cities is twice as fast as available urban land area against its population and is expected to reach three times the global urban land area by 2050 based on current urbanisation trends^{[8][9]}. Consequently, a requirement of adequate attention for land and natural resources utilisation towards sustainable development and future is imperative, whereas deficient management of urban expansion would lead to unsustainable consumption patterns, pollution and environmental deterioration. Hence, complying with objective eleven of sustainable development goals presented by

the United Nations, governments should enforce sustainable cities and communities by implementing forward-looking policies^[10].

1.1. Surveillance and Monitoring

Subsequently, for successful implementation of such policies to be enforced sustainable cities and communities should be monitored or surveilled to avoid malpractices in urban landscape management - especially in the context of LEDCs with high corruption rates and inefficiencies in communication channels between community and administration^[11]. Concepts of “smart cities” and ‘e-government’ popularisation in the late 1990s were inevitable being backed by the exponential growth of information technology (IT) to increase efficiency in functions of a city, i.e. integrating operations and services of a city with the aid of computation while disseminating information of these functions to the community^[12]. In addition, while addressing inefficiencies in communication, the concept of “urban informatics” or “big data” was introduced which concentrates on gathering real-time information while providing a detailed spatio-temporal record on implemented functions via ubiquitous computing or ambient intelligence. Such techniques are being embedded in built environments, targeting better productivity and efficiency by reducing the communication gap between community and government administration^{[13][14]}.

1.2. Urban Heat Island Effect

The rapid growth of urbanisation results in an apparent increase in demand for dwellings. In a majority of developing countries (LEDCs)

growing demand for housing is furnished by slums (one-third of the urban population in LEDCs lives in slums or informal dwellings by 2012^[15]) which is occupied by lower or poor income class demographic segment. However, rapid growth in the rural-to-urban migration of lower-middle class and middle-class demographic segment has resulted in an increasing demand for formal housing projects which is often furnished via towering apartments (flats)^[16]. Although these apartments effectively utilise land extent of confined urban areas, environmentally unsustainable structures contribute to the Urban Heat Island (UHI) effect. As further illustrated in figure 2 (*appendix 2*), it is evident that temperature of urban area is greater than that of suburban or rural areas as a result of UHI which would result in increased urban energy demand on air conditioners in buildings^[17]. Although UHI could be mitigated by green roofs, cool roofs and pavements, light exterior structures and facades, reflective light exterior paint with high albedo effect etc.^{[18][19]}, monitoring of UHI is essential before commissioning, and progressive structural changes after commissioning.

In contrast, “big data mining” or “machine learning” is an expensive operation. When considering surveillance and monitoring of ethical practices to enforce sustainable cities and communities, IT infrastructure including server or data farms, sophisticated algorithms and monitoring equipment such as thermal sensors, PPM meters, CCTV etc., imposes a tremendous aggregate cost factor with regard to implementation of such systems, metro or country wide^{[20][21]}. In the case of monitoring UHI, most popular data collection methods are the utilisation of drones with thermal imaging, satellite thermal imaging and surveys with thermal cameras which also

imposes a tremendous aggregate cost factor for continuous data collection^{[22][23]}. In addition, cost of managing such systems including staffing, training, infrastructure etc. would additionally be a tremendous cost. Hence, attention by governments and urban government bodies on such monitoring systems or smart cities as a whole is not significant based on cost factor, especially in the case of LEDCs which is an underlying reason for unpopularity of smart nations concept. Thus, this research suggests that it is essential to develop cost-effective monitoring tools for collection of data on both surveillance and UHI monitoring.

1.3. Next tenants of urban areas

When establishing smart, sustainable cities, it is essential to understand the next social cohort who would dominate in future urban townships and how they would react to the concept of smart cities. Although the majority of current urban dwelling owners belong to Gen X or Baby Boomer cohorts, it is evident that Generation Y (Gen Y - a population that was born after the early 80s) social cohort have currently invested in the urban property market. Research reveals that nearly 70 percent of the Chinese Gen Y cohort have invested in properties while current global average stands at 40 percent. However, pertaining to future trends, global property ownership of Gen Y social cohort is expected to be at 83 percent within the next five years^[24]. Urbanisation by Gen Y in most parts of the world is inevitable by means of rental, inheritance or living with their parents – European countries being the exception where it is expected to decline^[25] in terms of investment in outright property ownership by Gen Y.

1.4. Gen Y and Sustainability

In contrast to expectations of Gen Y social cohort being negligent, slothful and self-centered, many studies portrayed that Gen Y are more concerned on sustainability than other social cohorts. Being born in the early 80s, when environmental movements have reached maximum potential, it is evident that Gen Y was inspired and ready to grasp future sustainable challenges especially in the case of environmental challenges and climate change. For example, when analysing purchasing behaviour of Gen Y, it is evident that majority are concerned about the impact on sustainability such as emissions, carbon footprint, water footprint, life cycle cost of the product, fair trade and ethical practices of producer, child labour etc ^[26]. In addition to consumer behaviour, rapid growth in participation for volunteering activities including environmental sustainability programs is observed within the Gen Y community in comparison with other generations ^[27]. Hence, Gen Y's healthy relationship with sustainability and the environment would provide positive opportunities to create smart, sustainable cities.

1.5. Gen Y and Personality traits

Additionally, Gen Y's enthusiasm on sustainability is further fuelled by their firm belief on making a difference in the world (being radical) and their steadfast dedication and collaborative effort to create such grassroot activism (differences), which is also a unique trait of this generation^[28]. Being tech-savvy than other generations is another trait that is unique to Gen Y and certainly another essential trait critical in the integration of urban informatics to smart cities. One crucial aspect of Gen Y driven by being tech savvy and being radical is the intention of sharing articles and photographs

of charities, and other volunteering events on social network pages belonging to Gen Y^[29] individuals, which is an underutilised big data source especially in the case of LEDCs. However, in the Sri Lankan context, two such social network communities are initiated- for traffic violations and consumer rights violations that function to raise awareness which instead would have otherwise been utilised for data mining in administration purposes by government and regulatory bodies. In addition, it was hypothesised that concern on anonymity by Gen Y when sharing information is negligible.

Thus, it is hypothesised in this research that as next generation of urbanisation, Gen Y, would positively contribute to the success of sustainable smart cities backed by their firm belief to make a difference in the world and being a tech-savvy generation which would result in the successful integration of urban informatics functions in smart cities.

1.6. Smartphone application

As an attempt to incorporate Gen Y's eagerness for radical change and sharing sustainable beneficence, a smartphone application (here on out referred to as "the app") is proposed to be developed under this research for data mining in smart cities. This simple-to-operate app which runs on both Android and iOS platforms resembles the appearance of modern social media smartphone apps such as Instagram or SnapChat. User accounts are created which requires ethical disclosure before registration that focuses explicitly on data mining purposes of the app while users are provided with a short video clip to be introduced to functions and objectives of data mining via this app. Upon registration and logging in, users can capture photographs (including selfies) and apply creative filters before

publishing to their social media accounts while the app accesses location data and thermal (infrared) sensors of the built-in camera which is stored in remote servers (cloud) for mapping purposes. Cloud computing is proposed over traditional server farms based on capital cost effectiveness and to eliminate hardware failures.

1.7. Surveillance and Monitoring

Surveillance and monitoring of inefficiency, and unethical and malpractices in smart cities are evaluated by users based on intuition. Situation ranging from an illegal construction to a clogged drain witnessed by users is reported by sharing a photograph of the incident to their social media pages while the app access location data and geotags the shared photograph. Collected information including location data and the complaint along with the photograph is mapped, and a notification is issued to relevant authorities to initiate prompt action. Interactive access is granted for competent authorities to view complaints and respond with required feedback on their assessment of the incident, action to be taken and marked as “resolved” at action completion. Further, the app enables a user to access his/her list of previous complaints and action taken by the relevant authorities whereas, in case of a delay or neglect causing problem persistence, the user is encouraged to share current situation which would generate further notifications to the relevant authority. Thus, inefficiencies in monitoring unsustainable development and operation in smart cities are expected to decline with information generated through the app and the active participation of urban population while efficiently mitigating the capital cost of traditional monitoring methods, especially in the case of LEDCs.

1.8. Thermal Imaging and UHI

In addition, the app utilises Gen Y’s growing trend of self-portraits, i.e. “*selfies*” to analyse and map thermal readings of the urban area. Gen Y is enabled to capture and share selfies with thermal (IR) filter on their social networking pages where the app utilises the thermal sensor of the secondary camera within the smartphone to capture the thermal image of the surrounding environment such as monuments, buildings etc. The captured thermal image is further analysed to understand the thermal reading of the surrounding environment and mapped based on the geotag of the image. A dynamic database is expected with an increase in usage as real-time dynamic thermal reading data of the urban area footprint is updated on the map with the date on a different period of the year, month and day. Such thermal reading of built environment including buildings and monuments is interpreted as heat island effect especially on the vertical axis of the building and collected data could be utilised by city planners and landscape architects to reduce UHI effect in the establishment of smart cities. Capital cost-effectiveness in collecting thermal data on built environment through the app would especially benefit governing bodies of LEDCs. However, secondary camera thermal sensor which is currently utilised for infrared facial recognition is available at the moment on a limited range of smartphones and is expected to be integrated into a majority of smartphones within a few years with the growth of facial recognition. Although external IR add-ons to the camera are available in the market, willingness to purchase by Gen Y is hypothesised as negative in this research.

2. Methodology

2.1. Sampling and Data Collection

The sample of this study consisted of 324 respondents in Gen Y social cohort i.e. who were born after 1980. An open online survey (with 21 questions) was designed to gather data. Sample encapsulates 89 percent from LEDCs and 11 percent from MEDCs. When consider demographics of the sample; (1) gender distribution between female and male is 38 percent and 62 percent respectively, (2) 58 percent of Gen Y are already living in urban areas, and (3) 67 percent of Gen Y are planning to migrate to urban areas over the next 5 years.

2.2. Measures

Since the objective of this research is to understand Gen Y's intention to participate in urban informatics to successfully establish smart cities, respondents were inquired on their "intention to use the app to monitor the sustainability of their living environment". In addition, secondary questions were inquired to understand; (1) users' perception on importance of sustainability, (2) current local government monitoring satisfaction, (3) lodged complaints on environment issues and unsustainable development being neglected, (4) willingness to share information on social media platforms, (5) ethical consideration in sharing information, (6) anonymity in sharing information, (7) number of smartphone users with IR sensors, and (8) willingness to purchase additional IR equipment.

3. Results & Discussion

It was evident from this study that majority of respondents (89 percent) were aware of sustainability and importance of sustainability in the built environment and urban landscape for a better quality of life. However, it is also observed that only 43 percent of respondents were equipped with

the required know-how to convert their lifestyles and living environment into a sustainable lifestyle. 98 percent of respondents were in the view that local administration and government are not efficiently monitoring the sustainability of urban landscape and also mentioned that construction activities and landfills for future developments are conducted without proper monitoring, and an efficient system of tracking such activities is essential especially in the case of LEDCs. Further, a total of 301 respondents (93 percent) strongly agreed that lodging complains about such instances are a slow and long process. If legal action is required, the processing time can be tedious which is a reason for them not to pursue the complaint, whereas, respondents who have made complaints are in the perception that their complaints are neglected by relevant authorities as taking action on such complaints are being delayed or neglected. However, with an introduction of the app, users are part and parcel of monitoring and surveillance system in the smart city, and they enable to react to malpractices and inefficiencies in real time while enhancing the efficiency of monitoring and surveillance mechanism and reducing time to lodge complaints. In addition, increased response rate on initiating action is expected by users ability to make reminders of the same issue to the administrative bodies.

All the respondents were actively participating in sharing information, selfies and photographs on social media platforms and they all were in favour of sharing information on malpractices and unsustainable development. However, many respondents (54 percent) reflected their concern on selfies as their identity is thoroughly exposed. Although, sharing selfies with a thermal filter which only

illustrates thermal readings but not facial features were responded favourably by 91 percent of the respondents. 86 percent respondents declared that ethical considerations related to data mining on sharing information on social media are flexible if information from the app is utilised for enforcement of smart, sustainable nations while increasing their quality of life but not utilised to data mine for commercial purposes especially in the case of thermal imaging. Many respondents from Gen Y (67 percent) felt that they are radical and adventurous hence, low concern on the anonymity of information they share via the app is observed. However, an option to select between being anonymous or fully disclosed on user profile information was suggested as a necessity.

99 percent of the respondents were users of smartphones. However, when inquired about IR sensing ability, only 3 percent were unaware of the availability of such facility in their smartphones, and only 1 percent of the respondents were using smartphones with infrared facial recognition. Pertaining to the hypothesis, willingness to purchase additional IR equipment was observed as negative (96 percent) based on additional capital cost and concern on the requirement to travel with additional apparatus for thermal imaging purposes.

In line with the hypothesis, 86 percent would subscribe when the respondents were inquired on intention to use the app as they understand the importance of implementing sustainable and smart cities while acting as responsible citizens who are part and parcel of urban informatics in the future urban environment.

4. Conclusion

With the exponential growth of urbanisation, active and effective utilisation of resources and urban landscape based is imminent for sustainable future. Hence, development of smart cities with its functions being integrated with urban informatics to increase efficiency and productivity of resources and urban landscape utilisation is an essential development goal. Monitoring of such sustainable development for unethical and malpractices is quintessential to strengthen sustainable development goals in smart cities further. However, high investment in capital cost for traditional surveillance systems to extract urban informatics, is the underlying reason behind only a few megacities have incorporated urban informatics to its functions. Especially in the case of emerging economies such as India, Sri Lanka, Bangladesh, etc., lack of monitoring and high corruption have led to catastrophic anthropogenic disasters.

Hence, a smartphone application is to be introduced for data mining of unethical and unsustainable urban developments and malpractices by enabling growing urban population to integrate into participatory research. Users would share photographs of such issues, and a report is generated by the database, and relevant authorities would be notified. In addition, a thermal image of photographs is analysed to evaluate and map urban heat island effect of the surroundings which city planners and landscape architects could utilise when enhancing sustainable features in the smart city. Majority of the respondents understand the importance of sustainable smart cities, and they are willing to contribute to monitoring driven by radicalism and heroism of the next generation urban tenants, Gen Y. Thus, the majority of

respondents were keen to subscribe to the app while illustrating participatory urban data mining a success.

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Appendix

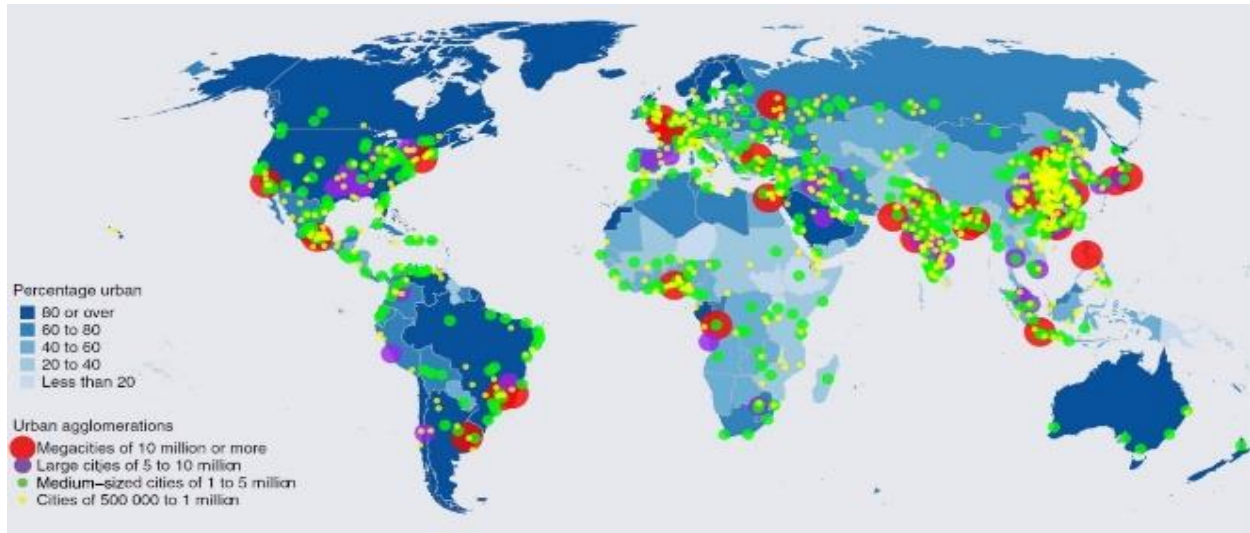


Fig 1:Percentage of urban and location of urban agglomerations with at least 0.5m inhabitants in 2014

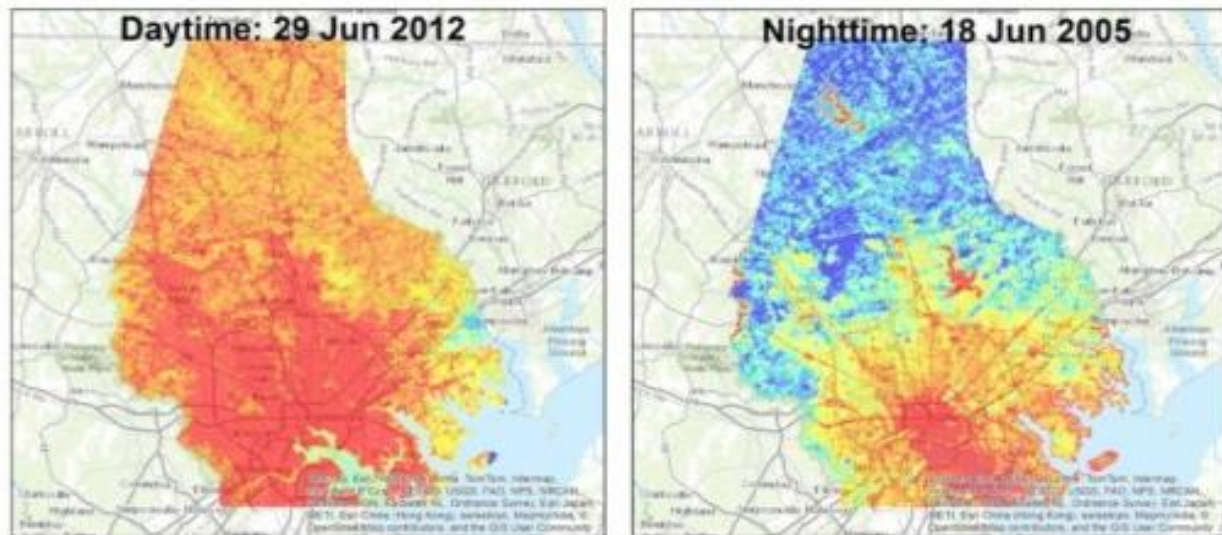


Fig 2:Thermal comparison between day and night in urban areas

The Application Of Information Technology In Contemporary Landscape Design

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Abstract

Landscape design is a work to coordinate the relationship between human and nature. It is an art accumulated in the process of human life activities. It is the result of summarizing and refining ecological, psychological, technological and cultural aspects. Information technology refers to all kinds of technology combinations that collect, transmit, store, process and express the information. It can extend the information function of human beings, and is an extension of human's function of perception. At present, computer network technology, expert system, artificial intelligence, multimedia technology and so on are applied to landscape design.

In the first place, more information is needed for contemporary landscape design. It must pay attention to the information that reflects the time dimension of landscape preference. Any design ideas are established in the context of the development of the times and society. Secondly, the development of multimedia technology provides new technical support for landscape construction. The corresponding design concept is gradually applied to lighting system, pixel system, waterscape system and so on. Thirdly, virtual reality technology has expanded more creative space for landscape designers, and has a new impact on the creation of design methods.

Therefore, it is necessary to intervene in the information technology in the landscape design under the new era. The paper focus on the analysis of information technology under the background of landscape design and landscape design theory, expounds the influencing factors of the information technology of the landscape design, analyses the Chinese examples of landscape design intervened by information technology, and points out its positive significance and development trend in the future, in order to produce reference and help to the landscape design practice in the future.

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Keywords: Information technology, Landscape design, Multimedia technology, Virtual reality technology

1. Introduction of information technology background

1.1. The development of the information age

As early as 18 years ago, Massachusetts Institute of Technology professor Negroponte wrote a book to describe the

possible digital future. In the book the people see the innovative way of life, and it is full of network. "Computing is no longer related to computers, it determines our survival," Negroponte said. The best way to predict the future is to create it.

Digital information bring people into a immaterial, movable, and intelligent era of information age. In a word, our daily learning, work, recreation, entertainment and other ways of life are all in the information. The human society has also formally entered the information society.

1.2. The development status of information technology in China

Information technology is developed on the basis of computer, communication and control technology. After several years of unremitting efforts, the information technology has developed to database technology, artificial intelligence, expert system, remote sensing technology, geographic information system, global positioning system, computer aided decision system, automatic control technology, monitoring technology, multimedia technology, computer network technology and many other applications. These technologies have been widely spread to people all aspects of life. Information is the big trend of the development of the world

today, and it is an important force to promote economic and social change. Our society and urban construction are increasingly inseparable from the support of information technology, and the landscape design is also deeply influenced by it.

1.3. The necessity of integrating information technology into landscape design

Modern information technology mainly contains many contents, multimedia technology, 3S technology, computer aided design software, remote collaborative design, landscape simulation technology. At this stage, landscape design and construction is an important project of city development, can beautify city environment, reduce the pollution of the city function. In its construction process, the effective integration of modern information technology, the landscape design can be set up in advance space layout, more intuitively in front of people. For example, in the application of GPS technology and GIS technology, not only can we collect extensive information about landscape design and construction, but also analyze all kinds of information in garden layout.

In a comprehensive view of the history of landscape development, the application of technology in the process of landscape creation has always been a concern of people. In an era of rapid development of information technology, the importance of this problem is particularly prominent. In the field of landscape design, information technology has been widely used as a means and tool. Therefore, our work theories and methods are inseparable from the support of information technology. However, we have not paid enough attention to the impact and change brought by information technology to

landscape design. Facing the coming of the information age in twenty-first Century, how to give full play to the advantages of information technology to create a unique and powerful service landscape system? we may need to summarize its impact on the status quo, and predict its future development.

2. Multimedia technology and landscape design

2.1 Features of multimedia technology

Media or media is the carrier of information representation and dissemination, such as daily people's use of text, graphics, images, animation, audio and video technology, video and audio. These media are also called single media.

Liu Zili made a more specific definition of multimedia: the digital technology media appearing after modern media, such as radio, film and television, is called multimedia. Including computer and microprocessor.

Therefore, "multimedia" refers to the technology of synthetically using words, graphics, images, sounds, animations, videos and hyperlinks of network to enable users to get information by interactive way. Multimedia technology is essentially a systematic integration based on a completely new concept and guided by existing technologies, such as audio-visual technology, computer technology and so on. It is the crystallization of the comprehensive development of modern science and technology. The rapid development of modern Internet technology provides an efficient and new platform and more rich content resources for multimedia technology. Human-computer communication is the

biggest difference between multimedia and traditional media, such as TV and stereo. While the Internet is added, the interaction between man and man, and the content of the media can be expanded.

The multimedia based information transmission method is compared with the traditional way. It has unparalleled advantages, which is determined by its characteristics. People exchange information with the outside world, relied on visual, auditory, tactile, olfactory. Information processing in the brain is also in a variety of media and multimedia technology will fully stimulate and mobilize the synchronous operation of these senses, using the information transfer mode of the "bandwidth" to avoid the information loss. So it can enhance the effect of information propagation, and it is a kind of comprehensive accord with human understanding and use of information media.

2.2 Development of multimedia art

Art has always been closely related to landscape. One art can provide diversified ideas for landscape. Secondly, landscape designers can learn rich forms of design language from the form of visual expression. Modern multimedia art has the characteristics of different form of art, which inspires the expression and thought of landscape design. On the other hand, multimedia technology is directly becoming one of the elements of modern landscape. Multimedia art, or new media art, mainly refers to the creation of computer and circuit transmission. It is an exploratory and experimental noncommercial technology created by digitalized tools and means. Its most distinctive characteristics are interaction and connectivity. The most important point of the

multimedia digital art is that it is different from other art forms. It is necessary to use digital technology in all or part of the process of creation. It is a new art form, which is based on modern media technology and digital science and technology, and integrates human art with rational perceptual thinking.

2.3 Multimedia technology and lighting system

LED -- Light Emitting Diode (light-emitting diode) is a semiconductor solid light-emitting device. In addition to its many advantages, it has gradually developed into an important lighting system.

LED as a display LED display technology has now been more mature in the advertising of various commercial advertising. With the rapid development of economy, the business media platform has almost all the corners of the urban space. Regardless of size or indoor and outdoor, business information is always wrapped around people. The application of multimedia LED in the display of city landscape is divided into two types, one is in the landscape space and architectural interface, such as the public space of city square construction interface LED display; on the other hand, LED displays have become independent elements in landscape space.

Firstly, it is attached to the LED display in the space of the landscape architecture. Nowadays, the skin of building is diversified. The LED display is helpful for the information expression of architecture, and at the same time, it is integrated with surrounding environment and landscape, reflecting the function of place.

Secondly is the independent LED display in the landscape space. Crown Fountain, as a

public art work and urban landscape sketch, is undoubtedly loved by many people, so it can be said to be a successful urban landscape. It is located in the Millennium Park Square in Chicago, United States, with the designer of the Spanish artist Jaumes Plensa.

The crown fountain is different from the classical fountain, because the crown fountain is a modern city landscape art



Fig. 1. The technical application of the Crown Fountain screen

pursuing the ever-changing lights and images. The fountain at the bottom of is the black granite reflecting pools. The curtain wall is currently the world's largest TV wall. The artist took 1000 Chicago residents face. Each facial expression can stay for 5 minutes at a time, from smile to grimace until the last lip looks like an interesting contemporary strange dripping mouth, and the water column will spout, resulting in the illusion of spitting water from the mouth. The LED multimedia device takes the most advanced technology to occupy the most original fountain in Chicago Millennium Park. It is a harmonious artistic works produced by water, art and multimedia LED technology. (Fig. 1.)

2.4 Multimedia technology and pixel system

CCTV media park is located in an open space in the CBD in Beijing. It will be on the visual image. So how to use media to make public space more public is a meaningful topic. (Fig. 2.)

The designer lifted the main space of the media park to the sloping field, and the pavement on the sloping land continued to use the concept of pixel in the environment



Fig. 2. CCTV media park's pixel system

design of the whole CCTV group, with the concept of "pixel source" as the design concept, and intensified the original design from OMA.

With the theme of "multimedia", the huge slope surface is covered by the new pixel system after the size variation. The system is alternately formed by the natural cover in pixels and the embedded grass grid around the pixels. In the planting plan of green space, the "coded information" is used as the language to express different information with variable lattice. Each pixel is a replaceable planting unit. By planting different shrubs or flowers, the color of each pixel is changed in a planned way, which makes the whole picture change continuously. In the new pixel system, the material and color of each point can be changed. This huge slope has formed a huge background, forming the role of the theme.

2.5 Multimedia technology and waterscape system

One is the music fountain. The music fountain, which combines light, water and music, is the core of its technology. The programmable central processor can synchronize all kinds of water type performances, lighting changes and music performances, control programming software and work in general operation platform environment, so as to update the performance content.

For example, Chongqing music fountain is 380 meters long and is the first dry fountain in China. The music fountain is designed into 5 parts, both in the long road to enjoy, can also be close to participate. Especially in the last chapter of music rhythm is very romantic. The fountain is mainly controlled by the computer. The form, the music and the color of the waterscape are unified controlled by the processor, and then achieve the perfect combination effect of water, music and light. The most important feature of the musical fountain is that any sprinkler can be called a dancer. Under the control of computer program, it can be flexibly changed according to the music rhythm. At present, most musical fountain in China cannot be done yet.

Water curtain film. The laser water curtain technology appeared in the 80s of this century, consisting of a laser system and a water curtain system. Laser system is mainly composed of laser beam and laser control system. Laser control system can change direction, color and pattern change of laser beam. (Fig. 3.)



Fig. 3. The display effect of the film on the water curtain.

In the water film sprinkled by the water curtain nozzle, the beam formed a beautiful and fantastic effect. The laser water curtain film has brought strong visual experience to people, equipped with thousands of waterscape, and let people's thoughts freely run. It adds a new scene to the urban nightscape.

3.Virtual reality technology and landscape design

3.1 The development of virtual reality technology

Experts and scholars in the United States in 1980s put forward the concept of virtual reality. Many international experts and scholars began to research and focus on the role and advantages of virtual reality technology since 1990s, with the pace of

development of computer technology and software system.

The use of computer technology to deal with the virtual reality technology, and to promote the application of virtual reality technology is more convenient and real. Therefore, virtual reality technology will be used widely in landscape design, which greatly improves the efficiency and, in addition to ensure the quality of landscape design.

3.2 The advantages of virtual reality technology and landscape design

The integration of virtual reality technology into landscape design can reduce the cost and improve the efficiency of the program. In the actual landscape design, we should fully consider all aspects of the content, not only to realize the effect of the design structure, but also to coordinate and match the surrounding environment and landscape design. Once we confirm the final design plan and make a large-scale modification, it will increase the cost. If the virtual reality technology is adopted to let the owners experience the scheme more truly, then the large scope modification can be avoided and the cost can be reduced. Therefore, in landscape design, we should improve and perfect the design. The use of virtual reality technology is to make landscape design more scientific and feasible. The virtual reality technology have more obvious three-dimensional features.

Virtual reality technology can increase the interaction between designer and owner. The landscape designer can expand or modify the details of the design according to the specific nature of the plan, so that the design scheme is more reasonable, and after that, the final design scheme is formed. In addition, although the current virtual reality technology can guide the construction, it can be more comprehensive and perfect display drawings. (Fig. 4.)



Fig. 4. Virtual reality technology helps designers communicate with owners

3.3 The application mode of virtual reality technology

Show the pattern. Virtual reality technology can be used in 3D or 2D, reasonably reflect the contents of landscape. This process may be unable to express landscape information and values, therefore, will show every angle of landscape and spatial detail, and then make the landscape design more scientific.

Supplemental mode. By using virtual reality technology to landscape design, general designer should actively communicate with the drawing designer, when there is a problem in the design process, to facilitate the timely solution, prompt and

efficient implementation of the landscape design, and meet the actual needs of the design drawings. It will be easy to find existing problems in the design drawings, timely adjustment, and it avoids the problems in construction, combined with the landscape design and construction to achieve the perfect.

The model of public participation. The landscape design process, but also the implementation of decision-making in practice, and let the public participate in the actual in landscape design. The construction of team cooperation and coordination is necessary so that in the landscape design process, designer should actively investigate and adopt constructive masses that prompted the landscape construction to meet the needs of landscape construction.

4. Conclusion

Technology is the basis for the realization of the material composition and spiritual structure of landscape. It is the driving force for the development of landscape. Many landscape is the expression of technological existence. With the development of society, the influence of information technology on society will increase day by day. As a human respect for nature and coordinate the relationship between man and nature, the landscape design will gradually change and improve with the development of information technology.

Technical change due to the emergence of information technology, such as multimedia technology, virtual reality technology and so on to provide a broader perspective, rich material and new ideas for contemporary landscape designers, and the application of new design method and tool will inspire

designers to create the novel form of the landscape.

Acknowledgments

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Study on Park Tourists' Behavioral Characteristics Based on Shared Bicycle Data: A Case Study of Guangzhou

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Abstract

The advent of shared bicycles has changed the habits of Chinese citizens in traveling and has also affected the behavior of citizens in using parks. The characteristics of shared bicycle gathering in and around urban parks can reflect the situation of citizens using city parks to a certain extent. Therefore, by analyzing the location data of shared bicycles, the spatial characteristics of tourists using parks can be explored. Taking the GPS location data of Mobike bikes measured on November 2nd and 4th of 2017 as samples, through the establishment of rasterization data and index weight analysis, the law of public use of parks after the promotion of shared bicycles was discussed. The main conclusions are as follows: (1) The number of different types of bicycles sharing different scales and different sizes of urban parks is different; (2) The changes in the number of shared bicycles entering and exiting the park and the impact of shared bicycle detention parks on the environment and order are analyzed; (3) Knowing the parks used by the citizens and analyzing the attraction levels of different urban parks for riding behaviors; this research method can assist planners to better understand the behavior of tourists under the background of sharing bicycles, and has important theories and Practical value.

Keywords: Shared Bicycle; Big Data ; Park

1. Introduction

Sharing bicycles is a breakthrough model innovation for the urban slow-moving system. While solving the last kilometer of the city, it is also setting off a new wave of green travel. However, as a new thing, many problems have arisen in the actual operation. Park green areas have become the hardest-hit areas for the proliferation of shared bicycles. In the Ching Ming Holiday in 2017, on April

3, the passenger flow during the peak period of Shenzhen Bay Park reached 300,000 people. The number of shared bicycles entering the park reached more than 10,000, far exceeding the normal flow load of the park[1]. Whether urban residents can use green land in a convenient and fair way and enjoy the service value of green land is an important indicator to measure the maturity of urban development, the level of modern development, and the harmonious

relationship between people and land. In other words, the fairness and social enjoyment of such resources. Equality is the necessary path and important principle for urban development.

Geographic Information System (GIS) is a commonly used technical method in the current macro-research of various disciplines, providing a convenient and effective way for the study of urban green space and public services.

Based on this, this study is based on shared bicycle positioning data, using a GIS data analysis platform, taking urban green land as the entry point and tourist behavior as the research content, conducting relevant research and analysis on the research area, and trying to reveal the current status of urban green space distribution in the study area. Reachability and propose planning.

2. Study area overview, data sources

2.1. Research area overview

According to the information released by the Guangzhou Municipal Department of Transportation, as of July 2017, the city's internet leased bicycles exceeded 800,000 vehicles, ranking the second in the country in terms of travel activity. Mobike bicycle users are relatively stable in both quantity and usage habits[2]. Therefore, the use of Mobike cyclist data to study the parking problem of shared bicycles in Guangzhou has certain typicalness and representativeness.

2.2. Data Sources

The research data collection method of this paper is to divide the city center of

Guangzhou into a 200*200m grid, and use the grid center as the collection point, using the Mobike APP positioning service on weekends and working days in one hour intervals within one day. Acquire 24 times of data to obtain bicycle ID, GPS location, bicycle type, and acquisition time. The urban parks and road traffic data in Guangzhou in this study were sourced from the OSM (OpenStreetMap) online geographic database. The population density data in the neighborhood was derived from Baidu POI residential data and OSM online geographic database synthesis.

3. Analytical method

3.1. Spatial Database Construction

The research used Excel, ArcGIS and its data analysis software package to clean up the original data and select a valid and valid subset of data. Using the multi-ring buffer and spatial link analysis tools of the ArcGIS analysis platform, the number of bicycles in the 200m area around the park and the number of bicycles inside, the road length, and the density of the road network were calculated, and the comprehensive analysis and calculation of the nature of the park's green space, green area, and other factors were performed. The cumulative attraction coefficient of 201 urban parkland[3]. After normalizing the data and inputting the urban green space distribution map of Guangzhou City in ArcGIS, the urban breaks of all the urban green areas in the study area are divided into 3 levels according to the natural breakpoint classification method. Finally, the image is output, and the shared bicycle and

park are judged as a whole. Time and space relations.

3.2. Time database build

Bicycle travel is greatly influenced by the weather. In order to reduce the impact of weather conditions on the research results, the characteristics of the day-long cycling activities with a predominantly cloudy condition and good air conditions were studied. The specific date was November 2. According to different collection times, the time distribution curve of the number of riders in the park on the day was obtained.

4. Cyclists' space-time characteristics

The spatial characteristics of riding behavior

The gravity of 201 urban green spaces in Guangzhou City was calculated and divided into first-level green space, second-level green space, and third-level green space according to the way of natural grading. The gravitational level ranged from low to high and corresponded to the intervals respectively. The specific data and spatial distribution were detailed. See Figure 1.

From Figure 1, it can be seen that different grades of urban green space in Guangzhou City are distributed throughout the region. From the data point of view, the total area of green space in the study area is 16.49 square kilometers, among which the level of the third-level green land reaches 5.21 square kilometers at most, accounting for 31.59% of the total area; the five-level green space is the highest level of gravitation, and the green space accounts for the least Only 6.71% of the

total area is 1.106 square kilometers. These green areas are divided into two types: one is a large area, well-known, convenient transportation, easy to pick up the car parking, can provide more public services for tourists riding, including Yuexiu Park and Guangzhou Sculpture Park, Liuhua Lake Park The other category is a specific service group, densely populated, with frequent use of shared bicycles.[4] Such as the campus green space of the South China University of Technology and the green space in the university city. In addition, through the calculation of the number of shared bicycles in the park, it was found that the park with the most dense cycling behavior was Binjiang Park, which reached 30.86 vehicles/km², of which the south of the park reached 70 vehicles/km². In the park, the most popular parks for tourists are Liuhuahu Park, Guangzhou Sculpture Park, Pazhou Ecological Park, Nanxun Garden, Tianhe Park, and some riverside ribbon parks. Most of these parks are along the river and along the lake lanes, and have a beautiful ecological environment and a wide field of vision. However, many tourists have also derived uncivilized behavior. Observing from the GIS positioning, some shared bicycles are located on the banks of the river and the bottom of the lake (see Figure 2).

From the map, the first and second grade urban green areas are roughly divided into two types: one is a large area but is affected by a single traffic structure, a low road density, or a park management method, which is not conducive to riding and has not been adequate. Urban green areas that embody the value of public services include Haizhu Lake Park, Liwan Lake Park, Xiaogang Park, Huangpu Park, and Yantao

Park. Others are large-scale urban afforestation buffers around streets or highways, such as Baiyun District overpass. Under the green land and the Haizhu Wetland, the population density of this type of green land is relatively low and it is far from the densely populated core areas of the road network. Therefore, both in terms of positioning and practical role, the value of public services provided to tourists is limited.

By using bicycle data combined with three-dimensional maps of Excel software and Baidu POI data, with the park 200 meters of multi-ring buffers as the calculation scope, and through spatial connections and importing three-dimensional maps, the distribution of park shared bicycles within the scope of the study is obtained as follows.

(see Figure 3) From the figure, it is found that the distribution of shared bicycles in urban parks in Guangzhou is basically represented by rivers, and the number of bicycles in northern parks is generally higher than that in the south. Liwan District, Yuexiu District, and Baiyun District Park have the most densely distributed bicycles, while Haizhu District has relatively scarce and scattered green space resources, and the number of shared bicycles is also low. The level of accessibility is limited by the overall level of resource constraints and there is a large area. The scattered greenbelts under the overpasses and greenery along the streets have not been effectively used. It is necessary to expand and transform urban greenbelts of a certain scale and construct slow-moving green corridors.

4.2. Time characteristics of riding behavior

(see Figure 4) In order to more accurately determine the peak demand of tourists riding,

to determine the maximum amount of sharing of bicycles, the study selected the highest demand for riding on the 4th of November for full-time analysis. As a result, it was found that the aggression of the day's cycling behavior was not obvious from 00:30 to 7:30, and the connection with the park was not prominent. From 8:30 to 15:30, tourists are active in cycling, and from 15:30 to 16:30, the number of bicycles in the park is drastically reduced. This may be due to the fact that tourists leave too many bicycles in the park in the morning. In order to keep the park open, park managers will Clean up. 17:30 to 22:30 form the last wave of night-time cycling activities, which may be a leisure activity for nearby residents. The maximum peak usage of the park was 3512 vehicles/minute on that day, with the peak of the early morning peak at about 11:30 and the peak of the late peak at around 17:30. At 15:30, the number of bicycles dropped sharply within a short period of time. Therefore, this time period is the heaviest time period for park cycling.

5. Conclusion

Through international comparison[5]. It was found that the parks in Chinese cities are large in scale and small in total number, and their spatial distribution is sparse. Such a function point requires people to pay more space to move to meet various needs, easily causing population and traffic aggregation in a short period of time, and increasing the amount of traffic. , resulting in the phenomenon of shared bicycle explosions.

There is a serious shortage of per capita transportation space in Chinese cities, and sharing of bicycles to a certain extent exacerbates the originally intense urban traffic space.

The influx of shared bicycles creates problems for park management. Currently, most of the parks deal with this issue by prohibiting the sharing of bicycles, parking most bicycles at the main entrances and exits, and spending a lot of time and manpower on the park. Carry out clean-up, but allowed the battery car and tour bus that signed a cooperation agreement with the park to charge in the park. Many tourists complained and complained, and many tourists still ride the shared bicycle to enter the park secretly, causing serious conflicts. The explanation behind this shows that the lack of time and space in the current park planning and even infrastructure planning does not take into consideration the differences in use requirements and the lack of applicability to the planning of shared bicycle facilities.

Based on the above analysis, it can be found that cycling bicycle users in the park have different time and space characteristics. The planning of its parking facilities needs to reflect the humanistic care of urban planning.

There have been studies that have proposed a humanistic planning model based on space-time behaviors.[6], Stressing the adoption of data acquisition and analysis, focusing on living space planning, life time planning and resident behavior planning, understanding individual urban space behaviors, understanding urban issues from daily life, understanding residents' needs from behavior analysis, and then identifying planning and construction The key points are the sharing of parking spot planning, parking capacity

planning and parking capacity management, optimizing the layout of parking facilities, and improving the efficiency and management efficiency of sharing bicycles.

For park planning, we should scientifically analyze the attractiveness of cycling and regular entrances and exits to determine the capacity of parking facilities. In combination with the user's riding habits, we can optimize the greenway route and set up a clear signage system. We should be able to use more on holidays. The intensive layout of parking methods forms a supply system that combines fixed-point centralized parking and scattered scattered parking to realize the balance between supply and demand in the diversion and park.

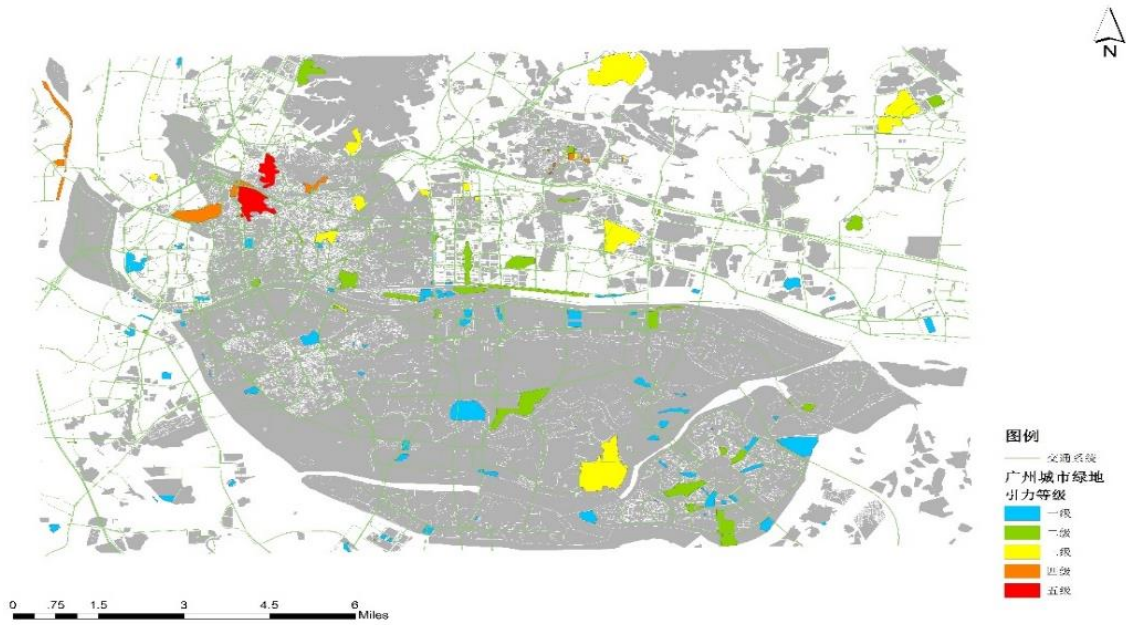


Fig. 1. The classification of urban green space in Guangzhou

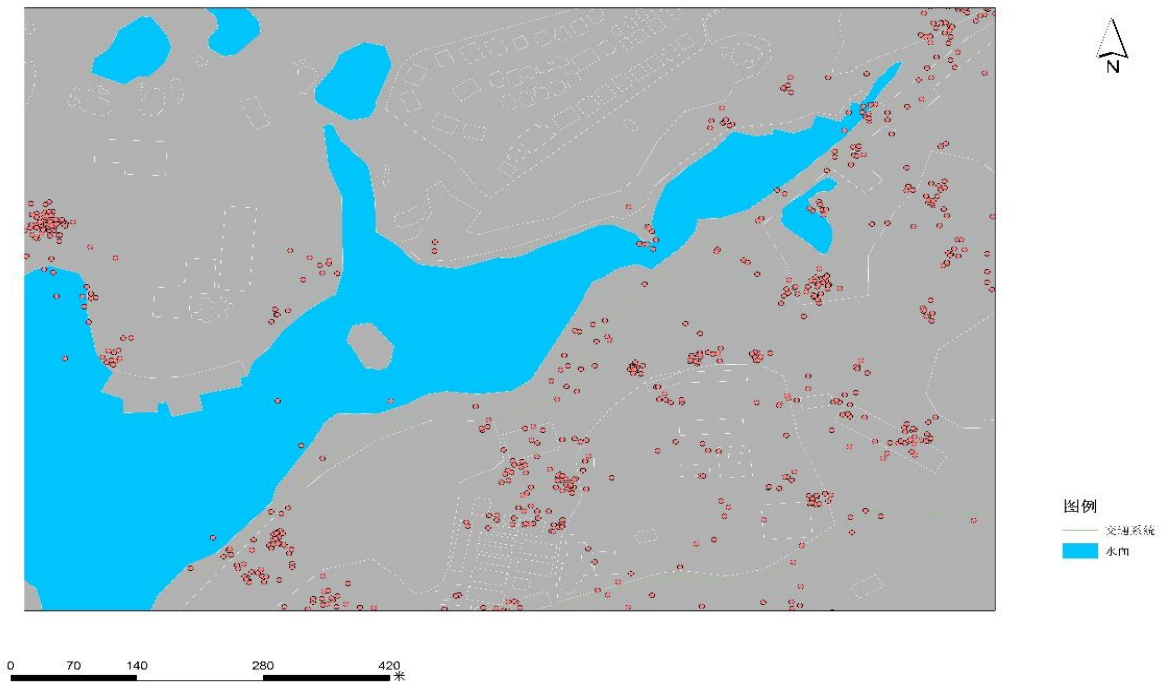


Fig. 2. Part of shared bicycles sink into the bottom of the lake

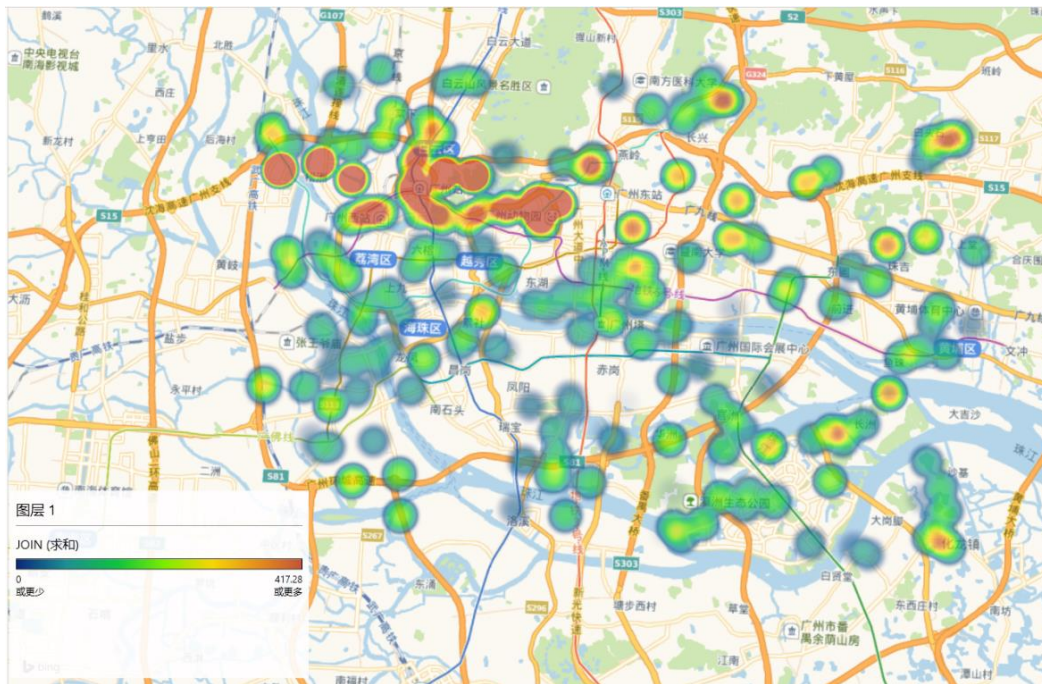


Fig. 3. Park shared bicycle distribution heat map

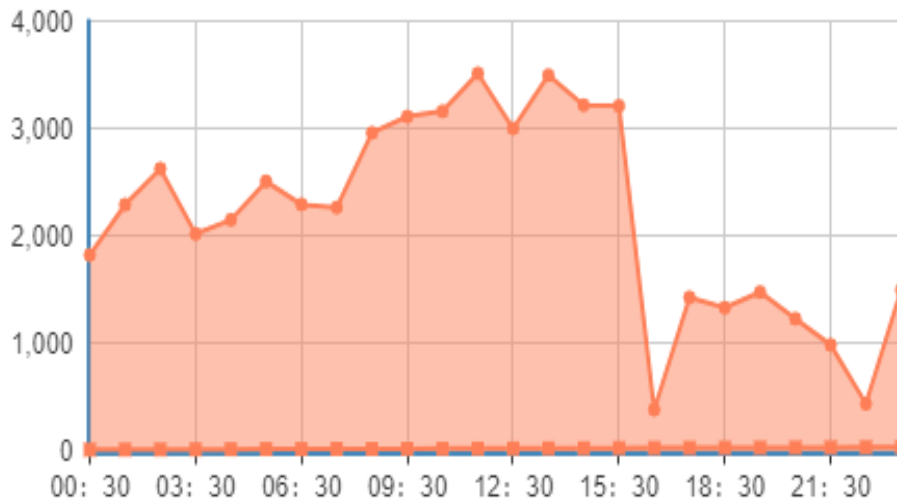


Fig. 4. Changes in the number of shared bicycles used in the park during the day

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Smart Landscape - Technology Modeling

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Abstract

Studies and projects dealing with environmentally efficient technologies for the management of rainwater flows already have a significant technical and experimental base, mainly in North American, European and Asian countries. In general, this technical production results in manuals, booklets, guidelines and technical information to make Best Management Practices (BMPs) which are additional and efficient technologies in urban contexts where water has become an environmental and socioeconomic problem due to climate change which affect the population year after year everywhere in the world.

Still in the international context, the insertion of the BMPs techniques assumed a retrofit position for the problems of urban drainage. With the additional function of the existing drainage systems, they allow the mitigation of the diffuse pollution caused by the superficial flows that bring with the polluting precipitations that follow the course of the drainage until they are launched in the natural water resources.

In Brazil, the absolute drainage system is predominant in most cities, as recommended by NBR9684/08. However, there is no oversight legislation for diffuse pollution and there are no legal parameters of permeability rate for road production.

Considering that the processes of production of urban and architectural projects have acquired an increasingly efficient technological support, through platforms that make the production and evaluation of efficiency parameters more flexible and accessible, this article aims to incorporate the advent of technology and information as a tool for mapping and identification of the urban built environment that present structural problems of rainwater drainage infrastructure, proposing to revert these problems through the installation of BMPs.

Thus, the development of a technological tool for the application of smart landscape infrastructure requires a change in mentality, of political support and in social education. The strategic purpose of the platform is to be adaptable to variations in inputs and outputs, given the mutability of cities and climate change. This platform induces the understanding of landscape design as an infrastructure that supports engineering techniques and the concepts of the natural sciences to develop technological and ecological solutions for cities in the production of socially fair, culturally rich and ecologically restorative urban spaces for all.

Keywords: Best Management Practices; Diffuse Pollution; Smart Landscape; Technology Modeling.

1. Introduction

The vulnerability of cities and communities around the world, to hydrological phenomena such as floods, means that the approach to storm water management in urban space is anchored in the proposal of mitigating strategies and adding to the current standardized drainage systems aiming to develop more resilient, smart and sustainable cities.

With a broad conceptual and scientific basis, the Best Management Practices (BMP) techniques are proposed as additional instruments of landscape architecture that through their organic composition matrices become efficient in capturing, retaining and managing urban rainwater. Therefore, decision-making in the implementation of this technology is still going through a slow and laborious process, except in countries of North America, Europe and Asia that have already made it more effective as an instrument of planning and management.

In Brazil, these technologies require, at first, a change of projective mentality and that research and experiments developed be tested as solutions to cities in a more forceful way. Besides that, it is necessary that the political sector of management and territorial legislation promote behavior change, regarding the policies that govern the production of the urban space in order to combat the socio-environmental damages

caused by the climatic changes that affect their communities.

As mentioned above, internationally, BMPs have strong productions in the form of manuals and technical guides. Among them, we have the Low Impact Development - LID¹ (2010) by the University of Arkansas and Maryland Department of the Environment Stormwater Management Manual by the City of Portland² (2016), which are a reference for defining the physical composition of organic matrices and their efficiency as a drainage infrastructure for urban stormwater.

BMPs as additional infrastructures and mitigation of urban storm water management in an attempt to make cities less vulnerable to climate change were also addressed by [1], [2].

Recently, water and sanitation, which are goals of the 2030 Agenda by ONU³, have resumed the discussion of the urgent need to reassess the issues of urban stormwater management.

¹ University of Arkansas Community Design Center. Low Impact Development – a design manual for urban areas. (2010) [online]. <http://uacdc.uark.edu/work/low-impact-development-a-design-manual-for-urban-areas> [accessed 8 september 2017].

² City Of Portland. Stormwater Management Manual. (2016) [online] SWMM (2016). <https://www.portlandoregon.gov/bes/64040> [accessed 12 september 2017].

³ On 20 February 2018, UNESCO session entitled “Science for Water: Effective Solutions for Achieving SDG 6 and Water-related goals and targets of the 2030 Agenda” at the UN Headquarters in New York. http://www.unesco.org/new/en/unesco-liaison-office-in-new-york/about-this-office/single-view/news/science_for_water/

This paper begins by addressing the BMPs as infrastructure of landscape architecture and urban retrofit. It then discusses how pollution has affected natural resources (e.g. the city of Fortaleza - Brazil). In order to evaluate in an exploratory way the possibilities of mitigation building an urban environment that present problems of structural and drainage infrastructure through the mapping of the site evaluating the installation of BMPs to mitigate the problems of flooding.

After establishing the place of intervention, algorithms that combine historical data with soil use patterns (e.g. occupation rate, soil waterproofing) and seasonal events as inputs of the technological tool for mapping flood points in urban space will be used.

2. Best Management Practices as a retrofit tool to urban drainage system.

Floodplains have been the most recurrent hydrological phenomena of the twentieth century [1]. With large-scale global urbanization, morphological transformations (e.g. occupation of protected areas, road construction, and urban infrastructure) eventually breaking in through the natural ecosystem cycles.

Historically, the chaotic production of urban spaces has treated urban drainage as an "accessory" to the urban land parceling [3], where much of this modern production happened by neglecting the biophysical bases and the natural processes of the landscape [4].

The increase of urban impermeable areas resulted in the reduction of the natural storage capacity of the flow [3]. With the increase of water volume accumulated in the soil, drainage systems were developed full of contradictions whose functions were the rapid capture of these waters to discharge it.

In this practice, it was the population and the ecosystem that faced the environmental costs of this urbanization [4], since with the increase of the downstream flow peak, floods became recurrent and affected especially the communities residing in lower levels near rivers and other water resources [3].

The movement to foster a new approach to compensatory urbanism in order to mitigate the environmental damages promoted in the construction of roads, dwellings and industrial areas, in an attempt to re-establish the quality of the environment [5], has become an emergency since when cities began to have countless socio-environmental damages resulting from climate change.

In order to break this questionable form of urban drainage production, the term "sustainability", which, despite being anachronistic, has been used to achieve new concepts aimed at stability through effective management and control [6], or less in predicting drainage infrastructure failure Fig.01.

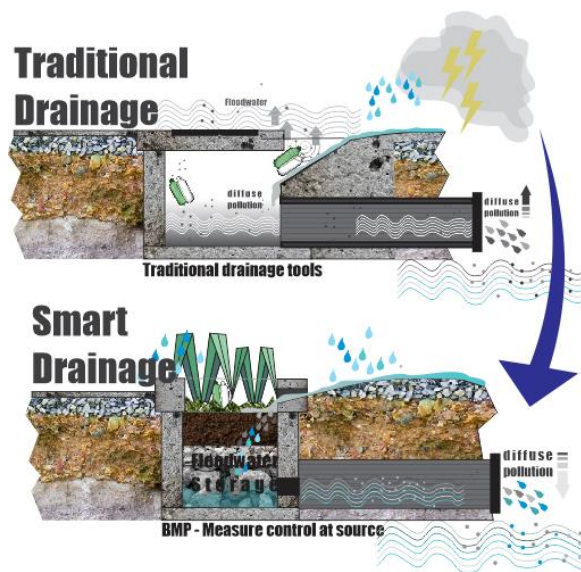


Fig. 1. Difference between the traditional system and the smart rainwater management system.

For the development of sustainable cities, it is necessary that the approach to the production of the drainage infrastructure establishes resilient and compensatory measures that are proactive and that reduces and prevents flooding, as well as becoming an effective tool to reduce socio-environmental impacts [1].

Although urban drainage infrastructure proposals to promote resilient spaces are sometimes questioned, urban resilience becomes necessary [1].

Increasing the hydraulic efficiency of traditional drainage systems, adding to the already existing modular and adaptable systems that develop an interconnected green infrastructure through an adaptive three-dimensional design [1], makes possible to obtain a multifunctional drainage infrastructure, resilient and smart [3].

One of the challenges of contemporary urbanism is urban drainage, emphasizing that its approach must be comprehensive and systemic, taking advantage of the architecture of smart and multifunctional landscape in the recovery of cities and the urban environment. However, it is necessary to understand the natural environment, built environment and urban infrastructure, so that new strategies are taken in favor of urban sustainability [7].

2.1. Urban Drainage and Community

The pollution of water, soil or air occurs through anthropic actions [8]. Urban environmental degradation is easily related to the production of urban sanitation infrastructure (e.g. combined system or absolute separator system).

Both systems present specific and structural limitations for effluent management (e.g. sewage treatment, or since they are developed as a monofunctional mechanism for the conduction and disposal of effluents, making them vulnerable to failures where they do not meet the demand for precipitation volume from climate change, or sanitary sewage from urban territorial densities).

In rural areas, the pollutants originate from the application of fertilizers and pesticides in plantations that through the infiltration into the soil ends up being transferred to the water resources [10].

Regardless of the scenario, urban or rural, the approach to the way the production of drainage requires attention since the pollution of water resources on a global

scale becomes something beyond an environmental issue, health problem and human economy [13].

The control of diffuse pollution requires management and implementation of control measures [11] so that socioeconomic and environmental factors stand out for the interests of land use in production for economic purposes only [12].

In Brazil, the problems of contamination of water resources caused by diffuse pollution are recurrent, due to the fact that this type of pollution load is not yet recognized by Brazilian legislation, nor is there any regulation and rate of permeability indexes for the production of roads, streets and sidewalks.

The predominance of the separate sewer system in Brazilian cities, as recommended by NBR9684/08, presents advantages and disadvantages⁴.

This type of system works as two systems, one for sanitary sewage management and another for stormwater management. Underpinned by the "hygienically safe" concept of drainage systems in cities, this concept needs reassessment. In Brazil, the sanitation infrastructure serves 82.8%⁵ of the population.

⁴ Moura, N. C. B, Modelo Biorretenção - Tencologia Ambiental Urbana para Manejo das Águas de Chuva. <http://www.teses.usp.br/teses/disponiveis/16/16135/tde-30052014-104153/pt-br.php>. Accessed in 22/06/2017.

⁵ Data Bank – World Development Indicators, The World Bank IDA

Brazil

population: 205,962,108.00 (2015)

Access to improved sanitation facilities: 82.8% (2015)

do not have satintation: **36.043.368,90**
 (people)

In most cities, especially in slum areas, characterized by overpopulation and lack of infrastructure, basic sanitation does not have adequate structural conditions.

Problems such as clandestine connections, open sky sewage and lack of efficient drainage promote flooding, during times of monsoon, contamination of water resources and public health problems Fig.2.

The city of Fortaleza, capital of the State of Ceará in Brazil, has developed its urban drainage infrastructure in absolute separate technology.



Fig. 2. Sewage disposal in the urban drainage network– Fortaleza City – Brazil.

In the State of Ceará, public health expenditures in 2015 were approximately \$

<http://databank.worldbank.org/data/reports.aspx?source=2&country=BRA>. Accessed in 12/04/2018.

600,000.00⁶ linked to hospitalization expenses due to diarrhea, which is a disease related to potable water and urban sanitation.

Located in a semi-arid region, there is a rainy seasonality, where 90% of annual rainfall occurs in the first half of the year (DEHA-UFC)⁷.

After this period, the pollutant load deposited on the surface of its territory during the dry period of the year is directly dumped into the drainage pipes of the rainwater, without any treatment, a condition that is further aggravated by the clandestine connections that throughout its discharge sewage, eventually generating an effluent laden with polluting loads Fig.3.



Fig. 3. Environmental problems arising from urban drainage – Fortaleza City – Brazil⁸.

⁶ Governo do Estado do Ceará, Secretaria das Cidades – CAGECE, Saneamento Básico – um compromisso de toso por mais qualidade de vida, 2ª ed. Fortaleza, 2016

⁷ Departamento de Engenharia Hidráulica e Ambiental (DEHA) do Centro de Tecnologia da Universidade Federal do Ceará. http://www.deha.ufc.br/ticiania/Arquivos/Publicacoes/Livros%20e%20Cap%20de%20Livros/capitulo_climatologia%20Aracati%20e%20Fortaleza_definitiva.pdf. Accessed in 28/03/2018.

⁸Top Image: <http://g1.globo.com/ceara/noticia/2014/02/praiade-fortaleza-tem-mancha-negra-apos-manha-de-chuva.html>.

2.2. Best Management Practices's Implementation

The implementation of compensatory techniques as a way to mitigate urban spaces encompasses issues of environmental, social and political development.

The BMP model and its dimensioning must correspond to the local criteria, since each urban context has its own geomorphological characteristics and has its own evaluative criteria regarding the degree of toxicity of the effluents and environmental legislation [8].

In the implementation plan of the BMP matrices, the structural knowledge regarding the flow of the existing urban drainage network by evaluating the quality, the flow and the characteristics of the site, as well as its routes and the integrity of the internal drainage of the systems to their point of discharge⁹ is necessary.

In the densely populated urban context, the parameters that will make up the feed inputs come from the type of paving, the

Middle
http://cnews.com.br/cnews/noticias/81701/mancha_no_mar_afasta_banhistas_no_mucuripe.

Bottom
<http://tribunadoceara.uol.com.br/noticias/cotidiano-2/praias-do-mucuripe-fica-com-enorme-mancha-de-poluicao-apos-chuvas-desta-quinta/>

⁹ Additional guidance on water quality considerations for land application is available in the IFC – World Bank Group for the Environmental, Health, and Safety (EHS) Guidelines: Environmental Waster and AmBient Water Quality. <https://www.ifc.org/wps/wcm/connect/026dcb004886583db4e6f66a6515bb18/1-3%2BWastewater%2Band%2BAmbient%2BWater%2BQuality.pdf?MOD=AJPERES>.

built density (e.g. buildings), the physical space and the surface drainage where it flows will be verified in clean or paved soil.

The implementation of the smart landscape can be incorporated in the buildings, streets, sidewalks and open spaces with the objective of dividing the rainwater management function, delaying the failure of the traditional drainage system and treatment of surface water previously discarded in the water resource Fig. 4.

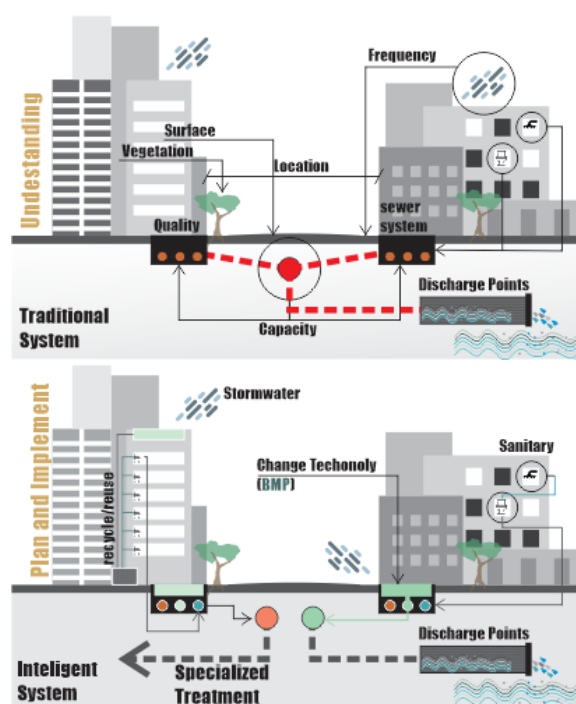


Fig. 4. Plan and implementation of retrofit of urban drainage network of urban rainwater.

With systemic planning it is possible to delay the saturation moment of the macro holding system [3], and for this matter, the strategy is to develop a preventive and corrective planning in the micro drainage

system in order to integrate it, composing a green infrastructure.

Taking into account that the BMP matrix has adaptable characteristics, which can be implemented before, during or after the production of the urban space, its sizing and application typology are evaluated to reduce or minimize the environmental or structural problems of the site.

Nowadays, the processes of production of urban and architectural projects have acquired increasingly efficient technological support, where, through software, the evaluations of efficiency parameters have become smarter. The modeling of BMPs rainwater matrices aims to incorporate the advent of information technology as a tool providing technical composition information.

Through the transformation of the geomorphological, pluviometry, structural and territorial occupation data, algorithms for the digital platform allow real conditions for smart urban intervention.

3. Landscape Modeling data

The immediacy of anthropic actions on the environment, practiced, in many moments irrationally, aim at economic results in favor of socio-environmental values.

However, reversing the negative impacts of urbanization requires integration between science, technology and society.

The methodologies and strategies adopted in the production of cities should understand the conditions and characteristics of microdrainage and macrodrainage as a single and intrinsically connected system.

Smart cities are looking for ways to improve technology to facilitate the understanding of the city as a unique organism. In order to do so, point-to-point flooding inputs should be evaluated comprehensively to assess their cause Fig. 5 and 6.

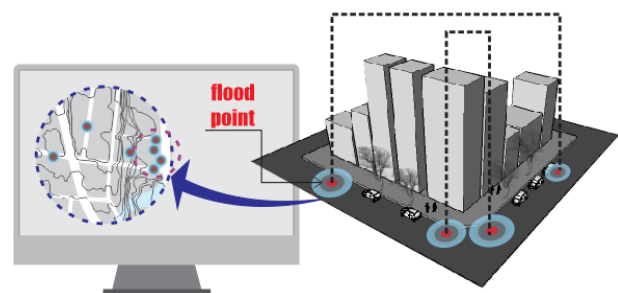


Fig. 5. Modeling landscape process.

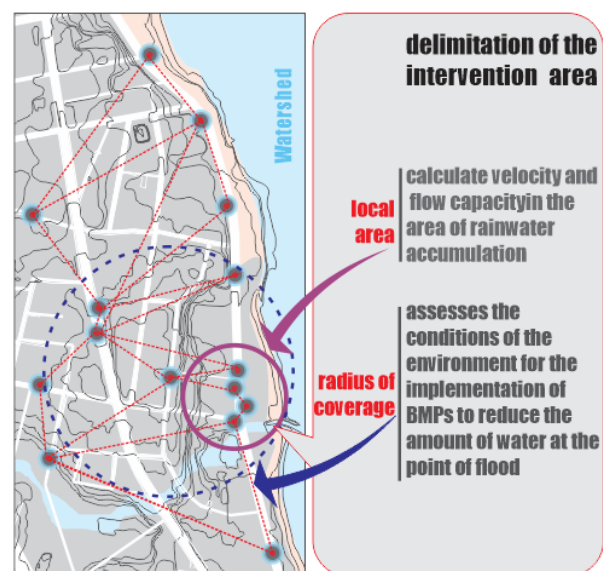


Fig. 6. Modeling landscape process.

In mapping the coverage radius, the platform identifies the conditions of the rated flood point and monitors the on-site BMP application conditions. For this, algorithms that combine historical data with land use patterns and seasonal events are used.

Inserting all radiuses of coverage's inputs corresponding to the flood point on the platform generates fundamental structural information to promote the development of the intelligent landscape modeling network. From this data we evaluate how many BMPs are needed to supply the flow demand at that point. In addition to enabling the virtual positioning and sizing of each matrix in real time, allowing it to adopt storage strategies of composition of the green infrastructure.

The advantage of the intervention study with a broader scope is that in situations where it is not possible to intervene at the site, the platform evaluates the physical and geomorphological conditions covered by the radius of coverage, punctuating strategic and possible points for the matrices to be implanted, producing, a sustainable rainwater management network to reduce flooding at the critical point Fig. 7.

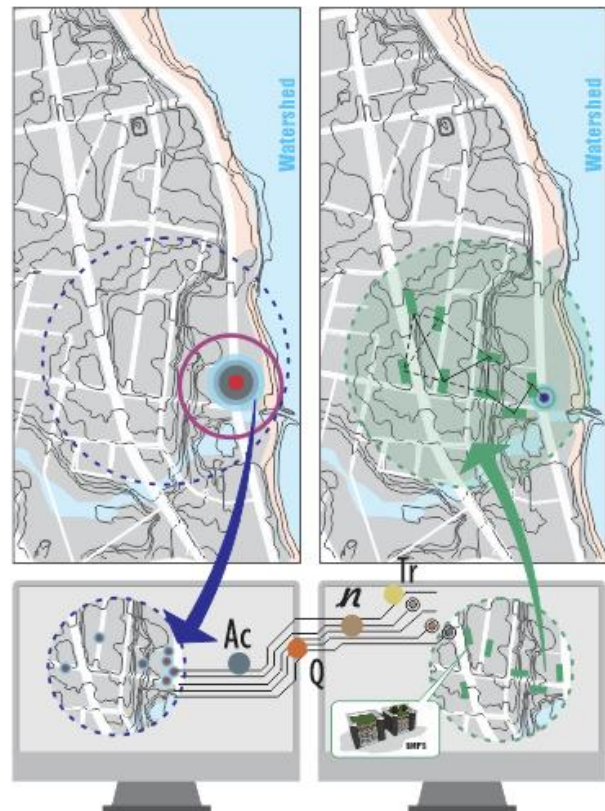


Fig. 7. Modeling landscape process.

Supported through a landscape modeling technology tool that uses BMP arrays in the production of low impact infrastructure, the path to more smart and resilient urban space production becomes possible.

Another fundamental aspect of this tool to be highlighted is its adaptability of inputs. The strategic point is the conception of a tool that allows the updated variation of the inputs and output, being flexible to the data coming from the climatic variations besides accompanying the physical and structural transformations of the city and the urban natural environment.

3.1. Best Management Practices's Technology modeling.

Based on the data resulting from the spatial and parametric evaluation of the site, the process of compatibilizing the BMPs (e.g. bioswales, rain gardens) to be implemented as a network of green infrastructure begins, assuming the technological function of the landscape in the mitigation and retrofit of the urban space.

In order to calculate the capacity of capture, retention and release of the effluents in the digital matrices, the possible volume to be stored at the storage substrate level will be counted. The size of the layers will be defined by the flow volume Fig.8.

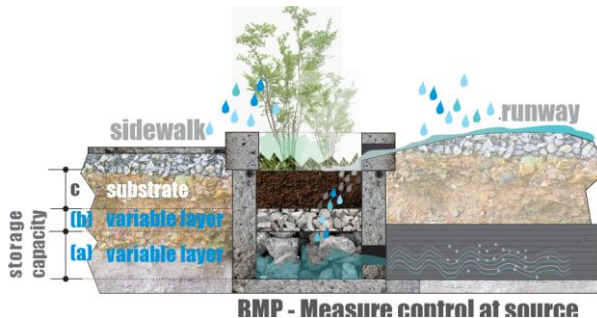


Fig. 8. Sizing of each BMPs substrate layer.

- Variable Layer a: composed with hydraulic macadam or gravel n° 4 and 5. In this layer will be held the greater capacity of reservation.

- Variable Layer b: composed of simple graded gravel (BGS), which, because of its granulometry of stones of different strips, performs a reserve in addition to damping the effluent. In this layer will be performed

the area complementing the necessary reservation capacity.

- Planting Substrate: This layer is not included for the reservation calculation. This assumption was based on the variability of the landscape design possibilities that are due to the climatic, spatial and social conditions of the site of implantation Fig 9.

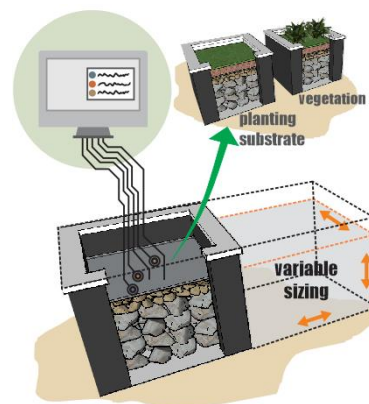


Fig. 9. Definition of planting substrate and vegetation.

4. Conclusion

The fundamental aspect for the transformation of a city into a sustainable city is the adoption of smart infrastructure in it is planning and management. However, it is necessary to change the mentality in all sectors that make up the urban organism, providing better living conditions for the citizen.

In Brazil, it is necessary to regulate urban water issues. Investment for sanitation exists, however, does not reach all parts of the population or all territorial expansion. In Fortaleza, public health problems are highlighted and can be even higher, because it is a coastal city, the contact of the

population is significant since it is part of the public leisure infrastructure. Therefore, the action by the public power to reestablish the adequate conditions of sanitation to the city and the community becomes an emergency.

Smart landscape architecture has a relevant function in mitigating urban problems, which through it is technology, facilitate and improve the urban landscape risk conditions of extreme natural events due to climate change. Nevertheless, it is application must be supported by innovative technology solutions to promote a more sustainable future for the city and communities.

Computational tools for stormwater management are currently restricted to specific site data, whether at the city, state, or country level (e.g., the National Stormwater Calculator). The rupture of this territorialism concept is an emergency, since the problems arising from natural phenomena are global, whereas, the excesses of one place, causes degradation in others on any scale.

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Evidence Synthesis as an Urban Informatics Tool in Identifying Peri-urban Landscape Typologies at Cavite, Philippines

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Abstract

Peri-urbanisation has altered the present cultural and ecological environment in the desakota region of Cavite, Philippines. This process influences the tangible and intangible values attached to the region's biocultural landscapes. Regardless of its physical and ecological impacts, the process needs evaluation in the case of its rapid effect in landscape production and alteration.

At present, a challenge for urban scholars is to provide a data structure to pieces of evidence that imply the effects of peri-urbanisation to Cavite's landscapes. Being able to address this challenge can create provisions for planning and decision making at this rural-urban fringe. As a method of inquiry to develop the baseline for managing landscape influences of the peri-urban process, the researcher searched for critical findings done to explore the relationship of peri-urbanisation and the landscapes of Cavite, Philippines.

The research inquiry used a structured examination of pieces of evidence developed through a quick scoping review. This approach extracted information that shows spatial and ecological impacts of peri-urbanisation in the form of land cover representations. The composition of results was multifold and took off from studies from various fields – economy, agriculture, geography, anthropology, etc. Through the quick scoping review, the researcher hoped to create a baseline data gathering approach that can enrich Philippines' peri-urban data informatics.

The initial approach for the evidence scoping was the development of the text string protocol to collate pieces of evidence at selected electronic reference databases. It is used to choose relevant studies starting with the selection of geographically relevant references. To further screen the reference list, inclusion and exclusion criteria were added to create a reference list for analysis. This list was filtered and was used to answer the question, how does peri-urbanisation affect the biocultural landscapes at the outskirts regions of Philippine megacities? The result of the quick scoping review showed implications of peri-urbanisation as it identified possible landscape typologies found in Cavite. The resulting findings and analysis from the collation and screening process are relevant in creating a baseline for future

evidence assessment needed to identify the role of the landscape in peri-urban placemaking at the outskirts of Philippine megacities.

Keywords: cultural landscapes, peri-urbanisation, urban-informatics, evidence synthesis, quick scoping reviews

1. Background

The Philippines is highly-urbanised based on its population density. Singru and Lindfield (2014) support this notion by making a morphological analysis of the urban and rural population from 1980 to 2010. From the 37.2% population living in cities

during the 1980's, they saw the increase of 48.9% during 2010 as a vital baseline of the rapid effect of urbanisation in population growth. Getting access to urban cores brings more people closer to highly-urbanised cities and to an extent, affects its outskirts regions as well. In the same report, they emphasised this effect to the outskirts by showing the rapid population growth rate of 3.86% to one of Metro Manila's most adjacent rural-urban region (RUR) of Cavite.

Peri-urbanisation happening in the RUR of Cavite alters the landscape character of Cavite's upland, lowland, and coastal towns. The process restructures Cavite's agricultural "hacienda" landscapes and the Spanish-organized plans of the "pueblos". It also changes the geographically and ecologically significant habitats of the native flora and fauna. It is also essential for the highly-valued visual resources and as an origin of the indigenous customs, beliefs, and practices established by the different settlements that migrate towards the adjacent archipelagic core of Manila ².

Notwithstanding the alterations to the cultural and natural environment, peri-urbanisation also introduces variations to the landscape creating Roe and Taylor's (2014) emerging cultural landscape patterns of the everyday.

The landscape patterns resulting from the peri-urban process in Cavite is arbitrarily written in academic publications as outcome of scientific research projects from other fields of study. These patterns can be pieces of evidence that supply spatial information needed to understand the peri-urban landscape phenomena in Cavite, yet has not been thoroughly investigated in landscape architecture research. This gap in landscape pattern data is consequently looked at as a critical aspect for further research inquiry.

A lack of peri-urban landscape overview at Cavite, Philippines calls for a fact-finding tool that can generate policy and management approaches for the sustainable future of its landscapes. For this type of research inquiry, snowballing literature reviews is typical, but is argued to create unstructured results that gather different references and lowers evidence gathering efficiency. Case study analysis is also ideal for fact-finding but can also be considered to form more evidence bias on the chosen case study results and can exclude some evidence that the researcher may or may not intentionally eliminate. In mapping evidences, the tool should minimize bias and should be structured ⁴ to increase the

confidence to its result. As a possible fact-finding tool, the evidence synthesis (ES) approach through the quick scoping review is applied to test its capability to retrieve and combine scientific information about peri-urban landscapes. In this paper, we follow the ES Approach as a peri-urban informatics tool for extracting and combining scientific information on topics related to the peri-urban landscape of Cavite.

2. Goals and Objectives

This study aims to collate peri-urban landscape information through evidence synthesis. This systematic evidence gathering technique is adapted from the NERC Quick Scoping Review⁴ approach where documentation of references becomes the source of meta-analysis. The following are the evidence gathering objectives:

- Interrogate methodologies and studies done to explore the ecological and cultural relationship of peri-urbanisation to the landscapes of Cavite, Philippines
- Create a structured list that maps pieces of evidence. This systematic map can form the general understanding/ awareness of the peri-urban landscape character at the rural-urban fringe of Cavite, Philippines
- Extract contextual information that states the central issues leading to the changing landscape character of Cavite
- Create a landscape typology list based on the qualitative statements gathered from the final reference screening process

3. Methodology

The systematic search of academic

Table. 1. PICO Framework used to arrange the Query Protocol

literature started with the identification of vital elements used to structure the question. These elements are structured by applying the PICO Framework⁴⁻⁶ which contains the Population, Intervention, Comparison, and Outcome text strings that can be used to create the search strategy. These four elements were generated to define the literature search for the query, *“What landscape typologies exist as pieces of evidence resulting to the altered ecological and cultural landscape valuation at the rural-urban region of Cavite, Philippines?”*. Although serving as a guide, the PICO framework may not capture all the relevant database that contains pieces of evidence to support the query but is hypothesised as a useful tool in minimising biases and raising confidence in the literature list generated by the search string protocol.

Boolean text operators combined the search term matches found to generate screening of literature searches from the PICO framework. These text operators helped in producing a list of literature from the electronic reference database, Google Scholar, last February 5, 2018. With the Boolean text operators, the text string protocol with the search syntax below was generated:

(Philippine* AND Cavite) AND effects AND landscape AND environment “peri-urban”

CODE NO.	AUTHORS	TITLE	DETAILS	TYPE OF RESOURCE	MAIN ISSUES / PROBLEMS/ EFFECTS IDENTIFIED	INTERVENTIONS PROPOSED TO IDENTIFY EVIDENCES (TO CATEGORIZE AND SUMMARIZE)	LAND COVER IDENTIFIED		EVIDENCE SCOPED	REMARKS
							BEFORE	AFTER		
01	Sarriena, Rame	(Google Scholar List)	Publication details	Book	Effects of land-use/ socio-economic changes	Mapping	Landscape Types	Emerging PU Types	Economic / Environmental / Socio-political Structure	
02				Journal Article		Case Study Analysis				
03				Thesis (unpublished)		Survey (Field/ Interviews)				

Table. 2. Sample of the Extraction Table Generated for Gathering Evidences from Literature Reviewed

Because there is a limitation to human resources that are vital in reviewing the precision of the search string, the initial evaluation of search string protocol was presented in an Evidence Synthesis Workshop held in London last February 28, 2018. In this workshop, experts from the Centre for Ecology and Hydrology of the Natural Environment Research Council and other postgraduate participants identified nuances of the search whereby improvements of the search string went in

POPULATION	<i>Landscape Quality; Landscape character; Landscape Typologies</i>
INTERVENTION	<i>Peri-urbanisation - systems, drivers</i>
COMPARATOR	<i>Before/After; With/Without; Current/Old; Countryside/Urban</i>
OUTCOME	<i>New Landscape Typologies ; Ecological Values; Cultural Values</i>

order. In the workshop, a one-to-one consultation was also held to improve the search syntax and additional guidance on the procedure. Thus, a new search was rendered last March 8, 2018:

“(Philippine* AND Cavite) AND (landscape* OR environment* OR ecolog*) AND (quality* OR value*) AND (periurban* OR peri urban* OR peri-urbanisation OR peri-urbanization)”

Added in the search string is the geographic location criteria, “Philippines and Cavite”, to generate location-specific references.

From the 104-paper resulting from the search, four were initially removed for null content.

Inclusion criteria also include resource types that are considered good quality sources most of which are published journals, published PhD thesis and printed books. After setting the inclusion criteria, exclusion criteria were also generated. The exclusion criteria used were:

- (1) No data on the current landscape situation of Cavite,
- (2) No pieces of evidence that show the present peri-urban landscape character of Cavite,
- (3) No content that can be accessed and read for analysis,
- (4) Not in the English Language,
- (5) unpublished work,
- (6) Duplicate copies of published work, and are
- (7) Quoted evidence from other published work; not primary evidence in the text.

83 literature were removed for further analysis leaving 17 relevant papers for review.

An assumption of the evidence review includes the confidence in the online database algorithm that can generate a well-selected reference list. Adding some research not selected during this search (i.e. published books that are not available online and other published journals not obtained by the search string protocol) is suggested in future searches for evidence enrichment.

From the 17 relevant papers that passed the screening criteria, an extraction database resulted in an information list of the

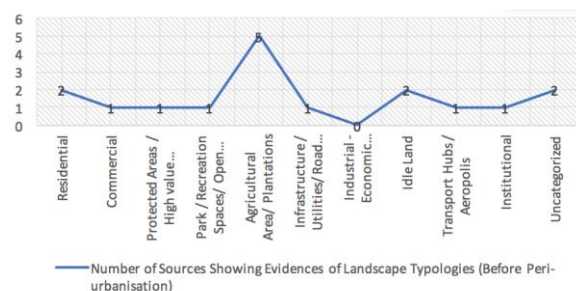
landscape typologies discussed in the reviewed literature.

Each land cover column cannot be counted in

duplicates per paper assessed, i.e. residential character evidence on one article, regardless of duplication and repetition within the text, shall be counted as one in the tally chart. Therefore, the maximum number of results per category shall only be 17 which is the total number of final papers assessed.

After tallying the number of statements stating different land cover, the next step included the modelling of textual results into possible drivers, landscape forms, and landscape

Fig. 1. Number of Sources showing Land Cover Classification as affected by the peri-urban process



descriptions. The results are listed to be able to reclassify the types within the identified 11 land cover types. This approach enriches the list with a more comprehensive report of emerging landscape typologies.

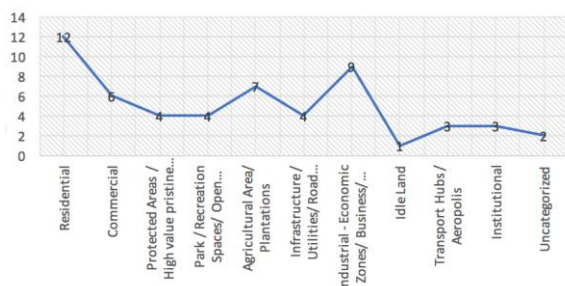
4. Results and Data Analysis

11 major land cover types as

guided by the Philippines' landcover categorisation⁷ infers a representation of the 11 categories in peri-urban Cavite based from the 17 texts reviewed. The land cover

Fig. 2. Number of Sources showing Land Cover Classification before the peri-urban process

classification used in identifying land typologies were: Residential, Commercial, Protected Areas, Agricultural Areas, Infrastructure/ Utilities, Industrial/Economic Zones, Idle Land, Transport Hubs, Institutional, and Uncategorized.



The landscape character based on 17 reviewed texts imply present attachment of migrating population to Cavite as a residential/settlement location. The driver of actors towards Cavite shifted the land cover from being highly agricultural^{2,8-12}. It also connects it to its present highly residential character dominated by new towns, gated subdivisions, and resettlement housing developments^{8-11,13-16}.

Another highly relevant implication of the references reviewed is the attachment of Cavite to its industrial land-use by the appearance of business process outsourcing developments, export and manufacturing oriented economic zones. Being the second highly cited land cover character implies the close attachment of Cavite’s placeness to this type of industry. This type of land cover offers not just a driver of change to large plots of lands that were idle or once considered agricultural but also affect the periphery as it attracts services needed by the population working in the industries. As

an effect, availability of food, shelter, and transport connectors are also being built within or near its vicinity.

Entirely a revelation was to see that Cavite is still closely related to its agricultural character as it ranked third in the number of evidence generated. Despite the desperate attempt to connect Cavite to its new market of migrants that live in settlement location within the region, some of the authors still closely associate Cavite to its “hacienda” plantation roots.

After gathering the 11 land cover classification from the Coding Extraction Table (See Table 2.0), some of the texts were then reclassified to create a more detailed Peri-urban Landscape Typologies. The researcher started with the results of the residential land cover types. The results were categorised according to two characteristic patterns: patterns of land management and patterns of spatial forms. The following were peri-urban landscape typologies coded from the residential text categorization:

CODE	PERI-URBAN LANDSCAPE TYPOLOGY / CLASSIFICATION
P001	Developer-managed New Town Subdivision Designed Landscapes
P002	Developer-managed Retreat / Summer Homes / Rest Homes Designed Landscapes
P003	Non-Government Organisation – initiated Resettlement Village Landscapes
P004	Necklace / Corridor-driven Landscapes of the Dispersed

	Residence / Village
P005	Necklace / Corridor-driven Landscapes of Informal Settlements
P006	Employer-driven Informal Settlement Landscapes
P007	Employer-driven Rental / Dormitory Housing Village Landscapes

The industrial texts were coded to reveal a possible landscape classification that is economic zone oriented and IT park oriented. With the labour character, quite distinct in these two development types, landscapes are also hypothesised to adapt to the needs of two types of employee and investor market.

CODE	PERI-URBAN LANDSCAPE TYPOLOGY / CLASSIFICATION
P008	Landscapes of the Export and manufacturing oriented Economic Zones / Estates
P009	Landscapes of the Business Processing Outsourcing (BPO's) – Information Technology (IT) Parks

Other landscape typologies reveal the following:

- (1) Landscapes of the agriculture and aquaculture plantations;
- (2) Landscapes of the old markets, massive commercial developments and the smallest “sari-sari” convenience stores;
- (3) Landscapes that are driven by landform-dominated natural habitats;

- (4) Amenity landscapes of the sports-initiated golf developments and leisure parks;
- (5) transport-driven landscapes of various corridor types;
- (6) landscapes of new and old town institutional nuclei; and the
- (7) enveloped areas and the idle lands.

A total of 29 land typologies were initially considered by the researcher to move forward to mapping the peri-urban landscape phenomena happening in Cavite, Philippines.

CODE	PERI-URBAN LANDSCAPE TYPOLOGY / CLASSIFICATION
P010	Landscapes of the Agricultural Plantations / Farm Estates
P011	Landscapes of the Aquaculture Plantations
P012	Commercial and Retail District Designed Landscapes
P013	Local Wet and Dry Market Streetscapes
P014	Convenience-driven Streetscapes of the “Sari-sari” Stalls
P015	Volcanoscapes
P016	Waterscapes (Lakes, Rivers, etc.)
P017	Coastal Landscapes (beach, sea, reef, etc.)
P018	Upland Mountainscapes
P019	Amenity Landscapes of Golf Country Club Developments
P020	Amenity Landscapes of Leisure Parks
P021	Streetscapes of Connectivity Corridors (Highways,

	Expressways, etc.)
P022	Transport-Driven Landscapes of Ports and Naval Towns
P023	Transport-Driven Landscapes of Aerotropolis / Airports / Air Base Towns
P024	Transport-Driven Landscapes of Local Transport Hubs (Jeepneys, Tricycle, FX, Van, Etc.)
P025	Landscapes of Historical / Old Town Centre
P026	Landscapes of New Town Centres / New Institutional Hubs
P027	Landscapes of New School/ Spiritual Districts
P028	Landscapes of Envelopment / Enveloped Areas
P029	Idle Land

5. Evidence Summary and Conclusion

Albeit the limited references demonstrating a more direct analysis of the changing landscape in Cavite, pieces of evidence from the field of geography, agriculture, economics, and urban studies indicate its effect. In the references scoped, the peri-urban landscape is contextualised in landcover types and not precisely according to its functions and uses as space and place. It may reveal the physical, tangible patterns, but lack a more intangible value characterisation as the attempt to ascribe meaning to the landscapes is not the primary goal of the kinds of literature reviewed. It, therefore, revealed an effort to ascribe attributions on what authors see rather than

in what the stakeholders reflect upon or attribute to their landscape.

Relevant studies can be added to the reference scoped to support the landscape character codes generated. There is a gap in written publication seeing the landscape as a possible mirror of the effects of peri-urbanisation in the cultural and ecological environment. To answer the differences, more books that were not included in the online search and perhaps, a new Boolean operator may be used for a series of query to identify other possible unique references.

There is also difficulty in attributing landscape type per category as cooperation and further discussion with stakeholders and other tools to identify the landscape types can improve the typology list and improve the evidence base on this topic. A cross-examination and dialogues to enhance the search strings can, therefore, be done again to funnel more findings to support the coding approach.

Overall, Evidence synthesis can be a tool to generate answers to queries related to the landscape, but should be further supported by other landscape mapping tools and interventions to generate less bias and create a more grounded, well-evidenced result.

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7. Appendix

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CO DE NO.	Reference Information / Citation	Type of Resources
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02	Boquet, Y. (2017a) Farm Productions and Rural Landscapes. The Philippine Archipelago. Switzerland: Springer International Publishing.	Book Section

03	Boquet, Y. (2017b) The Growth of Greater Manila. The Philippine Archipelago . Switzerland: Springer International Publishing	<i>Book Section</i>
04	Connell, J. 1999. Beyond Manila: Walls, Malls, and Private spaces. Environment and Planning A , 31(3): pp.417-439.	<i>Journal Article</i>
05	E.A., E., Acosta, L. A., Enano, N. H. J. & Magcale-Macandog 2016. What Influences Awareness of Farmers on Sustainability of Bioenergy Feedstock in the Philippines? Asia-Pacific Network for Global Change Research Science Bulletin , (6): pp.	<i>Journal Article</i>
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08	Kelly, P. F. 2013. Production networks, place and development: Thinking through Global Production Networks in Cavite, Philippines. Geoforum , (44): pp.82-92	<i>Journal Article</i>
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11	Mojares, J. G. 2013. Urbanization and its Effect in the Calabarzon Area. Journal of Global Intelligence and Policy , 6(10): pp.24-40	<i>Journal Article</i>	14	Rivera, F. T., Alviola, P. A., Sombilla, M. A. & Cataquiz, G. C. Integrated Crop-animal Systems in Rainfed Rice Lands: A Philippine Study. In: SOMBILLA, M. A. & HARDY, B., eds. Integrated Crop-animal Systems in Southeast Asia: Current Status and Prospects, 2005 Philippines. International Rice Research Institute, 153-186.	<i>Journal Article</i>
12	Ortega, A. A. C. (2012) Building the Filipino Dream: Real Estate Boom, Gated Communities and the Production of Urban Space . PhD, University of Washington.	<i>Published PhD Thesis</i>	15	Villanueva, R. H. (2010) The Human Endeavor of Intentional Communities: The Gawad Kalinga Movement . Doctor of Philosophy, University of Arizona.	<i>Published PhD Thesis</i>
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Landscape Health Assessment Index Using Nature Sounds: A Methodological Summary of Soundscape Mapping Design for the Preservation and Conservation of Natural Soundscape

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Abstract

Unwanted sound or noise can very much damage one's psychological health like [1] hypertension, high stress levels, tinnitus, hearing loss, sleep disturbances and other harmful effects. Specifically, it can also pose physiological changes to wildlife like increased heart rate, body shifting and wastage of stored energy, panic and escape behavior, avoidance of habitat and unattractiveness to mate. From all of these, the need to study and preserve natural soundscape comes into play. Natural soundscape, as concluded by many scientific studies can provide a good escape from noise pollution in the metro, thus, preservation and conservation of natural soundscape as a biophilic approach in designing and planning urban designs tapped new urban informatics and methodological analysis beneficial for the modern age metropolitan.

[2] One of the perspectives of the evaluation of ecological significance focuses on the conservation of the biological diversity, an exemplary innovations is the use of acoustic recordings to monitor spatial-temporal wildlife activities. The chosen study site was plotted in a map using the triangulation network. A total of thirty sites were selected to conduct the bioacoustics recordings. Collection of acoustic samples lasted for 16 weeks. This interval allows the researcher to keep track of the bioacoustics produced by the presence of wildlife. The microphone selected had the capacity to capture the acoustic frequency range from 20 to 14,000 Hz which covers most songs and calls in the study area. The recordings were converted into digital formats for the quantification and analysis of the soundscape. After the researcher analyzed the forty wetland areas, the landscape assessment scaling index was determined by comparing the computed Simpson's index and frequency and sound dynamics of the different areas. This landscape index are arranged using ten colors, red being the lowest soundscape level and white having the highest soundscape level. These colors correspond a particular Simpson's Index value which can be used to assess a particular habitat area. Soundscape maps

corresponding each 16-week soundscape recording were then plotted to test the efficacy of the proposed health assessment index.

This study takes a scientific and mathematical approach in measuring landscape health using the researcher’s specifically-designed Landscape Health Assessment Index. It is strongly believed that through the strategic investigation of soundscape ecology, thorough exploration of ecological characteristics of sounds and their spatial-temporal patterns as they emerge from landscape can share considerable parallels of effects and changes within the landscape ecology. This study further investigates these changes and soundscape ecologies that may be beneficial to help study, assess, record and analyse landscape status and conditions that can be utilized as an important factor in creating, conserving, preserving, designing and managing ecologically significant areas. The focus of finding a new landscape measuring tool allows this research to come up with indices that can be applied to various ecological typologies and situations, thus, this new methodological approach of landscape mapping can be very beneficial in designing biophilic smart cities.

Keywords: Soundscape Mapping; Soundscape Preservation; Natural Soundscape; Ecological Services; Landscape Health Assessment Tool

1. Determining Standard Soundscape Level

To compare the efficiency of the proposed landscape standards for natural soundscape level, the researcher determined the benchmark that served as guideline for landscape health assessment. The target site was chosen through the investigation and selection of a healthy wetland and measured the soundscape present within that site. [3] The traditional normal counting system was used first to assess the health of chosen wetland sites within the Cavite province and computed for its biodiversity using Simpson’s Diversity Index. The comparison include forty wetland areas and divided into two groups to come up with a strong claim and comparative soundscape levels. The results were then interpreted and compared to determine the average soundscape level produced from a healthy wetland. This numeric standard will be used as a guideline to assess the thirty selected sample study area and produced the soundscape map to help analyze the condition, problems, needs

and probable solutions to the anthropogenic noise present within the adjacencies of the site.

The following steps were meticulously conducted by the researcher to determine the standard soundscape measure / level a particular healthy wetland can produce.

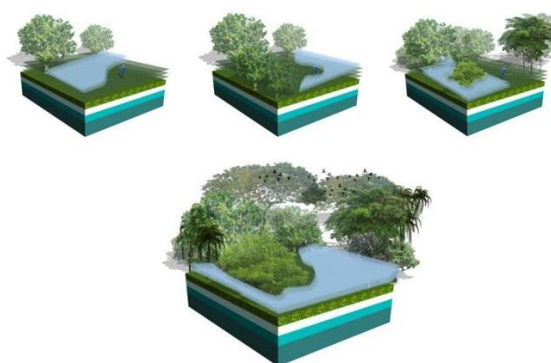


Fig 1. To determine the standard soundscape level of a healthy wetland environment, forty wetland environments were located and compared. This step allows the researcher to assess and compare results in various factors and analyze these results

to derive the target landscape health assessment index.



Fig 2. Locate the healthiest wetland environment by examining the present tree species and compute for biodiversity using Simpson's Diversity Index. This step provided the researcher the knowledge about the certain acoustic level or sound dynamics a particular wetland can produce. By locating the healthiest wetland, the researcher determined the standard and maximum acoustic level that can be produced.



Fig 3. The soundscape level were recorded from the samples of different wetland environment to determine the degree of loudness and or softness (pertains to sound

dynamics) of biophony a particular wetland can produce. The study of different wetlands with different health status allowed the researcher to compare and analyze clearly the existing and varying sound dynamics among these wetland environments and determined the related intervening factors.

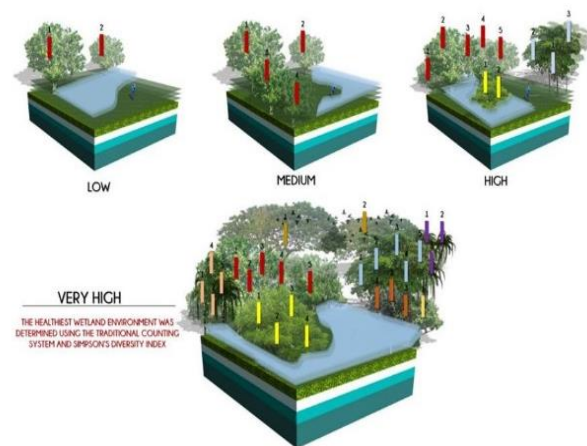


Fig 4. The standard soundscape level produced by the healthiest wetland environment was recorded and used the numeric output as a basis of a natural soundscape produced by a healthy wetland.



Fig 5. The two healthiest wetland environment were compared in terms of their soundscape levels in order to verify the determined standard acoustic level after the investigation and comparative analysis.

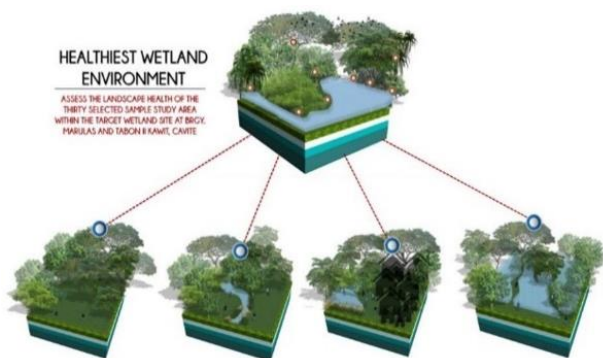


Fig 6. Landscape health assessment of the thirty selected sample study area within the target site.

2. Instruments Used:

This research study was conducted at Brgy. Marulas and Tabon II, Kawit Cavite and a degraded wetland with adjacent underutilized parcels of lands were chosen as the target site for this investigation. The site was plotted in a map using triangulation network. This mapping system was used since the site is large in scale and is normally used for surveying big areas.

A total of thirty (30) sites were selected to conduct the bioacoustics recordings. Most of the target areas of the site were a collection of underdeveloped parcels of lands and wetland edges with small number of woodland areas and riparian areas. The middle of wetland areas and adjacencies like commercial, residential

and institutional establishments were also surveyed and recorded.

Acoustic samples were collected during Saturdays and Sundays from the 29th of August until 18th of October, 2016. This interval allows the researcher to keep track of the bioacoustics produced by the presence of wildlife. The chosen weekend dates were strategically investigated and carefully examined without severe weather conditions to minimize the background noise of the sounds produced by the environment. At each 30 areas within the site, an acoustic recording was deployed. The recording technology used was powered by Omni-directional boundary microphone (Model 330-3020, RadioShack Co.). [3] The microphone selected had the capacity to capture the acoustic frequency range from 20 to 14,000 Hz which covers most songs and calls in the study area. Each acoustic unit was set to record 3-min duration, three times in the morning during 5:00, 6:00 and 7:00 am, and another three times during the evening, 5:00, 6:00 and 7:00.

[4] The recordings were converted into digital formats for the quantification and analysis of the soundscape. Since the maximum frequency range of the microphone was 14 kHz, it was necessary to digitize the sound samples at a sampling rate to avoid aliasing. Each recording was divided into six 30-s sound clips. The first 2 clips and the last one were removed and only the 3 middle clips were analyzed. This was done to minimize interference due to mechanical sounds and other hindrances.



Fig 7. Map showing 30 selected sample study area from Barangay Marulas and Tabon II, Kawit, Cavite, Region IV-A, Luzon, Philippines.

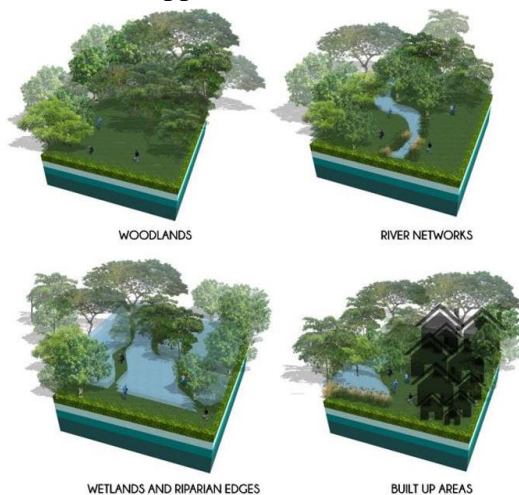


Fig 8. Four common typologies of the 30 selected sample study area.

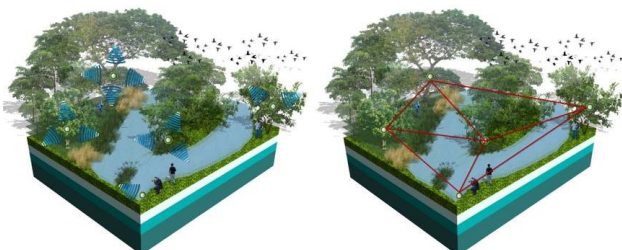


Fig 9. The different locations of the recorder (left) allows the recording of biophony well-distributed and well-represented for the mapping analysis. The triangulation network (right) provided an imaginary representation of the map as a boundary and scope for every selected sample study areas.

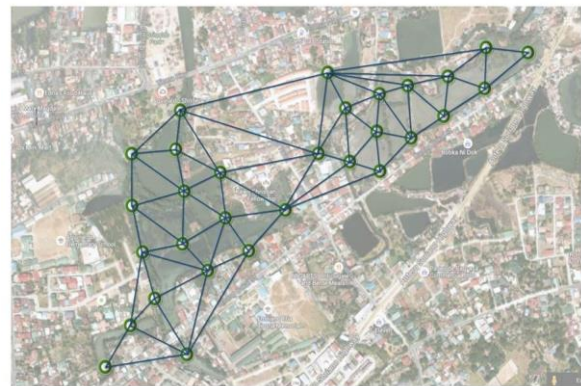


Fig 10. The product of triangulation network of the selected 30 sample study areas.

3. Statistical Tool Used

[5]The researcher used the formula Simpson's Diversity Index to determine the healthiest wetland environment among the ten wetlands sample found at Cavite Province. Through the use of this formula, the wetland with the healthiest assessment in terms of biodiversity was set as the standard wetland and its soundscape level was recorded and compared to other healthy wetland environment from the two studied groups.

[6]Since the Simpson's formula is widely used for measuring habitat diversity, it is also a good measure to determine the healthiest wetland from the sample by taking into account the present species and the

abundance of each species. Furthermore, Simpson's Index (D) measures the probability that two individuals randomly selected from a sample will belong to the same species (or some category other than species). There are two versions of the formula for calculating D, either is acceptable but consistency should also be considered. The value of this index ranges from 0-1 which indicates that the greater the value computed, the greater the diversity present.

$D = \sum (n / N)^2$	$D = \frac{\sum n(n-1)}{N(N-1)}$
<small>n = the total number of organisms of a particular species N = the total number of organisms of all species</small>	

4. Presentation of Results from the Gathered and Computed Biodiversity Index of the Forty Wetland Areas

The forty wetland areas were located and studied by the researcher in order to determine the standard soundscape level a particular wetland habitat can produce. These chosen forty wetland areas were compared using their biodiversity characteristics via Simpson's Diversity Index, Simpson's Index of Diversity and Simpson's Reciprocal Index. Here is the presentation of the gathered results from the landscape biodiversity assessment using the traditional counting system method.

See Table 1. Biodiversity of the Forty Wetland Areas using Simpson's Index

Table 1 shows the computed Simpson's Index using three indices: Simpson's Index, Simpson's Diversity Index and Simpson's Reciprocal Index. Each index

has different analysis and interpretation. For the Simpson's Index, the lower the value computed, the more diverse the environment. For the Simpson's Diversity Index and Simpson's Reciprocal Index, the higher the value, the habitat is considered as more diverse.

Results showed that habitats from swamps area had the lowest Simpson's Index with 0.06 index followed by another swamp area with 0.01 index. The third and fourth most diverse habitat was comprised with marshland areas with index of 0.12 and open water with 0.15. On the other hand, the wetland areas like riverside had the lowest index of 0.35 and for the shallow water, an index of 0.23. The interpretation for Simpson's Diversity Index and Simpson's Reciprocal Index also indicated the same results with swamps areas as the most diverse habitat followed by wetland areas and open water respectively. Areas at the riverside and adjacent to open water ranked last, respectively.

According to the survey and inventory conducted among the 40 wetland areas, the swamps also had the highest number of recorded trees with a total of 37 trees species, followed by marshlands with 34 recorded trees species and 29 trees species were tallied from all the open water areas. Riverside areas had 13 trees species present at the site while the shallow water had 10 total recorded trees species.

5. Presentation of Results from the Gathered Soundscape of Forty Wetland Areas

See Table 2. Results of the Recorded Soundscape of the Forty Wetland Areas

After the soundscape of the forty wetland areas were recorded, the analysis of each significant sound materials were converted to digital format and analyzed using Spectrum Lab, a sound analyzer and visualizer software. As shown from the table, swamp areas garnered the highest soundscape level with frequency of 2500-4000 Hz and soundscape dynamics of 58-64 db and a total of 68 soundscape recorded activity. It was followed by marsh areas with frequency at 2500-3500 Hz, sound dynamics of 48-52 db and a total of 63 soundscape activities. Marshlands were followed again by open water areas with the highest frequency of 2000-2500 Hz and sound dynamics of 46-50 Hz and a total of 55 recorded activities. The riverside ranked next with a frequency of 1500-200 Hz, 29-33 db and 53 recorded aural activities. Lastly, the shallow water areas with a frequency of 1500-2000 Hz, 15-23 db and 36 tallied aural activities.

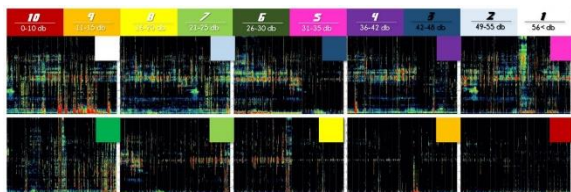


Figure 11. Proposed landscape health assessment index and scaling using soundscape level.

After the researcher analysed the forty wetland areas, the landscape assessment scaling index was determined by comparing the computed Simpson's index and frequency and sound dynamics of the different areas. This landscape index are arranged using ten colours, red being the lowest soundscape level and white having the highest soundscape level. These colours correspond a particular Simpson's Index value which can be used to assess a particular habitat area. For instance, a particular wetland area produced a 31-35 db of soundscape dynamics, its colour pink (Scale 5) has a particular correspondence which tells something about the area's health. Through the recordings of these soundscape present in particular site, landscape healthy assessment can now be conducted in a much faster and more efficient way.

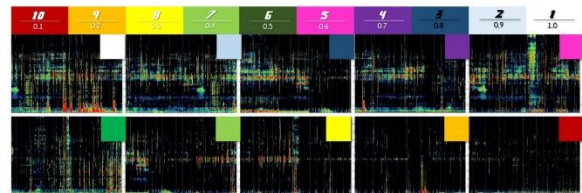


Figure 12. Proposed Landscape Health Assessment Index after the Investigation of the Forty Wetland Areas studied by the researcher.

Figure 12 shows that the colour scheme of the proposed landscape index has a corresponding value of the Simpson's Index of Diversity. Remember that as the value gets higher, the more diverse the habitat is, thus, the healthier the ecosystem can be.

This proposed landscape health index were applied to the target site. Using the 30 sample study area with varying typologies and wetland environment, the researcher determined the status of the landscape health and determined which areas have high soundscape level to integrate in the final design.

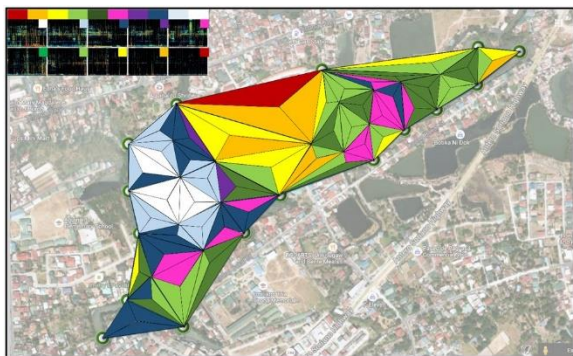


Figure 13. Application of landscape health index to the 30 sample study area. First recordings.

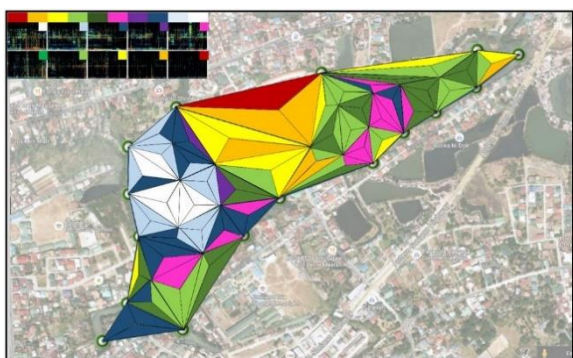


Figure 14. Application of landscape health index to the 30 sample study area. Second recordings.

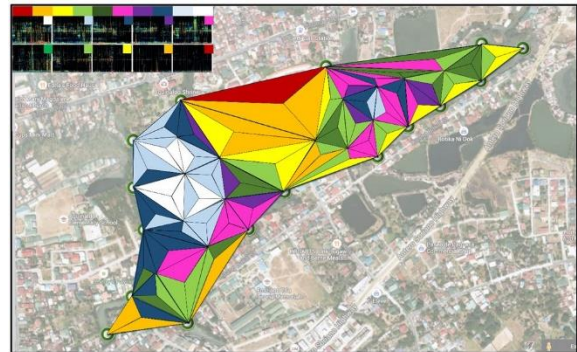


Figure 15. Application of landscape health index to the 30 sample study area. Third recordings.

6. Application of the Proposed Landscape Health Assessment Index to Landscape Design and Spatial Planning

One of the cores of the study is to find easier and more efficient way of assessing landscape health through the use of present nature sounds. After studying forty wetland areas and deriving the proposed landscape health assessment index, the researcher was able to determine on how to possibly apply the index to multiple disciplines, especially in landscape and spatial planning.

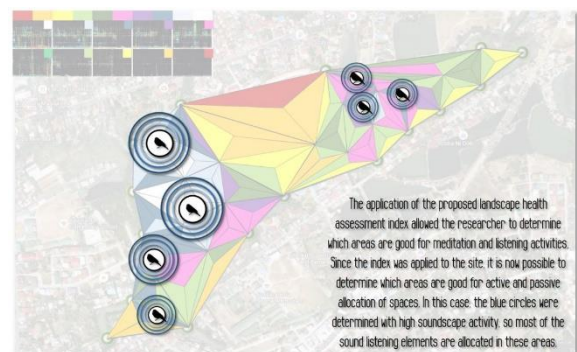


Figure 16. Application of the proposed landscape assessment index. Determination of areas with good soundscape activity.

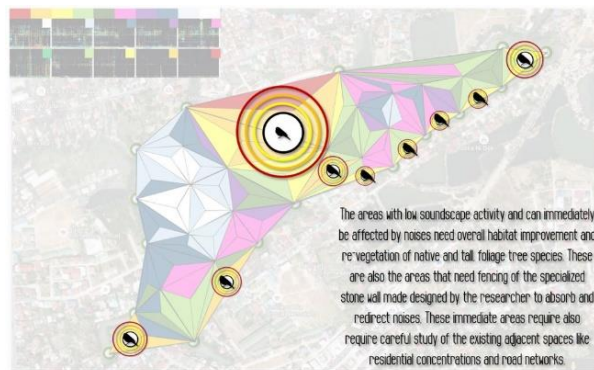


Figure 19. Application of the proposed landscape assessment index. Determination of areas that need overall habitat improvement and re-vegetation.

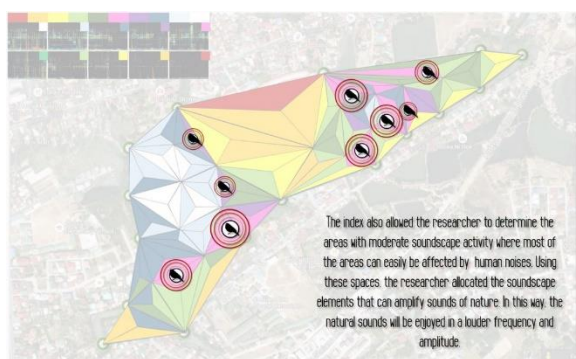


Figure 17. Application of the proposed landscape assessment index. Determination of areas with moderate soundscape activity.

Figures 16-19 shows how the proposed landscape health assessment index was applied in the chosen target site.

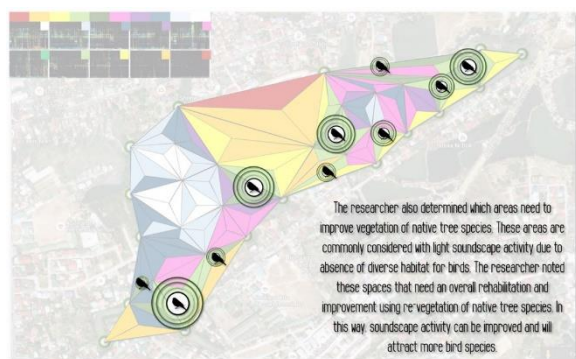


Figure 18. Application of the proposed landscape assessment index. Determination of areas that need to improve vegetation of native tree species.

Figure 16 discusses how to areas with good soundscape activity can be utilized into actual landscape spaces. Using the index, a sample landscape plan was specifically designed to listen and maximize the surrounding soundscape potential of the vicinity of the area. Figure 17 shows which area has moderate soundscape activity that can suggest how designs should focus on preserving and improving the site's soundscape potential. Figure 18 on the other hand, shows which areas require immediate improvement of vegetation and introduction of more native tree species while Figure 20 suggests which areas need overall habitat improvement and re-vegetation.

See Figure 20. Proposed Landscape Design for Brgy. Marulas, Kawit, Cavite,

Philippines Envisioned to be World's First Soundscape Park.

See Figure 21. Proposed Smart Soundscape Planning Design for Kawit, Cavite, Philippines Derived from the Researcher's Landscape Health Assessment Index for Preservation and Conservation of Natural Soundscape.

See Figure 22. Sieve Analysis Designed to Determine Natural Soundscape Potentials and its Preservation and Conservation Measures

7. Conclusion

This research study mainly focused on the preservation of natural of soundscape using landscape architecture standards and landscape design. After a series of compilation of case studies, online researches, bioacoustics recordings and finalization of site development plan, the researcher concluded that the preservation of the natural soundscape can be summarized into three parts namely soundscape management through vegetative studies, integration of mimetic biophony and reduction of noise stress levels through landscape elements and design.

This study takes a scientific and mathematical approach in measuring landscape health using the researcher's specifically-designed Landscape Health Assessment Index. It is strongly believed that through the strategic investigation of soundscape ecology, thorough exploration

of ecological characteristics of sounds and their spatial-temporal patterns as they emerge from landscape can share considerable parallels of effects and changes within the landscape ecology. This study further investigates these changes and soundscape ecologies that may be beneficial to help study, assess, record and analyze landscape status and conditions that can be utilized as an important factor in creating, conserving, preserving, designing and managing ecologically significant areas. The focus of finding a new landscape measuring tool allows this research to come up with indices that can be applied to various ecological typologies and situations, thus, this new methodological approach of landscape mapping can be very beneficial in designing biophilic smart cities.

With the use of the Proposed Landscape Assessment Index, the researcher was able to come up with multiple design strategies and spatial planning standards that will not only be beneficial in both preserving and conserving natural soundscape but also to design a soundscape park that helps users on how to train their ears with the natural soundscape present around them. The immense benefits of soundscape to human have been a subject to several studies, and although this research does not necessarily focus on that, the researcher highly believed that the Index can provide multi-disciplinary actions not only in the field of landscape architecture and urban planning but also to health and nutrition, policy making, environmental ethics and law, ornithological and bioacoustics studies and many more.

8. Recommendations

In order to further improve this research study on soundscape preservation, the researcher recommended the following:

1. Provide more related literature focusing on the reduction of noise stress levels using both architecture and landscape architecture designs in order to design a multitude noise reduction strategy and scheme.
2. Conduct an in-depth analysis and research on the effects of amplification of biophony to different wildlife species.
3. Discover other good sources of biophony such as amphibians and reptiles in order to further study the elements of soundscape ecology.
4. Apply the proposed landscape strategies and designs in a more diverse and busier urban environment.
5. Conduct a more specialized and detailed landscape elements proposal focusing on the hardscape materials installation and construction like the floating bridges, constructed grasslands and the proposed specialized stone walls.
6. Integrate the conceptual framework to other design application, especially in form finding and form composition, in order to prove the effectiveness of the proposed framework.
7. Study on other bird species present not only in the province of Cavite but also to the other bird congregations found in the Philippines.
8. Record more biophonic samples from different parts of the Philippines in order to standardize the proposed landscape health assessment index.
9. Provide a more specialized plant list focusing on the proposed planting design with deflecting, absorbing and reflecting vegetation buffer.

Table 2. Results of the Recorded Soundscape of the Forty Wetland Areas

WETLAND	TYPE	D	FREQUENCY	SOUND DYNAMICS	RECORDED AURAL ACT.
1	SHALLOW WATER	0.23	1500-2500HZ	35-44 DB	35
2	SWAMP	0.66	2500-4500HZ	59-64 DB	68
3	MARSH	0.3	500-3000 HZ	26-33 DB	56
4	MARSH	0.12	500-3000 HZ	46-58 DB	52
5	SWAMP	0.1	2500-4000HZ	48-52 DB	66
6	OPEN WATER	0.15	1500-2000 HZ	49-50 DB	38
7	OPEN WATER	0.29	1000-5000 HZ	22-28 DB	42
8	MARSH	0.19	2500-3000 HZ	34-38 DB	54
9	SHALLOW WATER	0.46	1500-2500 HZ	15-22 DB	25
10	SHALLOW WATER	0.35	1000-5000 HZ	25-31 DB	33
11	SHALLOW WATER	0.23	1000-5000 HZ	33-35 DB	36
12	SHALLOW WATER	0.54	500-1000 HZ	15-23 DB	28
13	OPEN WATER	0.38	1000-5000 HZ	22-27 DB	35
14	SWAMP	0.28	2500-3000 HZ	35-41 DB	56
15	RIVERSIDE	0.47	500-1000 HZ	22-29 DB	46
16	RIVERSIDE	0.55	500-1500 HZ	25-33 DB	52
17	MARSH	0.15	2500-3000 HZ	35-43 DB	58
18	MARSH	0.26	3000-2000 HZ	33-38 DB	49
19	RIVERSIDE	0.41	1000-5000 HZ	25-29 DB	33
20	MARSH	0.36	1500-2500 HZ	22-28 DB	45
21	SWAMP	0.32	1500-2500 HZ	35-42 DB	55
22	SHALLOW WATER	0.43	1000-5000 HZ	25-28 DB	48
23	SWAMP	0.24	2500-3000 HZ	35-42 DB	63
24	SHALLOW WATER	0.39	1000-5000 HZ	22-28 DB	46
25	SHALLOW WATER	0.5	1000-5000 HZ	15-23 DB	36
26	SWAMP	0.38	2000-2500 HZ	35-44 DB	53
27	MARSH	0.2	2000-2500 HZ	39-46 DB	66
28	RIVERSIDE	0.35	1500-2000 HZ	29-33 DB	53
29	MARSH	0.38	2000-2500 HZ	39-42 DB	49
30	OPEN WATER	0.71	500-1000 HZ	12-18 DB	38
31	OPEN WATER	0.23	500-1000 HZ	11-19 DB	35
32	MARSH	0.65	1000-5000 HZ	15-20 DB	39
33	MARSH	0.35	1500-2000 HZ	36-39 DB	60
34	MARSH	0.19	2500-3500 HZ	45-50 DB	63
35	MARSH	0.5	2500-3500 HZ	22-28 DB	53
36	SWAMP	0.29	3000-3500 HZ	39-45 DB	59
37	OPEN WATER	0.21	3000-3500 HZ	37-40 DB	60
38	RIVERSIDE	0.36	1000-5000 HZ	28-33 DB	49
39	OPEN WATER	0.25	2500-3500 HZ	38-43 DB	58
40	SWAMP	0.25	2500-3500 HZ	38-49 DB	46

LEGEND:

S	NUMBER OF SPECIES
N	NUMBER OF FLORA IN EACH SPECIES
D	SIMPSON'S INDEX
1-D	SIMPSON'S DIVERSITY INDEX
1/D	SIMPSON'S RECIPROCAL INDEX

3	MARSH	5	56	514	0.3	0.7	3.37	3	2
4	MARSH	10	103	1250	0.12	0.88	8.41	7	3
5	SWAMP	11	126	1504	0.1	0.9	9.9	9	2
6	OPEN WATER	7	113	1160	0.15	0.95	6.73	6	1
7	OPEN WATER	4	76	1659	0.29	0.71	3.44	4	0
8	MARSH	9	104	2016	0.19	0.81	5.31	6	3
9	SHALLOW WATER	4	51	1512	0.46	0.54	2.19	3	1
10	SHALLOW WATER	3	182	12012	0.35	0.65	2.833	0	3
11	SHALLOW WATER	6	95	2176	0.23	0.77	4.1	3	3
12	SHALLOW WATER	2	126	6480	0.54	0.46	1.86	0	2
13	OPEN WATER	5	136	6992	0.39	0.62	2.66	3	2
14	SWAMP	5	115	3694	0.28	0.72	3.611	2	3
15	RIVERSIDE	4	130	7864	0.47	0.53	2.13	1	3
16	RIVERSIDE	3	32	562	0.56	0.43	1.76	2	1
17	MARSH	7	114	2012	0.15	0.85	6.27	2	5
18	MARSH	3	79	1626	0.26	0.74	3.79	0	3
19	RIVERSIDE	4	65	1718	0.41	0.59	2.42	2	2
20	MARSH	6	97	3314	0.36	0.64	2.89	4	2
21	SWAMP	5	57	1050	0.32	0.68	3.03	3	2
22	SHALLOW WATER	4	92	3506	0.43	0.58	2.33	2	2
23	SWAMP	6	102	2482	0.24	0.76	4.23	3	3
24	SHALLOW WATER	4	64	1614	0.39	0.61	2.57	2	2
25	SHALLOW WATER	2	87	3758	0.5	0.5	2	0	2
26	SWAMP	4	101	3960	0.38	0.62	2.62	2	2
27	MARSH	6	92	1750	0.2	0.8	4.9	2	4
28	RIVERSIDE	3	59	1218	0.35	0.75	2.81	0	3
29	MARSH	5	130	6523	0.38	0.62	2.63	4	1
30	OPEN WATER	2	47	1538	0.71	0.29	1.41	0	2
31	OPEN WATER	7	114	3008	0.23	0.77	4.28	5	2
32	MARSH	4	35	394	0.66	0.33	3.02	1	3
33	MARSH	3	26	232	0.36	0.64	1.55	2	1
34	MARSH	5	29	154	0.19	0.81	5.27	5	0
35	MARSH	2	21	212	0.5	0.5	2	1	1
36	SWAMP	5	51	760	0.29	0.71	3.35	4	1
37	OPEN WATER	7	72	1051	0.21	0.79	4.95	5	2
38	RIVERSIDE	3	42	632	0.36	0.64	2.72	1	2
39	OPEN WATER	5	78	1510	0.25	0.75	3.4	4	1
40	SWAMP	4	36	318	0.25	0.75	3.96	3	1

Figure 20. Proposed Landscape Design for Brgy. Marulas, Kawit, Cavite, Philippines Envisioned to be World's First Soundscape Park.

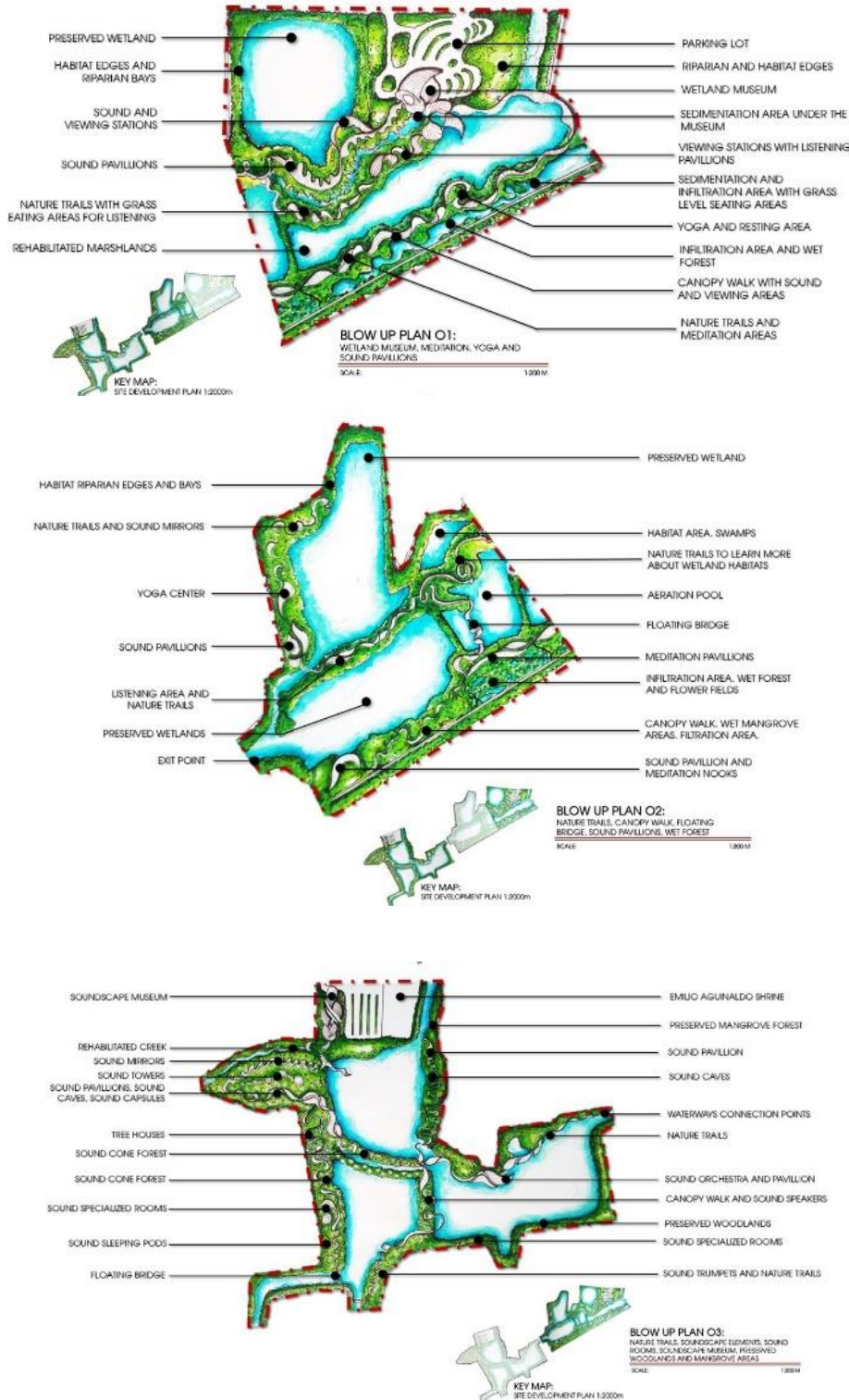


Figure 21. Proposed Smart Soundscape Planning Design for Kawit, Cavite Philippines, Derived from the Researcher's Landscape Health Assessment Index for Preservation and Conservation of Natural Soundscape.

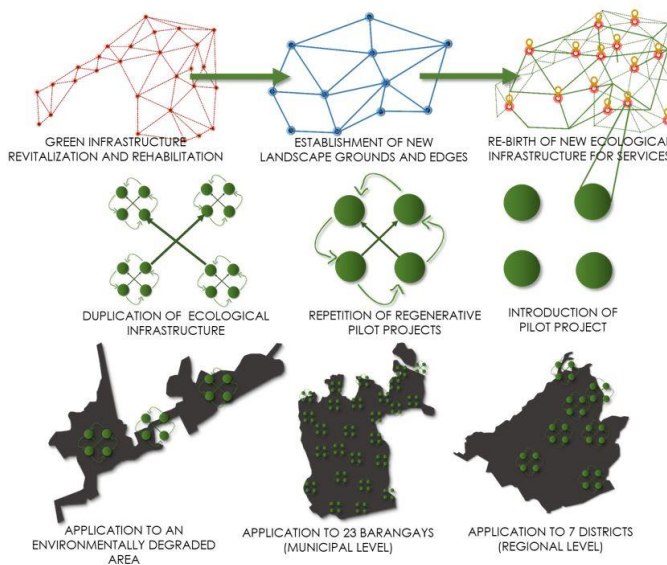
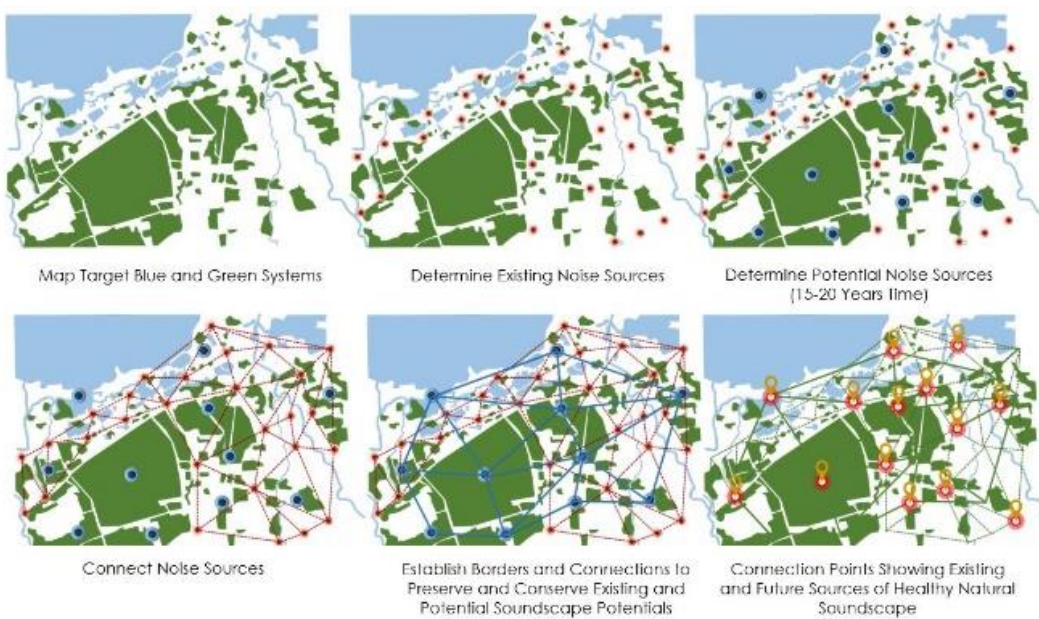


Figure 22. Sieve Analysis Designed to Determine Natural Soundscape Potentials and its Preservation and Conservation Measures



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Assessment of Online Public Opinion on Historical Gardens: A Case Study of the Humble Administrator's Garden in China

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Abstract

This paper presents an assessment framework to transform online public opinion on Chinese historical gardens into sentimental and topical indicators for rethinking and enhancing practices of public participation. Web crawlers were employed to gather online comments, and two natural language processing technologies, including sentiment analysis and topic modeling, were used to transform these comments into indicators for subsequent analysis. The Humble Administrator's Garden (HAG), which is a time-honored Chinese traditional garden and a world cultural heritage site in China, was selected as a case study for demonstrating the effectiveness of the proposed framework. In terms of 16092 comments collected from Chinese famous travel review sites, the assessment results illustrate key topics with different sentiments as well as summarize issues about management and tourists' experience. This framework can help policy-makers and landscape architects in potential decision-making in relation to the HAG, and is expected to be widely applied as a bottom-up strategy to assess public opinion in the ex-post evaluation stage of design and management approaches in the context of historical gardens.

Keywords: historical garden; social media; public opinion assessment; text mining

1. Introduction

The tourism industry and economic development are becoming increasingly significant in terms of historical gardens and its related conservation strategies. The design projects of such historical gardens usually require economic, social and environmental foundations. Although the title of "world heritage" can help to increase the number of visitors towards heritage sites dramatically, the issues concerning conservation, design, and management can be caused by different factors, due to the fact that local

communities, policy-makers, and the public have different desires and expectations intended for historical gardens.

The general public have a tendency to focus on the economic and environmental presentation of these historical spaces. While they can be directly or indirectly influenced by the historical landscape, cultural heritage and some other prominent features of these gardens by searching related content through social media. Associated with local communities, the social media users' comments and perceptions can contribute to

a relatively holistic evaluation of the historical gardens, as these informations would be more objective and unbiased [1]. Successful implementation of such landscape design projects depends not only on the practical and theoretical feasibility but also predominantly on the support from the public, who ultimately pays for and would be affected by these projects. Consequently, the public opinions are of vital importance for the conservation and restoration of historical gardens, and the public satisfaction play a significant role in association with ex-post evaluation and public participation. In addition, the assessment of public opinion should be taken into consideration in the overall design and restoration of Chinese ancient gardens. While, the complexity of such projects and diverse interests of the tourists can lead to some difficulties in the successful evaluation of public opinion.

Most of the researchers usually use questionnaire surveys to collect and measure public opinions on landscape design projects [2]. However, these traditional survey methods are regarded as costly, time-consuming and disturbing [3, 4]. Meanwhile, the general public might be reluctant to share and express their views and opinions in some cases, either due to lack of enthusiasm and related professional knowledge or for their concerns about the potential adverse impact of their comments. The above mentioned issues could distract the public interest and demands in the process of professional design and decision-making, and could ultimately affect the public participation and the development of democratic views [5, 6].

Recently, with the flourishing of social network services, the public have grown accustomed to record and share their views and opinions online, and the social media platforms thus highlighted a new opening for collecting and assessing the public opinions [1]. Social Media became a very essential

tool in our life. The interactions among social media users can respond to external events by viewing individual comments, which could also be considered as a vast and distributed network of sensors [4]. As a consequence, this paper used two natural language processing technologies, including sentiment analysis and topic modelling, which mark-up an assessment framework to transform unstructured online public opinions into sentimental and topical indicators for reconsidering and improving practices of public participation.

2. Methods

The public opinion study regarding the user-generated contents can be augmented by using different data mining technologies, especially sentiment analysis and topic modelling. Textual data can easily be account for the dominant part of online comments of the social media sites. Although these data sets are of high-dimension, sentiment analysis can shape them into an emotional measurement. That is to say, the sentiment orientation (e.g., negative or positive) of an online comment can be determined, by providing an indicator to help measure public satisfaction [1]. As well, the intellectual structure of an extensive collection of text messages can be uncovered with the help of topic modelling. Therefore, this data mining technology can extract significant topics of the public opinion on a particular issue.

Based on above mentioned techniques, the whole assessment framework included three parts: data collection and pre-processing, sentiment analysis, and topic modelling. The processes were mainly implemented in Python, and R. For demonstrating the effectiveness of the proposed framework, the Humble Administrator's Garden (HAG) was selected as a case study, as it is a time-honoured Chinese traditional garden and a world cultural heritage site in China.

2.1 Data collection and pre-processing

The online comments related to the HAG were collected from three different Chinese travel sites (i.e., dianping.com, ctrip.com, and mafengwo.com). Python was used for the coding of web crawler program in order to collect all online comments which were published in the time period between April 1, 2014, and March 31, 2018. Finally, 16092 online comments were acquired in order to satisfying the research purpose of the current study.

Unlike English texts, Chinese texts do not separate words with spaces in sentences, therefore, segmentation played an essential role at the beginning of mining process of the Chinese text. In this article, the segmentation tool called Jieba, (which is an open-sourcing Python library) was used to segment words from the collected online comments. Some comments were having different unimportant words, such as citations, hyperlinks, and locations, which might have adverse impact on sentiment analysis. Due to their specific patterns, these insignificant words were filtered out by using regular expressions.

2.2 Sentiment analysis

In this paper, the sentiment value (SV) for each online comment in the overall collected data were determined by a lexicon-based sentiment analysis algorithm [7]. Three types of words are correlated to the sentiment of a sentence: attitudinal words (AW), degree words (DW) and negation words (NW). Explicitly speaking, attitudinal words express the emotions or attitudes, as they determine the sentiment of a sentence; the existence of degree words and negation words can modify the sentiment of a sentence. In the lexicon-based method it is essential to establish attitudinal word lexicon (AWL), degree word lexicon (DWL) and negation word lexicon (NWL). The final AWL in this article was constructed of two widely-used AWLs

(including Hownet and National Taiwan University Sentiment Dictionary), and it consisted of 3443 positive attitudinal words and 9097 negative attitudinal words. DWL and NWL were both inherited from Hownet, which included 224 degree words and 23 negation words. In addition, each attitudinal word were given a sentiment value (SV_a) for representing its sentiment polarity, each degree word were given a modification coefficient (MC_d) in order to amplify or diminish the sentiment value of an attitudinal word, and each negation word were used in order to invert the sentiment value of an attitudinal word.

The sentiment value of an online comment was calculated in a sequential manner. In the first step, the comment was divided into different clauses in terms of the punctuations. In the second step, it was tried to search for attitudinal words in each clause. When an attitudinal word was found in a clause, then we further proceeded for searching degree words and negation words between this attitudinal word and the previous attitudinal word. Later on four rules (Table 1.) were established in terms of the relative positions of the three kinds of words, in order to assign the modified sentiment value (SV_m) to the attitudinal word [7]. In the next step, the sum of all the modified sentiment value of attitudinal words was considered as the final sentiment value of a clause. In the last step, the weighted average of all clauses in a comment was regarded as the final sentiment value of the whole comment. If the sentiment value of a comment was less than zero, the comment could be considered as negative emotions, otherwise it could be considered as non-negative (neutral or positive) emotions. Table 1. Rules of sentiment value modification

Rule	Examples	Formula
DW + AW	very easy	$SV = SV_a * MC_d$
NW + AW	not easy	$SV = -1 * SV_a$
NW + DW + AW	not very easy	$SV = -1/3 * SV_a * MC_d$
DW + NW + AW	very not easy	$SV = -1 * SV_a * MC_d$

2.3 Topic modelling

Topic modelling can help to classify and organize comments into different representative topics so that researchers could better understand what people have said about a specific object. It is an extension of frequency analysis, which uses a statistical algorithm to uncover the underlying intellectual structure and extract semantic information of document collections. We used Latent Dirichlet Allocation (LDA), which is one of the most common topic models. The main idea of LDA is that it assumes a document which is comprised of multiple topics, and each topic is composed of terms in a fixed vocabulary [8]. For example, an article about historical garden conservation may include two topics, “cultural landscape” and “heritage protection.” Words in relation to cultural landscape, such as “culture”, “traditional” and “history”, may appear in the “cultural landscape” with high probability; while words in relation to heritage protection, such as “stakeholder”, “assessment”, “protection” and “legislation”, may appear in the “heritage protection” with high probability.

In this paper, by conducting sentiment analysis, the whole online data were categorized into two groups according to sentiment polarity (i.e., negative or non-negative) of each comment. Then, both of the comment groups were analysed by using the topic modelling in order to summarize and interpret their main themes respectively. The R package, “lda,” was used for the modelling process, and MS Excel was used for the supplement of processing statistical data and plotting figures.

3. Results

3.1 Overall analysis

According to the calculation, the overall average sentiment value was 1.76, and 2231 comments were considered as reflecting negative emotions, which were only accounted for 13.6% of the whole collected data. The temporal analysis of the whole comments presented that the HAG is a continuously hot topic in social media (Fig.1 and Fig.2). The monthly average number of the online comments regarding the HAG was 335, including 289 non-negative comments and 46 negative comments. Also, there were about 12 peaks during the period of 48 months, and they can be partially caused by holidays, seasonal landscape and local activities.

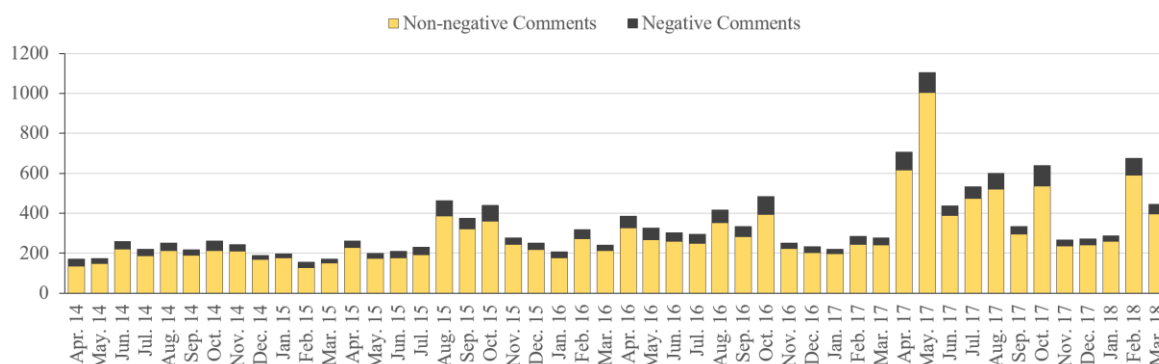


Fig. 1. Temporal trends of the online comments (Apr. 2014- Mar. 2018)

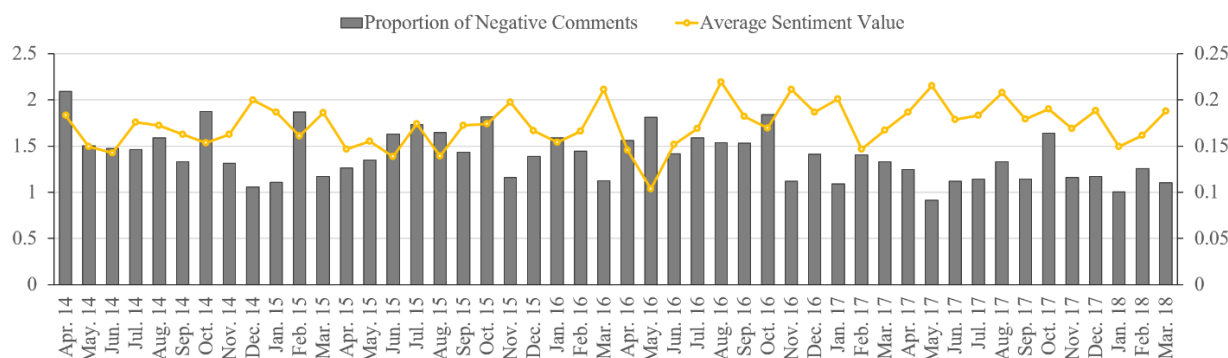


Fig. 2 Temporal trends of the sentiment polarity on the HAG

3.2 Synthesized “topics” on the HAG

After sentiment analysis, all of the online comments were categorized into two groups: negative comments group and non-negative comments group, and two topic models were established for fitting these groups. Table 2 illustrates the first twenty topics which have a relatively higher proportion, and the terms presented in these tables are the ten most frequent words of each topic. As the data was collected from Chinese websites, all the words in Table 2 were translated from Chinese to English. In order to make sure the results can have more detailed information, the keyword “the Humble Administrator’s Garden” was removed before modeling process. Based on our related findings of the HAG, we identified the subcategories of different topics by manual examinations of the two groups respectively. The interpretations of these subcategories of the topics are explained as follows:

3.2.1 Topics in the non-negative comments group

The first subcategory is about the status and identity of the HAG. For instance, Topic P8 contains words like “China,” “world,” “cultural heritage,” “tourist attraction,” “famous,” and “culture,” and thus addresses the importance and cultural significance of the HAG. Topic P20 contains words

including “four famous-,” “Beijing,” “Suzhou,” “honoured as,” “classical” and “famous garden.” Note that some other Chinese traditional gardens like “The Summer Palace,” “The Lingering Garden” and “The Chengde Summer Resort” also appear in this topic. It indicates that the social network users tend to compare the HAG with other famous gardens when expressing their views about the HAG.

The second subcategory emphasizes on the history and culture of the HAG. Topic P3 includes two names of famous Chinese scholars like “Xianchen Wang” and “Zhengming Wen.” These names are highly related to the HAG: Xianchen Wang was the owner of the HAG, and Zhengming Wen was the designer of the HAG during the Ming dynasty. Topic P5 contains “Ming dynasty,” “middle part,” “architecture,” “west part,” “layout” and “water,” and addresses the historical layout of the HAG.

The third subcategory is related to the tourists’ feeling and experience when visiting the HAG. Some of them were highly appreciating the Chinese culture and design techniques of the HAG, such as “beauty” and “Kun Opera” in Topic P7, “the ancients” and “wisdom” in Topic P10. Others were expressing their impression of the HAG, such as “quite large” in Topic P4, “beautiful” in Topic P9.

The fourth subcategory is about the characteristic of the traditional landscape in the HAG. Some tourists discussed the seasonal changes of the landscape, such as “lotus,” “summer,” “bloom” and “winter” in the Topic P12, and “rain,” “heavy snow” in the Topic P16. People also discussed the architecture of the HAG, with words like “pavilion,” “small bridge,” “rockery,” “landform and waterscape,” “flowers and trees” and “garden” in the Topic P15 and P19.

The fifth subcategory focuses on the garden management of the HAG. In this subcategory, some topics discussed the content of buying a ticket, such as Topic P1 contains “ticket price,” “low season” and “peak season”; Topic P6 contains “identification card,” “queuing,” “online” and “booking.” In addition, Topic P2 contains words like “explanation,” “tour guide,” “free” and “introduction,” and it addresses tourists’ experience about the service of guided tour in the HAG.

The last subcategory is about the travel recommendations which are shared by related tourists. Topic P18, which includes “morning,” “holiday,” “fewer people” and “seven o’clock”; Topic P26, which includes “tour guide,” “explanation,” “history,” “follow” and “knowledge.” Both of the topics address advices about how to have a better experience in the HAG respectively. Also, topics in this subcategory present some worthwhile tourist attractions near the HAG, such as “museum,” “must see,” “nearby” and “Lion Grove” in Topic P13; “Pingjiang Road,” “Guanqian Street,” “walk” and “bus” in Topic P17.

3.2.2 Topics in the negative comments group

According to the topics, the negative comments in this group is related to two factors. One factor is the tourists’ expectation

gap. Topic N14, N17, and N20 address the disappointment from over-high expectation or the comparison between the HAG and other Chinese traditional gardens, with words like “not worthwhile,” “Summer Palace,” “disappointed,” “imagination,” “ever seen,” “Beijing,” “Lion Grove,” etc. Topic N15 and N16 focus on the influence of weather condition, with words like “winter,” “influence,” “weather,” “pity,” “raining,” “summer,” “unfortunately.” Topic 21 contains “place,” “real,” “pity,” “time,” “cannot go,” and thus it presents the negative feeling regarding the traveling schedule.

Another factor is about the management and service of the HAG. Topic N6, N11, N13 and N19 discuss the price of the ticket, with words like “ticket,” “not worthwhile,” “cost-effective,” “too expensive” and “price.” Topic N1, N4 and N12 focus on the number of tourists, with words like “too many people,” “holiday,” “stagger visiting time” and “suggestion.” Topic N2, N5, N10, N22 and N23 focus on the service in the HAG, with words like “tour guide,” “explanation,” “buy a ticket,” “queuing,” “telephone number,” “customer service,” “bad” and “attitude.”

In addition, some topics also involved the content of the garden’s landscape, history and identity, although with a relatively neutral tone. For example, Topic N3 contains “elegant” and “pavilions”; Topic N7 contains “China” and “four famous-”; Topic N8 contains “beautiful scenery”; Topic N18 contains “Ming dynasty.” But there are no words with significant positive emotion can be found in these topics

In conclusion, Table 2 illustrates the key terms and proportions of the major topics in the non-negative group and the negative group respectively. According to the results, stakeholders can easily understand the factors which have different impacts on people’s

attitudes about the HAG and the importance of these factors.

Table 2. Major topics in the non-negative comments group (left) and the negative comments group (right)

Topic	Terms	Proportion	Topic	Terms	Proportion
P1	Ticket, ticket price, feel, peak season, hour, Suzhou, low season, feeling well, too expensive	5.1%	N1	Good, feel, nothing special, landscape, wander, too many people, scenery, place, low season, bad	9.2%
P2	Guide explanation, tour guide, free, visitor, hour, center, identification card, main entrance, scenic plot, introduction	4.6%	N2	tour guide, explanation, follow, free, suggestion, entrance, thing, feel, introduction, find	6.9%
P3	East garden, Wang Xianchen, well-arranged, water, garden, famous garden, feature, middle garden, Zhengming Wen, small bridge	4.6%	N3	step, scene, sigh, the ancients, garden, life, owner, slow, elegant, pavilion	5.6%
P4	Good, suitable, quite large, chance, next time, garden, too many people, landscape, scenery, weekend	4.2%	N4	suggestion, holiday, too many people, period, crowded, people, stagger visiting time, experience, garden, appreciate	4.7%
P5	Ming dynasty, middle part, architecture, nature, west part, layout, regions south of the Yangtze River, water, area, dwelling	4.1%	N5	tour guide, entrance, shopping, travel agent, one-day tour, fraud, scenic spot, scalper, boat, Suzhou	4.7%
P6	Identification card, enter the garden, queuing, ctrip.com, buy a ticket, need not, online, booking, ticket, QR code	4.0%	N6	Hour, less than, children, Suzhou, place, scenic spot, feel, ticket, half, half hour	4.5%
P7	slow, season, time, beautiful scenery, enjoy, experience, Suzhou, Kun Opera, quite large, feel	4.0%	N7	China, four famous-, Suzhou Garden, walk, regions south of the Yangtze River, private garden, landscape, small bridge, experience, representative	4.4%
P8	China, world, Suzhou, cultural heritage, tourist attraction, regions south of the Yangtze River, famous, all over China, located at, culture	3.9%	N8	Suzhou, photo, museum, afternoon, paradise, Suzhou and Hangzhou, tourist, beautiful scenery, season, reason	4.2%
P9	feel, beautiful scenery, first time, smartphone, photo, Suzhou, real, pity, place, discover	3.9%	N9	Student ID card, real, hour, entrance, ticket, museum, quite large, garden, student, half-price	4.2%
P10	The ancients, ancient times, China, architecture, design, feeling, wisdom, like, life, ingenious	3.7%	N10	Identification card, buy a ticket, online, enter the garden, queuing, ctrip.com, comment, phone, customer service, early	4.1%
P11	entrance, ticket, tour guide, ticket resale, cheap, scenic plot, buy a ticket, tourist attraction, Suzhou	3.7%	N11	tour guide, real, history, appreciate, explanation, garden, architecture, ticket, not worthwhile, culture	4.0%
P12	Lotus, summer, season, bloom, low season, winter, landscape, garden, Suzhou, unfortunately	3.6%	N12	Architecture, feel, too many people, appreciate, regions south of the Yangtze River, only, feel, landscape, method, name	4.0%
P13	Suzhou, museum, scenic plot, must see, Suzhou garden, nearby, deserve, representative, very large, Lion Grove	3.5%	N13	Suzhou Garden, four famous-, Suzhou, regions south of the Yangtze River, represent, China, famous garden, place, ticket, representative	4.0%
P14	So many people, Nation Day, influence, good, mood, period, holiday, Spring Festival, many people	3.5%	N14	Ticket, hour, not worthwhile, park, The The Summer Palace, disappointed, garden, scenic spot, imagine, Hangzhou	4.0%
P15	regions south of the Yangtze River, terraces and open halls, typical, small bridge, pavilions, rockery, elegant, bonsai, unforgettable, paradigm	3.5%	N15	Low season, winter, influence, weather, pity, rain, peak season, summer, lotus, landscape	3.9%
P16	unique, regions south of the Yangtze River, rain, prospect, fully appreciate, snowscape, heavy snow, summer, light rain, feel	3.5%	N16	Lotus, season, summer, good, scenery, landscape, lotus leaf, bloom, pavilion, rockery	3.8%
P17	museum, Suzhou, Pingjiang Road, Lion Grove, not far from, ticket, Guanqian Street, walk, nearby, bus	3.2%	N17	Feel, Lion Grove, garden, Yangzhou, The Lingering Garden, quite large, place, elegant, wide, see	3.7%
P18	suggestion, morning, hour, holiday, garden, tourist, open, photo, few people, seven o'clock	3.2%	N18	Four famous-, Xianchen Wang, architecture, garden, Suzhou, Ming dynasty, design, for a while, censor, center	3.6%
P19	Garden, elegant, surrounding, Landform and waterscape, center, flowers and trees, water, lush, strong	3.0%	N19	Cost-effective, ticket, not worthwhile, feel, too expensive, not high, ticket price, scenery, good, nothing special	3.6%
P20	Four famous-, The Lingering Garden, The The Summer Palace, Beijing, famous garden, China, The Chengde Summer Resort, honoured as, Suzhou, classical	2.9%	N20	Suzhou, museum, The Summer Palace, four famous-, Beijing, China, Lion Grove, scenic spot, famous garden, The Lingering Garden	3.4%

4. Discussion

4.1 Implications for the HAG

The Humble Administrator's Garden is one of the famous historical gardens of China and is highly significant in many aspects, including history, culture, environment, and tourism. As a consequence, it is of vital importance to assess public opinion about the HAG. This paper illustrates that the HAG is an increasingly attractive topic to the social media users. More and more people are willing to express and share their experience and views regarding the HAG online.

The sentiment analysis presents that only a small part (13.8%) of the social media users show negative sentiment. As a world heritage site which has been built for more than 500 years, the HAG is still welcomed by the tourists, and it is well-maintained. Hence, the results of our study is relatively cheerful for the scholars, managers, and policy-makers.

Topic modelling of negative comments group and non-negative comments group revealing the major concerns of the social media users about the HAG. The topics of the non-negative comments group illustrate that people tend to focus on the HAG from six aspects: prestige and identity of the HAG, history, and culture of the HAG, tourists' feeling and experience, characteristic of a traditional landscape, garden management and travel advices. These contents are also crucial for the conservation and development of the HAG. Meanwhile, the topics of the negative comments group show the most critical issues which have adverse impacts on the HAG, such as tourism consumption, crowd control, public service, etc.

4.2 Implications for related design and conservation project

Public participation is critical for policy-makers to deal with public projects. This research can help to better assess the public opinion on the management and design regarding historical garden. Some basic suggestions are shown as follows:

(1) Administrators and policy-makers should encourage people to express their views, appeals, and attitudes on the online platforms related to the discussion of historical garden projects. The existence of social media creates a convenient platform for the interaction among the general public, government and project managers. Social media can also contribute to building the awareness of public participation, and it is a more effective and economical method for scholars and policy-makers to collect and assess public opinion than traditional public participation methods. However, the effectiveness and accuracy of this method have to be based on a large number of participants, so it is necessary to encourage more individuals to join in this online approach.

(2) As the conservation and development of historical gardens are long-term work, monitoring online presence of these gardens should be a meaningful task. Historical gardens have been and will exist for a long time. Hence they often have a long-term influence on the society. The public satisfaction and attitudes of famous historical gardens usually vary with time and space. As a result, monitoring and studying historical gardens via social media seems to be the only effective way to measure the variations of the public opinion at the macro level.

4.3 Limitations

Although the user-generated contents from social media can be regarded as an alternative

approach which can help to provide rich information and save money, these data can be skewed because of the existence of selection bias, which means that the data are only collected from the social media users who can afford internet-enabled devices, and have enough leisure time to share experience online. Nevertheless, the analysis results in this work do reveal useful knowledge due to a large number of users.

In addition, the lexicon-based sentiment analysis algorithm in this paper is not well performed when processing ironical comments, so the accuracy of sentiment analysis is hopeful to be further improved by using the more sophisticated algorithm.

5. Conclusion and Future Work

The traditional Chinese gardens were initially been shaped and dominated by elite culture, and thus the public's everyday-life experience was prone to be neglected [9]. With the progress of democracy, understanding the public opinion is becoming increasingly crucial for the conservation and restoration of historic gardens. Due to urbanism and tourism trends, different historical places are facing different challenges regarding economic, social and environmental impacts, but social media provides a down-top strategy to address these issues from a public perspective. This technology also contributes to promoting the sharing of information between policy-makers and the public: government and scholars can gather and analyse people's own views and experience which are available on the Internet in order to better understand public attitude and needs in time, and individuals can have access to the latest policies and strategies related to historical gardens via social media easily and rapidly.

As such, this paper presents an assessment framework to transform subjective public

opinion into sentimental and topical indicators for rethinking and enhancing practices of public participation. By analysing online public opinion on the HAG, this study provides a more democratic and effective method to uncover how Chinese social media users think about the famous world heritage site, which is significant in the post-evaluation stage of design and conservation projects.

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FUTURE RESILIENCE



FULL PAPERS



Resilience Design Of Shallow Mountain Greenway Infrastructure Based On Safety Pattern Of Rainwater

A Case Study On The Design Of Shallow Mountain Avenue In Shijiazhuang,China

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Abstract

The relationship between urban construction and natural ecology is complicated. With the development of plain cities gradually spreading to shallow mountainous areas, the impact of this relationship has become even more far-reaching. Greenway is an early urban infrastructure in the shallow mountainous areas, therefore, it is important to study the effect of the flood control system in the construct of greenway landscape under the perspective of rainwater safety pattern. Combining with the planning and design practice, this article draws a comprehensive flood prevention strategy of defense, delay, storage and discharge, at the same time combined not only the analysis platform, practical exploration but also with macro-micro collaborative plan and design. Firstly, the ecological sensitivity of the study area was analyzed by GIS software, and the corresponding sensitive focal point distribution was obtained. Secondly, with the ecological restoration pattern and several steps to mitigation the rainfall, the overall planning and layout of infrastructure was combined with the site; finally, analyze the specific solutions, the corresponding runoff elimination results were obtained by SWMM simulation. We hope that we can draw a flexible greenway landscape model, while improving the functionality of the Greenway landscape to bring more resilience ecological impact.

Keywords: flood safety; shallow mountain;greenway; resilience design

1. Introduction

In recent years, the urbanization movement has developed rapidly. Many cities have already broken through the expansion of the current city area into surrounding areas^①. Take the North China Region as an example (This study focuses on the geomorphology, therefore, the limit scope of the North China mainly includes Beijing, Tianjin, Hebei Province, Shanxi Province, Shandong Province and Inner Mongolia Autonomous Region^②), during the process of development, lots of thorny problems like the residence, the transportation and so on are solved in highly efficiency, therefore, there also pay the cost of deteriorating ecological environment and insufficient landscape performance, etc. such of this problems mentioned are specifically embodied in the following aspects:

1.1. Urbanization extends to shallow mountain areas

The North China is located in the middle of the eastern edge of the second largest geomorphological terrace in eastern China. It has several types of mountainous like terrain, hills, plateaus, plains, and all other mountain types. It is a typical area suitable for construction and live. There have been many urban construction activities (such as Beijing and Baoding) since ancient times. However, with the development of the new era of urban development, related pressure like housing and transportation are increased, the traditional urban area can no longer satisfy the needs of the future, so lots of cities tends to set the shallow mountain area as a new area, Such as "Beijing Urban Master Plan (2004-2020)", while delimiting the scope of shallow mountains, it also make

a master plan for the development of shallow mountain areas^③.

Shallow Mountain, as a connecting zone between mountainous and plain ecosystems, has obvious regional characteristics compared with other regions, and has the advantages of various geomorphological features of plains and mountains. It is more suitable for urban construction and also good for enriches the urban landscape. The more importantly, it has difference in the distribution of natural resources, horizontal and vertical, all of this are resulted in a higher biodiversity of adjacent environmental systems than in other areas. Therefore, the development of cities needs to increase the emphasis on the habitat sector^④. In addition, shallow self-sustaining thresholds in shallow mountain areas are easily affected by human activities and are difficult to recover normally once they have been destroyed by humans^⑤.

1.2. The urgently contradiction between rainstorm and flood safety area

The shallow mountainous areas of northern China are located in the mid-latitudes and belong to the temperate continental monsoon climate. There have obvious season differentiation, less annual rainfall and with a serious shortage of water resources^⑥. Due to the location of the subtropical high-pressure ridges, rainfall is highly concentrated in 2017. Rainstorms are mainly concentrated in flood seasons from July to August. Precipitation in flood seasons accounts for 45%-65% of the whole year. Floods and floods occur along the mountainous areas. Among them, Yan mountain and Taihang mountain are concentrated areas of heavy rain in the region, and can easily form flood disasters

and enter the south of the plains, posing a serious threat to water security in the south of the plains.

1.3. The greenway has a functional-ecological double bond

The Greenway was first used by Whyte in 1959^⑦ and gradually became realistic construction in the subsequent development. Most literature approved that the Boston Park System completed by Frederick Law Olmsted in 1867 was a pioneer in the practice of greenery[®], its related discussion and research also provides guide for this research. Firstly, there are abundant landscape resources in shallow mountain areas, such as forests, wetlands, rivers, farmland, and so on, which are important constituent elements of the urban landscape in shallow mountain areas, and they are also rich in beautiful environment, abundant resources, and numerous historic sites, so there is enormously in the potential development. Secondly, as a linear element linking patches in different regions, it also improving the regional ecological connectivity.

2. Research object and significance

2.1. Research object

Taking the landscape design of the Shallow Mountain Avenue in Luquan District from Shijiazhuang as an example (Fig. 1), the site is located on the west side of the City and between the western mountainous region and the main urban area. The total length of the green road is 46.7 kilometers, surrounded by surrounding mountains and rivers. The greenway is based on the municipal roads and will

become a green line space that run through the vicinal shallow mountains.

2.2. Research significance

The research and design are based on the shallow mountain ecological base site for

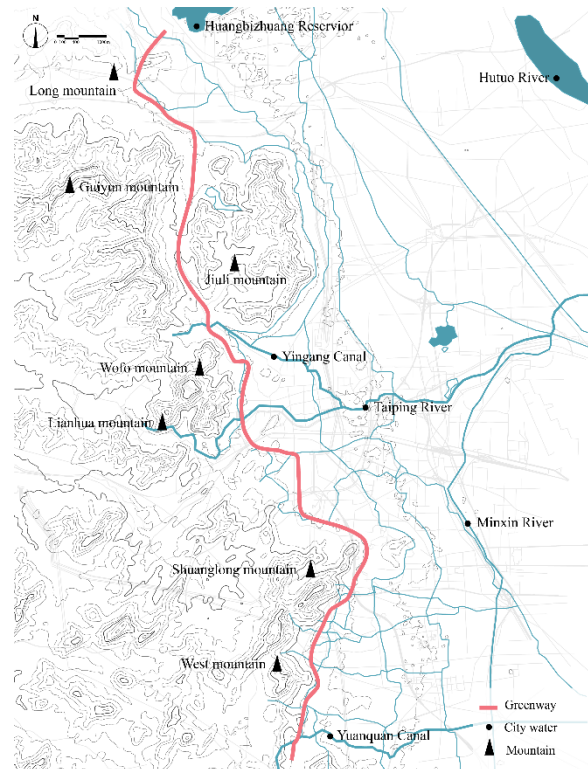


Fig. 1. The surrounding environment of the site in Luquan District, China

greenway landscape construction. It is hoped that the urban landscape can be expanded in the elastic landscape area and new sustainable construction strategies can be provided. It has the following effects:

As a linear greenbelt, the greenway can connect large-scale public greenbelts and natural greenbelts around the city at the municipal level. It can serve as an ecological corridor through the connection of green patches; at the urban level, the shallow mountain greenway can effectively maintain

and improve the shallow mountains' eco-environment, perfecting the greenspace system structure of mountainous cities^⑨, effectively communicating the energy conversion between the suburbs and promoting the circulation of the urban ecosystem; In the view of the practicality of rainwater management measure, China has proposed the concept of "sponge city"^⑩ by absorbing and introducing from foreign advanced concepts and practical experiences to solve urban stormwater disasters, especially about the LID facilities. Many water problems, such as the shortage of water resources, the drop of groundwater level, and the loss of habitat of aquatic organisms, all of what can help to solve the problems of rainwater flooding; Judging from the landscape entertainment, shallow mountain greenways can use the advantages of terrain to create a linear landscape sequence by coordinating multidimensional spatial perspectives of plains and mountains. In addition, the service function of the city can be improved, and a new type of shallow mountainous area can be created that is in line with the mountainous terrain and is fully functional.

3. Flexible mitigation methods for rain flood

Through research and analysis, the project will build a flexible sponge greenway system in defense, delay, storage, discharge parts.

3.1. Defense Methods

Considered the ecological restoration of terrain, firstly enhancing the ability of self-circulation and self-regulation through the current enhancement of vegetation, classifying the mountains according to the characteristics of the mountains surrounding

the greenway, and then combine different types of The mountain body (the near natural hill, the artificial interference mountain, and the barren mountain) is targeted for repair. The specific measures are as follows:

In the rehabilitation of near-natural hills, the main focus is on ecological conservation, adding vegetation at the same time, enriching the level of vegetation communities, establishing measures to maintain the sustainability of the mountain; for the artificially disturbed mountains, Through the arrangement and management of the greenway function in the design, human activities are regulated to reduce interference, and ornamental plants are mainly added in the node area; For the barren mountain areas, there are many impacts of piedmont runoff and flooding, and this is combined with many Layers of ponds, rain gardens and other buffer facilities to slow down the mountain runoff and improve the ecological safety factor.

3.2. Delay Methods

The construction of the rainwater retention system achieves the effect of delaying the flow of water, which is the key of the study. First of all, the elevation data in the shallow mountain areas surrounding the greenway are extracted from GIS, and the water collection analysis is performed on this basis to obtain the water collection point. Then choose a watershed with better and longer water points, and set up a series of rainwater retention facilities (rain gardens, submerged green spaces, etc.) to form a good water landscape (taking the northern forest water section as an example. Fig. 2.3). At the same time, in conjunction with the specific design of the station and

the venue, rainwater landscapes can be set up at important sites or venues that require a high degree of landscape viewing, and the height difference can be set to form a dynamic rainwater landscape.

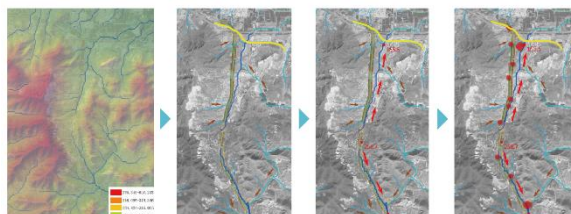


Fig. 2. The water collection analysis in the north part of the Shallow mountain greenway.

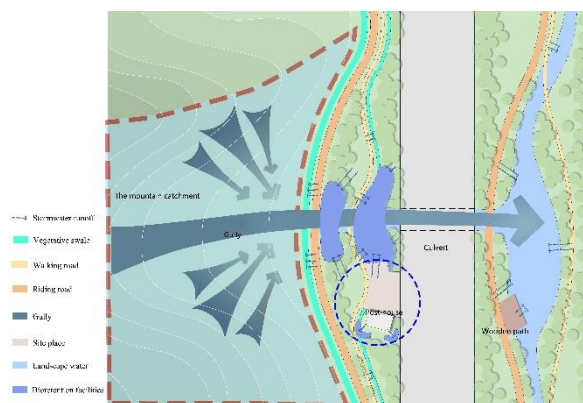


Fig. 3. The water collection pattern in the Shallow mountain greenway.

The specific process for rainwater flood mitigation in the design is as follows (taking the northern Wanghe River as example. Fig 4). When the rainstorm comes, firstly, the natural mitigation is carried out by supplementing planting quilts, ponds, and rainwater gardens. The ecological grass-groove ditch and underground culvert will re-dispatch the water and concentrate the excessive amount of rainwater to the flood discharge channel on the east side of the road section. Here, the excavation of small-scale waters increases the scope of flood discharge, and finally the rubber dam is used to adjust the flood discharge flow rate.

Finally relief the pressure of downstream flood discharge.

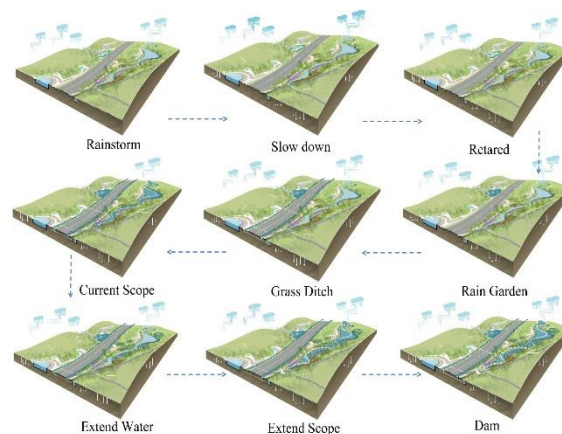


Fig. 4. The delay methods of rainwater in the north part of the Shallow mountain greenway

3.3. Storage Methods

The main purpose of the defense and delay strategy is to mitigate the rain and flood pressure. In addition to the synergetic relief pressure, the storage strategy can also form a dry and wet type landscape through the distribution and utilization of rainwater. In the water storage system, firstly, we use LID facilities (such as rain gardens, sinking green areas, etc.) to channel rainwater to form a preliminary retention effect, and then combine the ecological grass-grooves and underground culverts on both sides of the lane to drainage water into the existing anti-seepage treatment. In the channel, the rubber dam is used to allocate landscape water with different elevations, and the reservoirs and underground pipelines in the nodes are properly supplemented (Fig.5); in the landscape system, the design is based on different seasonal characteristics of drought and humidity to form the landscape space, and the plants are selected. The plant should have the characteristic which can resistant to

long-term drought and short-term flooding. Aquatic plants such as *Ceratophyllum demersum*, *Nelumbo nucifera* and *Eichhornia crassipes* are used in the deepwater area. The shallow water areas are mainly emerged plants, and the vegetation buffer zone is mainly planted with wet plants such as *Iris pseudacorus*, *Lythrum salicaria*, *Cyperus*, and so on.

3.4. Discharge Methods

The relevant design for site drainage is

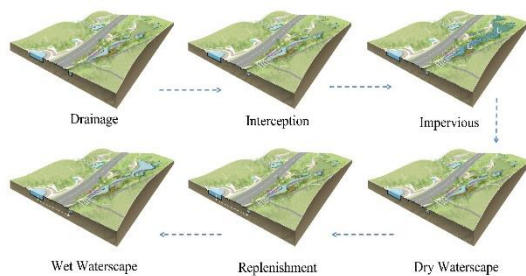


Fig. 5. The storage methods of rainwater in the north part of the Shallow mountain greenway

generally connected with the impoundment of water, the main purpose of which is to ensure that safe discharge could be achieved in the event of excessive rain and flood during the rainy season. The design incorporates a variety of sponge-like landscape infrastructures such as rain gardens,

4. Design and analysis calculation

The design of the elastic sponge greenway in this study mainly uses LID facilities to control stormwater runoff. In order to accurately quantify the effect of stormwater runoff control, a stormwater management

temporary flood discharge water bodies, etc. Rainwater gully, pipe culverts, etc. are used to regulate and divert rainwater, so excess rainwater is gradually discharged. The

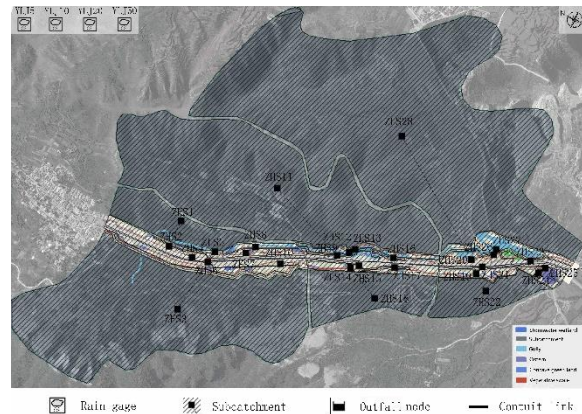


Fig. 6. Plain graph of LID control arrangement

discharged rainwater is mainly used in two aspects. On the one hand, it is discharged into the green space nearby. In the course of the water flow, wetland plants, stones and other materials are used for rainwater purification, eventually reaching a certain standard as irrigation water or landscape water; on the other hand, when the rainfall is too excess to storage nearby, the rainwater can not normally be used in the site area. At this time, it is necessary to use the municipal facilities to discharge the flood, and finally ensure the safety of the rain in the shallow mountainous area.

model (SWMM) was used for simulation studies to provide data support for the stormwater runoff control effectiveness of the sponge greenway. The section of the Huangyan Village to Wanghe Huangu section of the Luquan District is selected as the study object (Fig.6). The section has a total length of approximately 3.1 km and a total area of 46.1 hm² (including roads), of which the LID facility has an area of 123267

m², accounting for 26.7% of the total area of the section. The study area was generalized into 6 sub-water catchment areas. Sponge greenway development model and traditional greenway development model were established in the area. Using the SWMM model, the simulated return period was 5 years, 10 years, 20 years and 50 years. The statistics of the total amount of external runoff are receiving from two development modes (LID development and traditional development). Finally, peak flow, and peak present time were calculated (Tab.1). The layout plan for the specific LID facility in the study area is shown in the figure.

Tab.1 Simulated results of runoff under different rainfall intensities

Simulation item		Total runoff/ L	Peak flow/ (L·s ⁻¹)	Time of peak flow occurrence
Onc e 5- yea r,1 hou r	LID develop ment	0	0	Elimina tion
	Traditio nal develop ment	101700 00	713.83	03:09
	Differen ce value	101700 00	713.83	
Onc e 10- yea r,1 hou r	LID develop ment	0	0	Elimina tion
	Traditio nal develop ment	262200 00	2014.1 4	03:34
	Differen ce value	262200 00	2014.1 4	

Onc e 20- yea r,1 hou r	LID develop ment	0	0	Elimina tion
	Traditio nal develop ment	526900 00	3905.9 6	02:44
	Differen ce value	526900 00	3905.9 6	
Onc e 50- yea r,1 hou r	LID develop ment	356000	707.33	09:07
	Traditio nal develop ment	106525 000	7724.2 6	02:05
	Differen ce value	106169 000	70170 26	302min

5. Results

This study analyzes the climatic characteristics and geographical features of the typical shallow mountainous areas in North China, combining the development background of urbanization to summarize the importance of the application of the current elastic greenway landscape. From the perspective of rain-flood security, a number of studies have been combined to propose the idea which constructing an elastic greenway landscape as an infrastructure, and to guide specific designs. The discussion of this study mainly includes two stages which include the rainwater flood control and the LID design and specific layout: In the regulation of rainwater, four steps of defensive-delayed-storage-discharge are used to achieve the mitigation and regulation of different rainfalls; In the elastic

design and layout, through the construction of a rainwater regulation system for specific rainwater storage and utilization, combined with the results of the SWMM stormwater runoff simulation, it is concluded that the elastic sponge greenway has significant results in reducing stormwater runoff and delaying peak present time. Compared with the traditional greenway development model, the sponge greenery under this research design method has obvious advantages in rainwater storage and adjustment, and has certain application value and promotion potential in urban shallow mountain areas in North China. It is hoped that the multi-functional greenery will be used as a landscape infrastructure to make the shallow mountain area more flexible. In the end, it will not only protect the entire city, but also provide a more reliable basis for other related construction.

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Symbiosis with Rivers:

Guangzhou Urban Renewal Plan through Phased Strategy of Ecological Restoration

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Abstract

Though being born because of the river, destruction of river system in Guangzhou seems inevitable in the process of rapid urbanization when massive rivers were “over-engineering”, and even disappeared. Consequently, urban water systems can hardly cope with environmental problems such as floods.

Taking Guangzhou's intrinsic and unique features of urban river network conditions into consideration, this study tend to propose an ever-changing urban renewal plan that is symbiotic with rivers. Through on-site investigation and cases study, an exploration aiming to bring the covered river to light again through landscape strategies is proposed through in three main phases, and regional renewal is ensured to implement in a large scale, which make city's space reactivated. Meanwhile, humanistic landscape on riverbank of architectural culture heritage protection and leisure space construction are involved in integration method.

Key Words: Over-engineering, Phased Strategy, Sludge Transformation System, Ecological River Restoration, Rejuvenation of Public Space, Green Infrastructure

1. Background: The Changes of River System and Waterfront Environment in Guangzhou

Owing to historic reasons and special circumstance of modern China, the evolution of river management in Guangzhou is unique compared to most cities. As a well-known oriental sea port and the starting point of the "Marine Silk Road", Guangzhou was born because of its location on Pearl River System. The tributaries of Pearl River named "Chong", which were densely distributed throughout the city, represent the most characteristic kind of rivers in Guangzhou, forming the backbone of the city's water system.^[1] With a small amount of water, they were natural waterways directly connected to major rivers. In the urban area, there are 238 rivers with a total length of 913 km, which merge into Liuxi River, Baihe River and Pearl River.^[2] And they employed an important influence on regulating water levels because of being affected by tides.^[3]

Fig. 1

1.1. The Period of Rivers' Cultural Development

Throughout the its long history, these rivers, as well as their environment, have been closely connected with people's daily lives, because they shoulder not only the city's task of flood management, irrigation and shipping transportation, but also the back lanes of residents' lives, such as taking water, washing, daily traveling and even recreational activities. Thus, instead of a merely beautiful natural landscape, the

urban riverfront is a unique cultural landscape, which has shaped the urban spatial pattern of style for more than 2,000 years. For example, East Hao Chong, once a moat in the Ming and Qing Dynasties, has gradually formed a commercial center along the river at the end of the feudal society, supporting the development of business.^[4]

Fig. 2

1.2. The Period of Rivers' Traffic Decadence

However, in the 1910s, with the modern urban city-building movement, Guangzhou began to demolish the ancient city walls, constructed a great variety of municipal roads, which eventually became the main transportation system.^[2] As a result, the traffic function of the rivers began to degenerate even gradually disappeared, signing an evident trend of transport declining, nevertheless, they did not lose their main function as the drainage channels. The development of the city was slow and orderly,^[3] and the rivers, with high quality of purity, at that time still played an important role in the urban ecosystem and residents' lives.

Fig. 3

1.3. The Period of 'Over-engineering' Rivers

After the 1950s, with the rapid development of the city's economy and the population growth, because of the disordered construction and management of the surrounding areas along rivers, the intensive buildings altered the original

natural bank form of the river, weakening their capacity of flood discharge. Consequently, the riverfront repeatedly experienced guilt during rainy season. In order to solve the problems, Guangzhou reformed the urban drainage system from natural embankments to upright rigid embankments under the guidance of the idea of flood control at that time. There is no doubt that destruction of river system seems to be inevitable in the process of rapid urbanization. Moreover, Massive rivers were ‘over-engineering’, especially when Guangzhou in an all-round way started to unify the open channels into underground channels with city roads on its cover. Those open channels with slate were changed to underground channels with reinforced concrete box culverts, as we can see in Xiguan Chong and Yudai Hao. [2] What caused more serious problem is that the pollution of industrial and domestic sewage discharged into rivers was increasing, so the rivers in the central city become black and odorous as sewage pipes for the city.

1.4. The Period of ‘Disappearing Rivers’

After the 1970s, especially the beginning of the Reform and Opening-up in 1979, Guangzhou entered a new period of booming development and its urban area has expanded dramatically. Thus the urban landscape has undergone major changes in the rapid increase in population, traffic jams, and the emergence of viaducts. However, the deterioration of the riverfront water environment was still intensifying. The environmental problems and traffic pressure brought about by the abnormal development of the urban construction have caused more rivers to lose their original ecological

functions and landscape environment. As a result, many rivers in the city have gradually disappeared such as West Hao Chong, Yudai Hao, Lizhi Wan and many other rivers have been replaced by underground culverts. Only the effluvial East Hao Chong flows on the ground with the high-rise buildings around, with scarce slate road left over from history. The original bustling life scene disappeared and the river have almost been forgotten by the world. [3] There is no longer the scene of ‘clear creek and green space’ everywhere and Guangzhou lost its ‘Water City’ feature. What’s more, the quality of rivers are becoming increasingly polluted and blocked. In 2016, the rivers that did not reach the standard of water quality accounted for 88.79% of the total. Consequently, urban water systems can hardly cope with environmental problems such as floods.

Since the 21st century, more and more people have improved the awareness of the rivers’ importance to the urban ecology and living environment. [5] However, the contradictions between gray infrastructure and green infrastructure are particularly prominent. There are two core problems of the rivers’ status: the decline of the urban water system and the decline of urban space. The former, caused by being covered, has resulted in serious water pollution and weak capacity of flood management. The latter, plenty of negative activities such as illegal possession and garbage dumping, has led to the monotonous urban space without regional features and vitality. Thus it is against this background that we have started this large-scale project of comprehensive renovation of rivers.

Fig. 4

2. Objectives: The Concept Based on the Idea of Resilience

Taking Guangzhou's intrinsic and unique features of urban river network conditions into consideration, this project seeks to find a solution based on the idea of resilience by establishing ever-changing urban renewal places that is symbiotic with rivers. The city's adaptation to disasters should reflect the temporal dynamics. The traditional engineering measures dealing with flood only with a single function of defense, or simplex ecological remediation, resulting in waste of urban space and resources.

Our plan is proposed to improve the construction and development of the cities built downstream along the river by solving

3. Methods: Three Main Stages and Ecological Technology

Through on-site investigation and cases study, an exploration aiming to bring the covered river to light again through landscape strategies is proposed through in three main phases:

3.1. Stage I: Restoration Plan Both on the Urban Surface and Underground

In the first stage, in order to form the foundation of ecological and cultural river restoration, reconstruction is divided into two parts: the treatment plan on the urban surface and underground. On the one hand, underground excavation is conducted locally to form a stagnation space, where sludge is transported to by the process of river's automatic force. Then biogas power

the problems both under covers and on urban surface. The water flow plays a role of transporting sludge to the confluence or estuary considering time effect. A system aiming to transform sludge into humus is constructed underground, which will also provide opportunities for the renaissance of urban green space. After uncovering, various possibilities were re-introduced into the city and the waterfront areas became the basis for activating the urban space once decayed. Except for protecting cities from flooding it also has the function of revitalizing the public space and improving the eco-environment. Moreover, it is also an optimal strategy of balance between the tense land use and the protection of natural ecology.

generation is used to convert concentrated sludge into humus. On the other hand, at the beginning of the restoration of the river, we ought to find waste space and potential areas on the ground to build some pocket parks. And electricity generated by that process of biogas could partly supply public infrastructure. The sludge transformation system is constructed underground since oxygen is exposed through openings of equipment on the ground, which will also provide opportunities for the construction of green space and the renaissance of urban public space. After uncovering, the purified sediment can be used directly for the construction of the revetment, as the foundation of the new waterfront space composition. So there is no doubt that it is an efficient way to restoring ecosystem of the rivers.

3.2. Stage II: Uncovering and Diverse Treatment of Revetments

In the second stage when the regional sludge water system has basically been constructed, the large amount of sludge under the cover plate would gradually transform into soil containing humus, which will become the foundation of the new waterfront space composition after opening the cover plate. Obviously, the river will become visible, evoking the public environmental awareness. In particular, it is necessary to consider the status and adopt targeted methods to reconstruct revetments for different levels of urban density.

While uncovering sufficient space for the urban ecosystem, the comprehensive rectification of riverfront must first adopt diverse treatment of revetments according to the specific conditions of different rivers, making the river line richer in both morphology and function.^[6] Because the revetment of river is not only a defensive line to ensure the safety of watershed, but also an important component of the waterfront landscape and spatial utilization. Modern ecological technologies are used to design different riverbeds and revetments including semi-permeable fabric-formed concrete channels, tubular mesh fabric growing containers and gabions in limited estuary water level change areas, different ways to form a high ecological potential green infrastructure that has flexible functions of flood control, as well as meets the needs of various animals and plants. For example, in the downtown area, where the space is relatively confined with over-engineering revetment, semi-permeable fabric-formed concrete channels and multi-

level platforms with tubular mesh fabric growing containers are set up in order to meet the flood control requirements.^[8] Only by this way could we weaken the rigid coastline to form an interesting waterfront with various needs such as hydrophilicity and recreation. In different circumstance, there is wide range for ecological restoration of the river, especially on the outer edge of city. For the treatment of such river banks, the design mostly uses natural grading treatment with natural materials such as rubble, wooden piles and gabions to stabilize slopes, and sometimes it also includes tubular mesh fabric growing containers to form a flexible ecosystem with functions of flood control.

3.3. Stage III: Reactivating urban space with Diverse Possibilities and Technology of Water Purification

In the third stage, in the case that single landscape could be easily eroded by the construction of other lands, aggregation and transformation is necessary in the contemporary context rather than tearing apart river and city. The new functions replaced the original monotonous blocks, giving the blocks diverse possibilities, consequently the old city's space being reactivated. Meanwhile, humanistic landscape on river bank of architectural culture heritage protection and leisure space construction are involved in integration method.

There are three representative types of revival spaces. Cultural rivers, as the first type, are mostly located in the old urban area of the city with an attractive style of historic neighborhood, surrounded by a great

variety of historical and cultural resources. There are massive scenic spots such as Morning Tea Market, River Museum, Outdoor Café, Street Corner Garden and so on. The second type called rejuvenated rivers, located in the developing part of urban area, have a lot of opportunities for the development of commerce and entertainment industries. The industrial transformation and activation of public space will make it the central area of future urban vitality, as we can see in City Terrace, Waterside Theatre, Water Steps and Bridge Park. Because of being located in urban fringe areas and important ecological nodes, the third type named ecological rivers have plenty of room and flexible space. Through Silt Garden, Rainwater Pond, Suburban Wetlands and Popular Science Park, in the future, they will become important regional eco-corridors or ecological parks.

Fig. 5

Water purification in the river is another important, long-term ecological mechanism for the comprehensive renovation. Plant purification is a common method: combining the requirements of the landscape, a combination of aquatic plants with highly effective purification is planted in the river fluvial to achieve the effect of adsorbing and degrading river water pollutants and purifying sewage. Since many rivers in the city are tidal rivers, the water level varies greatly with the tide of the Pearl River. In order to solve the impact of water level changes on wetland plants, ecological floating beds have been widely used for planting aquatic plants. The ecological floating bed is free to rise and fall as the

water level changes, and it can respond well to tidal changes.^[7] Moreover, aquatic plants, semi wet plants and damp-tolerant terrestrial plants preserve the natural environment and waterfront habitat as much as possible.^[2] Through the purification of water quality, the rivers in the central urban area have changed from stagnant water to live water, and the river water environment has been improved.

Fig. 7

Fig. 8

4. Methods: Regional Renewal Strategy in a Large Scale

In a large-scale planning, the regional update strategy is also conducted through three main phases: taking Guangzhou's unique terrain and surrounding mountains into consideration, in the first phase, while starting ecological restoration of mountains, the sewer network is constructed as the foundation of all other process of ecological restoration.

Most of the rivers in central Guangzhou have lost their navigational functions, however, they are still the city's 'blue line' in the psychological of the public.^[2] So in the second phase, we clearly defined the control area of rivers and the band-shaped green space reserved for the rivers. The control area of rivers could not only act as the natural site for the construction of the urban ped-bike system, but also guide the public to intimate contact with the waters, establishing dialogues and exchanges between the 'blue line' space and the greenway system.

In the third phase, various possibilities were re-introduced into the city and the waterfront areas became the basis for activating the urban space once decayed. Ultimately, the riverfront environment can serve city life in a more extensive scope. In return, river network regeneration can benefit from the urban space revival.

Fig. 8、9、10

5. Results: Unique Space to Rebuild Close Relationship Between Waterfront Environment and Urban Life

Once as a real ‘water city’ being born in water and living in water, the river network in Guangzhou is widely distributed everywhere just like lanes, so the rivers are original place where the residents have live for thousand years, which employ an indispensable influence on their life-styles, however, after decades of urban development, the rivers have become no longer relevant to everyday life in urban city. The rivers are not only an important component of the urban ecological environment, but also a stage for the urban life. So the improvement of the riverfront environment is not only a simple ecological restoration or scenic construction of rivers, but also a repairing process of the relationship between city and river.

Taking social concern of riverfront improvement into consideration, urban riverfront remediation should fully measure the functional orientation, cultural inheritance, and life style of the surrounding urban area, so that it will become a space truly correspond to Guangzhou’s flavor, carrying local life-styles. For example, if the

houses along the riverbanks of East Hao Chong, once a moat in Guangzhou with a long history, were almost demolished during the renovation, the living space pattern of this area, which was rich in old Guangzhou, will disappear. In terms of the protection of urban life forms, the complete construction is often irreversibly destructive. While preserving selective part of the residential area and it will be transformed into an integral part of the riverfront green space. The existing neighborhood and unique urban life will continue, which should be a better choice to create more vitality with the temperament of Guangzhou.[3] Eventually, far from reverse to river as it used to be, the vitality of the waterfront environment will redirect the urban life facing the river, rebuilding the close relationship between waterfront environment and urban life. It is bright future prospect to contrive a beautiful vision of harmonious co-existence between people and river through the phased rejuvenation strategy of ecological restoration, exhumation and spatial integration.

Fig. 11

6. Enlightenment of Constructing Green Infrastructure Based on Ecological Restoration of Rivers in Guangzhou

As we can see in restoration of rivers in Guangzhou, there is no doubt that the implementation of green infrastructure in the process of rapid urbanization is bound to encounter unimaginable difficulties, but it also contains unprecedented opportunities. I would like to conclude the enlightenment of constructing green infrastructure.

In urban construction, we must strictly protect existing key natural ecological areas that have not been destroyed through forward-looking planning. Next, we must seize the opportunity of urban development to explore a series of potential urban space construction and restoration of natural functions through creative means.[9] In particular, it is necessary to consider the combination with the urban status and adopt more targeted strategies and methods to reconstruct green infrastructure for natural, semi-natural, productive areas, suburban expansion areas, low-density and high-density urban core areas.

Moreover, the updated space with renewal of urban area could constitute green infrastructure with internal connectivity and systematic natural ecological functions, which would be compatible with the spatial and functional characteristics of modern cities. It is not merely a natural space, but also an efficient ecological framework for ensuring sustainable social and economic development, and an optimal strategy of balance between the tense land use and the protection of natural ecology. Some single landscape strategies can easily make the land eroded by the construction of other land. Instead, a compound urban strategy should be adopted to focus on the vitality and development potential of the multi-functional space, clearly defining a mixed proportion of land uses.

In addition, the green infrastructure in the urban environment must be protected by artificial means to make it more efficient,[9] reduce its existing vulnerability, and rely on the continuous development of advanced technologies and engineering facilities to

enhance the functional efficiency of the green infrastructure.

The last but not the least, the construction of green infrastructure needs to solve the problem of short-sightedness, which only exists in the immediate future, which prevails in the process of rapid urbanization. It fully recognizes that its ecological role is played gradually, but its functional effect is long-lasting and low-cost. It will be a long-term development strategy and long-term ecological mechanism for the “green modern city” in the future.

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Appendix

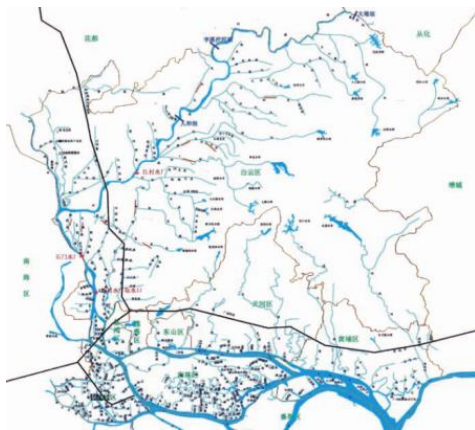


Fig. 1. The Densely Distributed Structure of Water System in Guangzhou



Fig. 2. The Period of Rivers' Cultural Development



Fig. 3. The Period of Rivers' Traffic Decadence



Fig. 4. The Period of 'Over-engineering' Rivers and 'Disappearing Rivers'

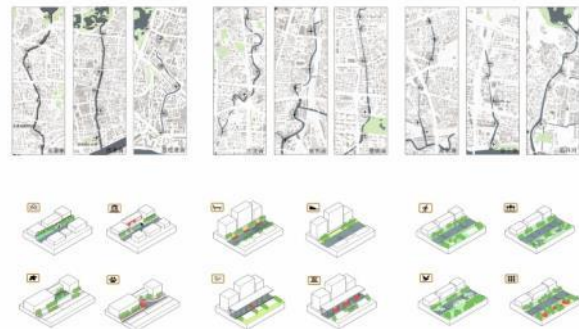


Fig. 5. Three Representative Types of Revival Space



Fig. 6. The Mode of Three Main Stages

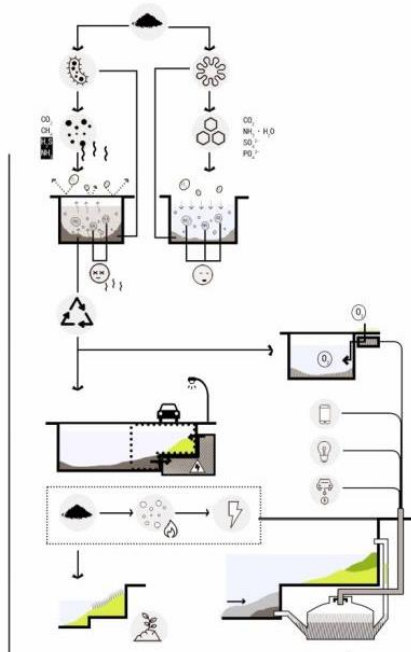


Fig. 7. The Technic Mechanism of Ecological Restoratio



Fig. 8. Regional Renewal Strategy I



Fig. 9. Regional Renewal Strategy II



Fig. 10. Regional Renewal Strategy III



Fig. 11. Diverse Space to Rebuild Close Relationship Between Waterfront Environment and Urban Life

The Spatial Landscape Characteristic of the Traditional Impounding Lake System in Jiangnan Region

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Abstract

As a significant category of traditional agricultural landscape, the impounding lake system was widely distributed in the south of China historically, which formed a typical vernacular landscape through thousand-years evolution. The study takes Jiangnan region as the research area, lying in the south of the Yangtze River, with both plains and hills scattering in. From the perspective of landscape architecture, several typical impounding lakes of Jiangnan region in the history are chosen as research objects by consulting ancient books and chorographic maps. Firstly, the relationship among the impounding lake system, the environmental background and the traditional city is discussed at the macroscopic level. Further, the paper summarizes forms of impounding lakes at the macro level and landscape elements at the micro level. The multiple functions of the impounding lake system are analyzed in three aspects: economy, ecology and culture. The purpose of this paper is to draw the attention of scholars who study in related discipline to focus on the traditional impounding lake system in China. Simultaneously, use ancient water management methods and apply them to the resilient landscape construction of modern cities.

Keywords: Landscape Architecture; impounding lake system; spatial landscape characteristic; Jiangnan region; resilience

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1. Introduction

The impounding lake system is a typical category of Chinese agricultural landscape. As agricultural landscape occupies most of Chinese territory [1] and embodies diverse geographical environment as well as long agricultural history spatially, it is the core component of vernacular landscape. Vernacular landscape reflects the natural and cultural characteristics of specific regions, including not only natural landscape, but also the landscape derived from dwellers' production and daily life through history [2]. Settlement landscape in architecture is the main aspect of current vernacular landscape study in China, while the connection among natural landscape, agricultural landscape and settlement landscape is often overlooked.

Because of various topographical and hydrological characteristics in vast territory, agricultural landscape emerges different characteristics. Long-distance diversion canal system is mainly used in northern China, but impounding lake system in southern China. As a typical hilly agricultural landscape, traditional impounding lake system is widely distributed in Jiangnan region historically [3](Figure 1), and forms unique regional feature. Jiangnan region lies in the south of the Yangtze River, with both plains and hills scattering in. Flash floods brought by abundant rainfall along with uneven precipitation lead to complex agricultural issues [4]. Therefore, a large amount of traditional impounding lakes were built in history for flood control and irrigation. But most of them have gradually disappeared because of urban sprawl or the policy of reclaiming farmland from lakes. The paper selects typical impounding lakes in Jiangnan

region including Chishan Lake in Jurong, Lian Lake in Danyang, Jian Lake in Shaoxing, South lake in Yuhang, West Lake in Hangzhou, Guangde Lake and Dongqian Lake in Yinxian as research objects for comparison, in order to summarize the spatial landscape characteristics of traditional impounding lake system, which can put forward proposals for resilient urban landscape construction in Jiangnan region and maintaining of landscape diversity in China.

2. Formation and Development of the traditional impounding lake system in Jiangnan region

From the Spring and Autumn Period to the Western Han Dynasty, water conservancy construction focused on the development of large-scale irrigation channels in the north of China. Although the impounding Lake also developed during the Western Han Dynasty, it mainly concentrated in Hanzhong, Nanyang and Runan region. Until the Eastern Han Dynasty, the eastward movement of political center led to economic development in the southeast of China, combined with the natural conditions of the hilly areas in Jiangnan region, so the traditional impounding lake system that is suitable for such environmental conditions was built in Jiangnan region. In the Southern and Northern Dynasties, the continuous war in the north gives rise to a large number of population moving southwards, which accelerating the process of economic development in the south and further development of impounding lake construction. Until the Song Dynasty, rapid growth of population in Jiangnan region resulted in insufficient arable land. People changed lakes and mountains into

farmlands, so the number of large lakes in Jiangnan region is significantly decreased. On the contrary, the number of small lakes which are suitable for mountain irrigation increased.

3. The spatial landscape characteristic of the traditional impounding lake system

3.1. On the macro scale

The vernacular landscape pattern in Jiangnan region was formed by the long-term mutual superposition of agricultural landscape, natural landscape, and settlement landscape. Therefore, it is particularly important to discuss the mechanism among the impounding lake system, the environmental background and the traditional city, which can be spatially characterized.

First of all, the ancient water system organically connected the impounding lake system with the environmental background and the traditional city. The traditional impounding lake system in Jiangnan region is presented as a “catchment-impounding-flow” resilient structure. The "catchment" process starts from the water source in the environmental background, which can be divided into two types, the rivers and the mountain stream. The "impounding" is the adjustment and storage of the water by impounding lakes. The "flow" includes drainage and diversion system. In the dry season, the lake water can be used for agricultural irrigation, water supplement of canals and urban water system (Figure 2). Moreover, it can be drained into rivers or ditches through overflow system to ensure the security during the flood season. For example, Dongqian Lake impounds the water from surrounding mountains. The lake

water flows into Zhongtang Canal, Qiantang Canal, Houtang Canal and Xiaoxia River respectively through the four sluices of Mozhiyan Sluice, Dayan Sluice, Qianyan Sluice and Meihu Sluice, then irrigates farmland through the water network of the Yindong Plain. In the flood season, the lake water is discharged into the Fenghua River or the Yong River [5].

Secondly, taking into account the distance between the impounding lake and the city, the impounding lake system can be divided into two types: the near city type and the far from city type (Table 1). The traditional impounding lake system usually has a variety of functions such as agricultural irrigation, flood control and water supplement for canals and cities. The far from city type is mainly used for agricultural irrigation. Take for example Guangde Lake and Dongqian Lake, which respectively irrigated in the Yinxi Plain and Yindong Plain. The near city type is more suitable as a sustainable source for urban water system because of its distance advantages, such as West Lake in Hangzhou. In the Tang Dynasty, six wells were built in Hangzhou city convenient for diverting water from West Lake [6]. The study found that in the near-city type impounding lake system, there are mainly two kinds of positional relationship between the city and the impounding lake: the city is located between impounding Lake and river, such as Jian Lake and West Lake, the city and impounding lake are separated by the river, such as Nan Lake, Lian Lake.

3.2. On the intermediate scale

The impounding lake system has obvious landscape features, which are closely related to the natural condition.

According to the location, impounding lakes can be divided into three categories (Figure 3) with different levees alongside the lake: The first category of the lake uses intermountain depressions to construct in the valley with multiple mountain streams as the water source, such as Dongqian Lake and Chishan Lake (Figure 4). This type of lake has only a partial arrangement of levees at the gap between two mountains. The length of the levee is short, which greatly saves construction volume. For example, Dongqian Lake has a total of 9 levees (excluding 2 separation levees), whose total length is only about 2,550 meters, of which the longest Fangjia Levee is 819 meters long. The second category is built in the plain area that is backed by mountains. The levee is semi-enclosed and has a relatively long length. Taking Jian Lake as a case study, the total length of three levees is 59,400 meters, of which the shortest one is 4,700 meters long [7]. The water sources for second category lakes are mostly several mountain streams, such as Guangde Lake, Jian Lake, South Lake and West Lake (Figure 4). The third category of the lake is built on lowland with full-enclosed levee, such as Lian Lake, which uses Malin Stream as the only water source (Figure 4).

According to the lake structure, the impounding lake can be divided into two categories: simple and complex. Because of the different lakebed elevation and the dredging activities during the evolution of lakes, separation levees are often built in impounding lakes. The simple-type lake (Figure 5a) is a single lake with no separation levee, such as Chishan Lake and Guangde Lake. The complex-type lake is divided into two or more parts by separation levees. Some of complex-type lakes have no difference in height (Figure 5b). Their

separation levees are made of silt from the dredging project. This not only saves the cost of moving the silt out of the lake, but also separates the lake to make dredging much easier [5]. Examples for reference include Dongqian Lake and West Lake. Another type of the complex lake, such as Jian Lake and South Lake, is composed of upper and lower lakes (Figure 5c), and is separated by separation levees to accommodate the difference in lakebed height. This will save the construction volume of levees alongside the lake, and at the same time reduce wind waves against levees. In addition, some of lakes have undergone several changes between simple-type and complex-type due to the development of water conservancy technology and different needs of different periods. As a typical example, Lian Lake changed from simple-type to complex-type after many times of siltation and renovation. Later, the lake was converted into a simple-type structure, because its upper lake was occupied by farmland in Ming Dynasty.

3.3. On the micro scale

There are two approaches to form the traditional impounding lake system: one is storing water by levees at the place where the runoff converges, and the other is building levees alongside natural lakes to expand the impoundage. These two approaches embody the process of interaction between artificial construction and natural environment. With the development of engineering technology and the ever-increasing spiritual, religious and aesthetic needs of humans, the impounding lake system has become increasingly mature. In addition to the lake itself, the complete traditional impounding Lake system also includes water management infrastructure and landscape infrastructure.

The water management infrastructure consists of levees, islands, sluice gates, weirs, covered drains, wells and etc. Firstly, the levee and the island constitute the spatial framework of the impounding lake system. According to different functions, the levee can be divided into levee alongside the lake and separation levee in the lake. The main use of levees alongside the lake is to store water, including three forms of partial levee, semi-enclosed levee and full-enclosed levee. The irreplaceable function of separation levees is to accommodate the difference in height and reduce the scour by flowing water. In addition to the most common linear separation levees, cruciform separation levees have also emerged. South Lake is divided into 4 parts by the cruciform separation levee [8](Figure 7), with mulberry trees planted on it to strengthen the levee and get maintenance costs by leasing land. The wooden piles excavated from the site of South Lake illustrates that the method of building levees was still used today by drilling the row of wooden piles down into the ground to strengthen the foundation, and then filling the soil. The silt produced during the dredging process can also be mounded into islands. There are countless mounds in South Lake. The higher one is more than ten meters high and the lower one is only a few meters high. The Reed Mound and the Wild Duck Mound are named after lush reeds and numerous wild ducks respectively [9]. It can be seen that the artificial islands in the lake constitutes abundant small ecosystem, which not only has ornamental value, but also brings certain ecological benefits to the water system. Secondly, the irrigation and drainage facilities, such as sluice gates, weirs, covered drains and etc., serve as key nodes in the water management system in order to establish links between internal and external water systems. For example,

Dongqian Lake impounds from 72 streams in the southeastern side of the mountain (Figure 6 shows the direction of main streams). Nine levees are mounded at the gap between two mountains on the northwest side, and two separation levees between the two sides of the lake where has the shortest distance. Seven weirs are still in use, except for Limu Weir and Meihu Weir that disappeared with Mei Lake. The lake water is discharged into external water systems including Zhongtang Canal, Qiantang Canal, Houtang Canal and Xiaojia River through the four old sluice gates [10]. From the spatial analysis, settlements around Dongqian Lake are close to the water source, namely on the plains of the lakeside or both sides of the watercourse. And some of settlements are also distributed on the open flats near weirs and sluice gates, named after these water infrastructures. It's convenient for management and maintenance of these facilities. For example, Qianyantou Village, Mozhi Town, Dagong Village, Dayan Village and Guojiazhi Village are located near Qianyan Sluice, Mozhi Sluice, Huxin Levee, Dayan Sluice and Guojiazhi Sluice respectively.

The landscape infrastructure consists of a series of landscape elements including temples, pavilions, towers, bridges, stone tablets and etc. Take South Lake (Figure 7) as an example. These landscape elements are often built in the lake (on separation levees and islands), on the boundary of the lake (on levees alongside the lake) and around the lake (where has broad view), such as Fuhu Pavilion on the cruciform separation levee in the lake, Dizang Palace, Shiliang Pavilion and Youfei Pavilion on the northern levee, Sanxian Memorial Temple, Tiancao Temple, Sanguan Palace and Sanyi Palace on the eastern levee, Anle Tower on the top of surrounding Anle Mountain,

Dongxiao Palace on the western mountain around South Lake and Guanyin Pavilion on the cliff of Xiaofeng Mountain. Wang Shaozhen, a poet, wrote “The trees flutter in the wind. You can overlook the lake here and see Dongyue Temple through the fog”, which reflects Guanyin Pavilion is a lovely location overlooking the lake with comfortable environment. Meanwhile, from the perspective of Guanyin Pavilion, visitors can overlook Dongyue Temple at the foot of Phoenix Mountain. These landscape elements are often used to define the scope of impounding Lakes. It is recorded that South Lake was served Sanguan Temple as the eastern boundary, Xiaofeng Mountain as the southern boundary, Shanyu Port as the western boundary, Shiliang Pavilion as the northern boundary, Dongyue Temple as the southeastern boundary, Sanxian Temple as the northeastern boundary, the wilderness as the southwestern boundary and Shimen Bridge as the northwest boundary. (At that time, the upper South Lake has been silted up). Eight stone tablets were set up to define the lake boundary.

4. The multiple functions and values of traditional impounding lake system

4.1. Economic value

The traditional impounding lake system is a paradigm for harmonious development between humans and nature in Jiangnan region. As an important form of land use in the agricultural landscape, impounding lakes take full advantage of natural resources, in order to ensure the sustainable water supply for agricultural production, figure out the problem of crop drought caused by uneven seasonal precipitation in Jiangnan region and promote the prosperity of agricultural economy. Apart from the agricultural function of irrigation, the ecological

function of water supplement for canals is also worthy of attention. For example, after the middle period of Tang Dynasty, the north part of Jiangnan Canal (from Zhenjiang to Wuxi Wangting) used tidal water of the Yangtze River as the source in summer and autumn. In winter and spring, if tides cannot flow into the canal, Lian Lake water became the source of canal. In order to ensure the normal operation of the shipping industry, sluice gates and weirs were established to control the impounding and discharge [11]. There is an old saying that “If the water level of Lian Lake is dropped by one inch, the canal’s will rise one foot”. In the course of mutual adaptation between humans and nature, the distinctive agricultural landscape in Jiangnan region is finally formed.

4.2. Ecological value

The traditional impounding lake system also has considerable ecological value. It is interconnected with regional water system to form the water adaptive landscape through resilient deployment of water resources [12]. Thereby, disruptive natural events such as flash floods caused by uneven seasonal precipitation in the hilly Jiangnan region are figured out. With the long evolution, levees and islands mounded in dredging process promotes the natural formation of secondary wetlands, which provides habitats and eco-corridors for local wildlife. This helps to improve the diversity and stability of the ecosystem.

4.3. Cultural value

After satisfying the basic material living conditions, the impounding lake also serves as a vehicle of the cultural creation for spiritual needs. Thus the traditional impounding lake system has an extraordinary vernacular cultural value. A

representative case is West Lake, which still retains the natural beauty of lakes and mountains and profound cultural significance currently. West Lake attracted a lot of literati in history. They left plenty of famous poets, ancient books and paintings. Bai Juyi, a poet in the Tang Dynasty and prefectural governor of Hangzhou, dredged six wells and formulated the corresponding impounding lake management system. Meanwhile, he wrote the Qiantang Lake Inscription (West lake was called Qiantang Lake in ancient) which includes renovation strategy and relevant issues, and carved the inscription on stone by the lake. These cultural and artistic creations have promoted the inheritance and development of vernacular culture. He also left famous verses, such as “The scenery of the lake is too enjoyable to leave, and the most lovely is the White Sand Levee canopied by poplars.” and “I do not want to leave Hangzhou and go home, half of the reason is the picturesque West Lake.”

5. Discussion

In the dynamic evolution over thousands of years, people continuously influence on nature under the premise of respecting nature. The interaction between nature and humans has formed the vernacular landscape with regional uniqueness and landscape diversity. Satisfying the needs of production, spirituality, religion and aesthetics, these landscapes are also spatial reflection of formation and evolution of regional characteristics in history. However, with the acceleration of globalization and urbanization, people no longer respect nature and work with nature. Vernacular landscape of China gradually shows a trend of homogenization and simplification. Therefore, an overall and in-depth study of vernacular landscape is of great significance.

The analysis of the agricultural landscape, which is the core component of the vernacular landscape in China, will provide the basis for the maintenance of the diversity and uniqueness of vernacular landscape. Although some of traditional impounding lakes have disappeared, natural and cultural relics can still be found in the preserved impounding lakes, ancient books and chorographic maps. Teasing out the relationship among the impounding lake system, the environmental background and the traditional city, and summarizing the resilient mechanism of the traditional impounding lake system, helps to provide reference for resilient urban landscape in Jiangnan region in the future.

Acknowledgments

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Appendix

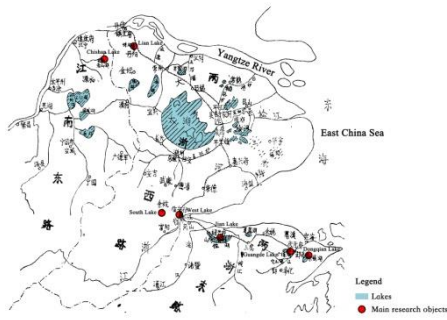


Fig. 1. Water system of Jiangnan region in Song Dynasty.

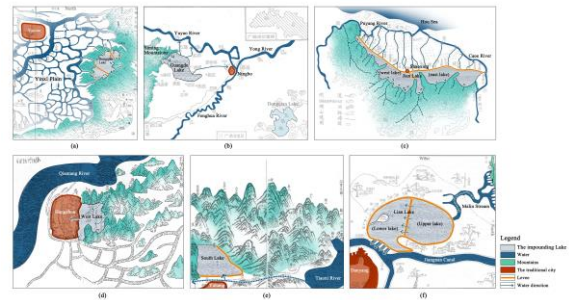


Fig. 4. The landscape characteristics of impounding lakes because of their different location.

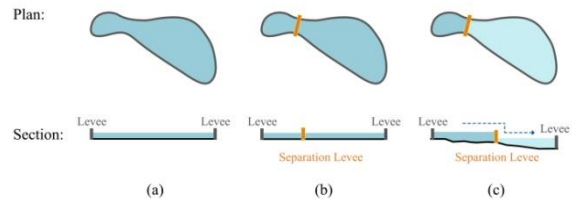


Fig. 5. The classification of the impounding lake according to the structure

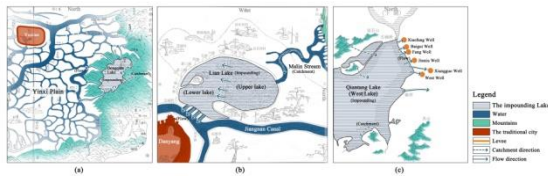


Fig. 2. a. Dongqian Lake diversion irrigation system; b. Lian Lake supplement for canals; c. Guangde Lake urban water system

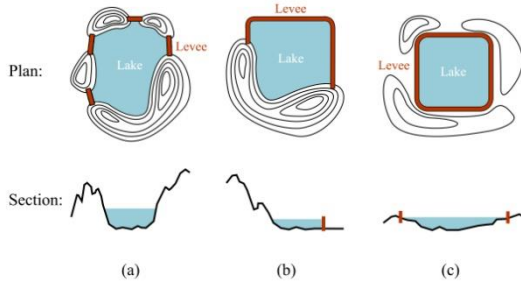


Fig. 3. The classification of the impounding lake according to the location: a. Plan and section of the lake built in the intermountain depression; b. Plan and section of the lake built in the plain area that is backed by mountains; c. Plan and section of the lake built on the lowland.

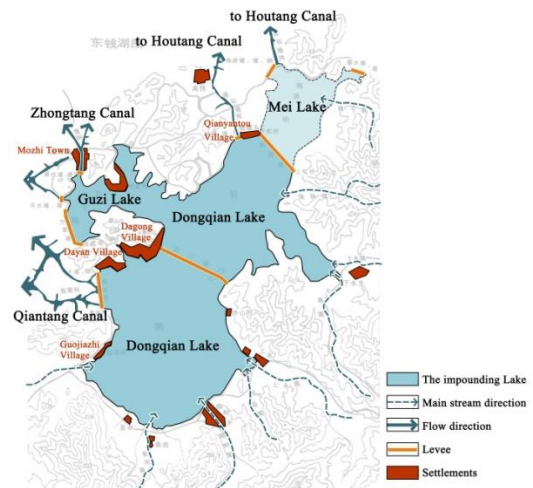


Fig. 6. The water system of Dongqian Lake with spatial distribution of the water management infrastructure

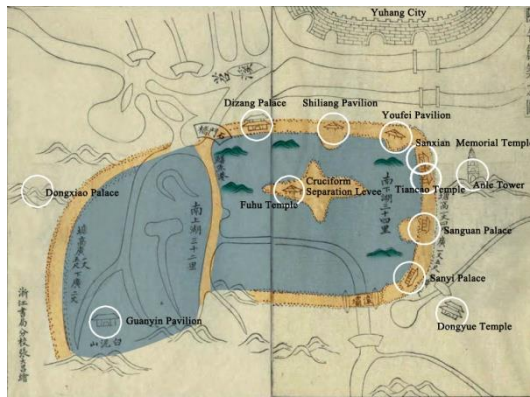


Fig. 7. Spatial distribution of water management infrastructure and landscape infrastructure in South Lake

Name of the impounding lake	Category	Surrounding city	Distance between the lake and the surrounding city
Lian Lake	Near city type	Danyang	120 step size
Jian Lake	Near city type	Shaoxing	3 li
South Lake	Near city type	Yuhang	2-5 li
West Lake	Near city type	Hangzhou	The lake is next to the city.
Chishan Lake	Far from city type	Jurong	30 li
Guangde Lake	Far from city type	Yinxian	12 li
Dongqian Lake	Far from city type	Yinxian	30 li

Table. 1. The impounding lake system is classified according to the distance between the impounding lake and the city

Landscape Resilience: Research on Landscape Process and Strategies of Water-Level-Fluctuation Zone in the Three Gorges Reservoir——Case Study of Gaoyang Town

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Abstract

Water-level-fluctuation zone in the Three Gorges Reservoir is the most typical artificial fluctuating zone in China, with a vertical drop of 30m. It is faced with huge ecological and social problems caused by flooding (great variety of the water-level). So it has been a worldwide problem that how to protect it ecologically, utilize it scientifically and develop it healthily. In the perspective of landscape resilience, taking the water-level-fluctuation zone of Gaoyang as a case, the paper attempts to make analysis of the land-use, hydrological situation and summarizing its characteristics and problems (ecological environmental deterioration, traditional customs and habits absence, farmland and public facilities disappearance). Then the paper puts forward a resilient solution from three aspects of ecological restoration, industry recovery and local cultural renaissance to study its landscape planning strategies.

The project is located in Gaoyang town, whose location is at the mid-south of Xingshan county, Hubei province. Gaoyang town, with profound cultural background and over one thousand years history. What's more, Gaoyang town was the last town moved out from the Three Gorges Reservoir Area because of the rising water level. Many problems are caused by flooding. The first problem is the ecological problems, such as the water loss and soil erosion and biodiversity loss, should be solved urgently. Secondly, the traditional customs and habits would lost as the rising water level flooded the ancient town and a large number of immigrants had to move out. In addition, Gaoyang town faced huge challenges because a lot of farmland and public facilities had been flooded. Therefore, how to promote rural landscape under the influence of the hydro-fluctuation belt and make it a healthy and sustainable development is the real question we ought to face straightly.

The paper puts forward a resilient solution that is using the existing "riparian zone" flood area, the change of water level forms a series of differences in the "ladder". Ecological restoration of riparian; Planting seasonal vegetable crops; Extension Agricultural ecological cycle system; Giving full play to the advantages of fishery. At the same time, the "ladder" provides a series of green open space for the residents, diverse landscape level changes which create the residents to carry out rich folk festivals, and become a link between the residents and the reconstruction of the close relationship between the river.

The paper is expected to construct resilient framework of water-level-fluctuation zone landscape planning strategies of Three Gorges Reservoir Region. These resilient measures make regions quickly recovered and develop sustainably after a devastating natural disaster.

Keywords: landscape resilience; biodiversity loss; flooding; water-level-fluctuation zone; Three Gorges Reservoir

1. Introduction

Since the completion of the Three Gorges Dam in 2006, large swaths of land have been flooded, forcing millions of people to relocate and creating a large area of water-level-fluctuation zone. The water-level-fluctuation zone refers to a special area where the flooded land around the reservoir periodically exposes to the surface of the water due to the fluctuation of the seasonal water level formed by the reservoir operation plan^[1]. Water-level-fluctuation zone in the Three Gorges Reservoir is the most typical artificial fluctuating zone in China, with a vertical drop of 30m. It is faced with huge ecological and social problems caused by flooding (great variety of the water-level). Therefore, how to make a flexible ecological protection and urban development plan to realize sustainable development in the water-level-fluctuation zone has become a worldwide problem.

Resilience is defined as "the capacity of an ecosystem to tolerate disturbance without collapsing"^[2]. Resilience is conferred in human and ecological systems by their capacity for recovery and future adaptation, as well as the given ability of humans to anticipate and plan for the future using these knowledge. There is increasing awareness that a greater understanding and emphasis of ecosystem resilience is required to reach the goal of sustainable development^[3]. In the perspective of landscape resilience, taking the water-level-fluctuation zone of Gaoyang town, Hubei province as a case (fig. 1.), the paper attempts to make analysis of the land-use, hydrological situation and summarizing its characteristics and problems. Then

putting forward a resilient solution from three aspects of ecological restoration, industry recovery and local cultural renaissance to study its landscape planning strategies.

In terms of the research on hydro-fluctuation belt (fig. 2.), some countries or regions such as the North America, Europe, Australia, Japan started early and relatively, obtained rich research results. In the early research, the interlaced zone located in the water and land ecosystem is called the "riparian belt" (the concept of riparian belt and the hydro-fluctuation belt is similar in early times)^[4]. Throughout the study abroad, it mainly concentrated in the wetland ecological restoration, vegetation restoration and reconstruction, riparian zone ecosystem management, the influence of land use of riparian zone, vegetation succession, etc. In the end of the 20th century to the 21st century, with the establishment of the Three Gorges Dam and the formation of the Three Gorges Reservoir area, the water-level-fluctuation zone in the Three Gorges Reservoir became a research hotspot, scholars mainly made researches from solving ecological environment problems, land resources utilization, reconstruction of ecological system, plant planting, etc. For example, Ren Wei (2016) studied the landscape characteristics of the hydro-fluctuation belt zone in Yunyang, Chongqing. The study classified the land usage, and put forward the plan of landscape planning based on it^[5]. Deng Cong (2010) pointed that fluctuating zone ecosystem is an open-ecosystem, the stability of its ecosystem and the security of landscape is essential for the whole reservoir ecosystem^[6]. Fu Juan (2015) made a survey

of water-level-fluctuation zone along the Xiangxi River of the Three Gorges Reservoir, the floristic composition and plant community diversity were reported. The research stated that species richness, community diversity, evenness and dominance represented the pattern of gradually increasing and then declining. The hydrological conditions appeared to be the important reasons of vegetation composition^[7]. Some exploratory studies have been carried out on tourism landscape planning and design. Bao Wen (2012) studied the development and administration of tour landscape in water-level-fluctuation zone of the Three Gorges Reservoir area, the study pointed that the tourism resources and landscape had huge change before and after Three Gorges Dam construction, which made great damages to local tourism resources. Then putting forward solutions to revitalize tourist industry^[8].

But there is a lack of research from the perspective of landscape resilience. Because the landscape research of the water-level-fluctuation zone is a multidisciplinary subject, it also lacks cases consideration from comprehensive aspects of ecology, economy, social, culture.

2. Background of Gaoyang town

2.1. Transition history of settlement

Gaoyang town, with 1026 years history, is famous for the Chinese distinguished figure named Wang Zhaojun and is also called as ‘the hometown of Zhaojun. Local villagers have the custom of worship Wang Zhaojun. Gaoyang town is the vital transportation hub as it closes to the Xiangxi

river. Gaoyang town is the center of politics, economy, culture and transportation of Xingshan county in the eighties and nineties of last century as the blocks expanded quickly and the town expanded along the Xiangxi river at that time.

In early October 2006, the Three Gorges Dam was filled with 156 meters of water, and the ancient town site of Gaoyang sunk into the water. Only parts of the historical sites with low water level appeared on the surface. Gaoyang town was renamed Zhaojun town and the existing more than 1,000 years of ancient town—Gaoyang in fact disappeared underwater forever. The concrete dam was built after the construction of the reservoir. However, the accidents that the collapse of the dam took place frequently because of the unstable foundations and river erosion. The hydro-fluctuation belt was finally abandoned because of the reason above and also because the town lacked its own character (fig. 3.).

2.2. Hydrological analysis

In the Three Gorges Reservoir area, the height of riparian zone that smaller range is about 3 to 10m, then the largest of it is up to 30m, with 349 km² of the area. In the flood season, from Jun.to Sep. , the water level is 145 meters. From Oct. To Dec. , in the storage period, the water level rises to 175 meters. From Jan. to May., in the flood period, the water level slow down to 145 meters. The water level holding in 145 meters is about 110-120 days, and in 175 meters is for about 35-40 days (fig. 4.).

The water level drop of 30 meters will enable the formation of a large area of the Three Gorges Reservoir Riparian zone.

Because the most of the town is located in the river flat of the both sides of Xiangxi River and Gengjia River in the elevation from 155 to 165 meters. By the water level is 175 m in the Three Gorges reservoir, Gaoyang's main street and municipal facilities almost all flooded. In addition, Gaoyang town is located at the tail section of Xiangxi river which belongs to the Three Gorges Reservoir Area. Geological problems such as soil erosion, landslides and mudslides always take place because the force of engineering activities and the changed environment.

2.3. Problems caused by flooding

Many problems are caused by flooding. The most serious problem is the ecological problems, such as biodiversity loss, water pollution and eutrophication, soil erosion and vegetation damage, should be solved urgently. As mentioned above, the the water level fluctuation season in water-level-fluctuation zone violate natural drought-flooding law, when the most hot and humid season comes, the heavy rains are frequent at the same time, will lead to great changes in terrestrial ecosystems, especially to plant communities. Therefore the ecosystem is quite fragile. In the other hand, before the formation of the water-level-fluctuation zone, the vegetation on both banks of the reservoir area is a natural ecological barrier, which has some function of interception and filtration of pollution from the reservoir bank, especially agricultural non-point source pollution. Nitrogen, phosphorus, etc. carried by surface runoff are equivalent. A part of it is digested and absorbed by vegetation to prevent it from entering the reservoir water body. After the formation of

the water-level-fluctuation zone, these functions will basically be lost, and more pollutants will enter the water body, leading to an increasing degree of eutrophication in the reservoir area.

Secondly, Gaoyang town faced huge challenges because a lot of farmland and public facilities had been flooded. Residents were forced to migrate from old Gaoyang town to other districts and most of the houses, roads and the public facilities had to be dismantled because the floods from the reservoir. Compared with the old town before, the land area of the town shrank and the residents lacked the necessary public facilities and public space. The figure 5 shows that 82% buildings are flooded and 130000 people are removed. As a result, 30% of the industry is affected and incomes are reduced by 20% (fig. 5.).

In addition, the traditional customs and habits would lost as the rising water level flooded the ancient town and a large number of immigrants had to move out. With the process of urbanization, the construction of Gaoyang town, like other towns in China, is facing a serious problem of assimilation.

Therefore, how to promote rural landscape under the influence of the water-level-fluctuation zone and make it a healthy and sustainable development, maintaining the unique historical culture of Gaoyang town at the same time, is the real question we ought to face straightly.

3. Resilient Strategies

Because the water level is constantly floating, the strategies must be resilient. So the study puts forward a resilient solution

that is using the existing "riparian zone" flood area, the change of water level forms a series of differences in the "ladder" (fig. 6.). Ecological restoration of riparian; Planting seasonal vegetable crops; Extension Agricultural ecological cycle system; Giving full play to the advantages of fishery. There are 4 layers in the "ladder" including folkway layer, fishing layer, crop layer and plant layer from low to high. The floating trails (folkway layer) are set on the river close to the flooded houses. Residents will recall the history when they get close to the folkways ladder, which also create many kinds of public space for people's activities along the river banks. The fishing ladder's altitude will change along with water level where people can fish and cultivate aquatic products on it. These activities and hygrophyte planted around the fishing ladders aim to build open waterfront space. The local crops and seasonal vegetables planted on the ladders are supplied to residents and the ladders create a scenic riverside landscape. The chosen hygrophyte can filtrate and settle nutrition, pesticide and microorganism. It is significant for water purification and conservation of water and soil of the water-level-fluctuation zone. At the same time, the "ladder" provides a series of green open space for the residents, diverse landscape level changes which create the residents to carry out rich folk festivals, and become a link between the residents and the reconstruction of the close relationship between the river.

The whole system can fluctuate according to the change of water level, so it can produce different landscape effect. In summer, the water level is the lowest, so these ladders will distribute in a stepped

vertical shape. In spring and autumn, the stairs located on the middle of the water-level-fluctuation zone will float because of the rise of the water level. After that, all the floating stairs will constitute a larger activity platform where people may have a spring outing or dry the grain. All the stairs will float and constitute the largest platform for festival and folk custom activities during the winter when water level is the highest.

3.1. Ecological restoration

Due to the periodic inundation of the river, the vegetation conditions in the area are very poor, mainly with wild shrubs and herbs, and the ecological balance is destroyed. Plants are the vital part of both ecosystem of the water-level-fluctuation zone and the sightseeing of riverbank. They are beneficial to reduce soil erosion and purify the water which contribute to the species diversity eventually. Therefore, the water-level-fluctuation zone need to consider the purification function of the community configuration and species selection for the formation of wetland vegetation, and establish an interception and distribution system for the sewage generated in the extension zone of the wetland belt, evenly distribute the runoff from farmland and cities into the nursing belt to fully utilize the wetland system. The purification function achieves a better effect.

Plants growing on the water-level-fluctuation zone spread as the plaque (just like our boat like stairs), which is helpful to plants growth when they are drowned. The plants also spread in four band like district along the water-level-fluctuation zone according to the altitude. Therefore, this system imitates the four natural band like

district. The plan designs four different plant stair districts according to the different altitude and grow ecological vegetation, cash crop, grain and hygrophilous vegetation in each district.

According to the different site environment condition, the suitable seedlings need to be chosen for aquatic or for terrestrial. Current research shows that plants suitable for the water-level-fluctuation zone in the Three Gorges Reservoir include *Taxodium distichum*, *Taxodium ascendens*, *Myricaria laxiflora*, *Glyptostrobus pensilis*, *Populus deltoids*, *Carya aquatica* and so on^[9]. In the plan, these plants are applied. In addition, management technologies including seedlings treatment, timely construction, reasonable close planting, drought resistance, and cultivation are also very important.

3.2. Industry recovery

In ancient times, Gaoyang town was an important port of Xiangxi River Basin. The agricultural products, tea and medicinal materials produced in Gaoyang town were transported from here to the outside. In modern times, Gaoyang town has also achieved certain development with its abundant agricultural and forestry resources, mineral resources and hydraulic resources. Therefore, industry recovery is the key to drive the economic prosperity of Gaoyang town. This system plans to plant local crops and vegetables seasonally in the ladders. Sow seen in spring, when the water level is low, harvested after a period of growth in summer or autumn, and when the water level is highest in winter, the area is submerged. In addition, the system uses the lower layer to develop fisheries products.

The baskets are placed below the decks and float freely as the water rises. The output value of the primary industry of Gaoyang town will improve through the revitalization of agriculture and fishery.

Moreover, the terraced landscape formed by the system will become a unique landscape in Gaoyang town, and the rural tourism can develop greatly with the help of the historical and cultural influence of Zhaojun's hometown.

3.3. Local cultural renaissance

The ancient Gaoyang town was once a city with a long history and a rich culture. As the water flooded, many historic sites were also permanently submerged under water. Only in summer, when the water level is lowest, some historic sites and buildings will appear above the water. So at the lowest level, the system set up a historical route to tell people that there used to be a beautiful old town. At the same time, cultural revival is also reflected in the heritage of festival activities and customs, the large floating plates formed on these decks can be used as places for folk festivals and cultural displays.

In addition, the response to culture is also reflected in many aspects, such as the cultivation of native plants, the application of native materials and so on, using these physical space environment to convey a rustic atmosphere. The excellent cultural traditions of the area evoke people's feelings for the ancient town that has passed away.

4. Conclusions

Because of the flood disaster, the Three Gorges area has a lot of negative effects, and many ancient villages are disappearing. How to improve the landscape in the area scientifically and rationally is an important aspect of landscape resilience. With the help of a simple, low-interference way to realize harmonious coexistence of human, society and nature, promoting the region's ability to respond to disasters, even transforming these bad conditions into favorable factors, is the embodiment of the landscape resilience. Through the case study of Gaoyang town, the plan creatively puts forward the resilient solution, which will have a positive influence on the planning of the other towns in the Three Gorges Reservoir area.

Acknowledgments

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Appendix

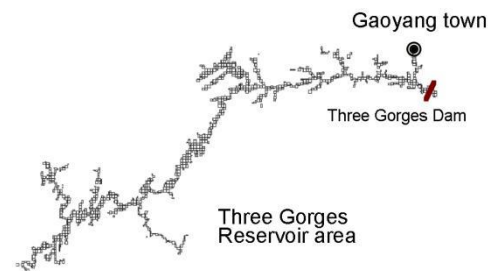


Fig. 1. The location of Gaoyang town in the Three Gorges Reservoir area

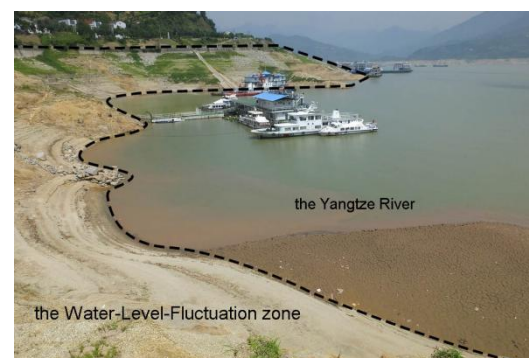


Fig. 2. The water-level-fluctuation zone



Fig. 3. The transition history of settlement

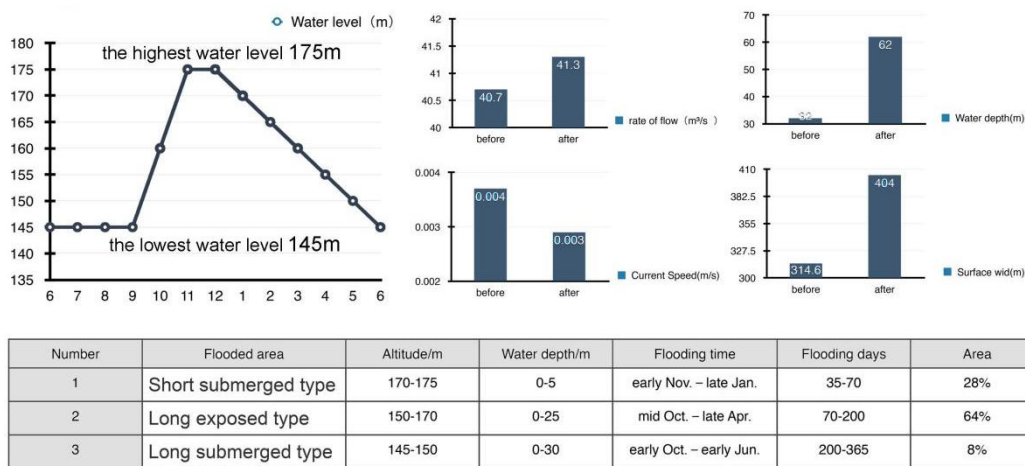


Fig. 4. Hydrological analysis of Xiangxi River

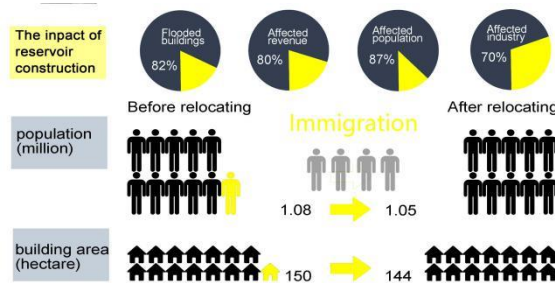


Fig. 5. The impact of reservoir construction

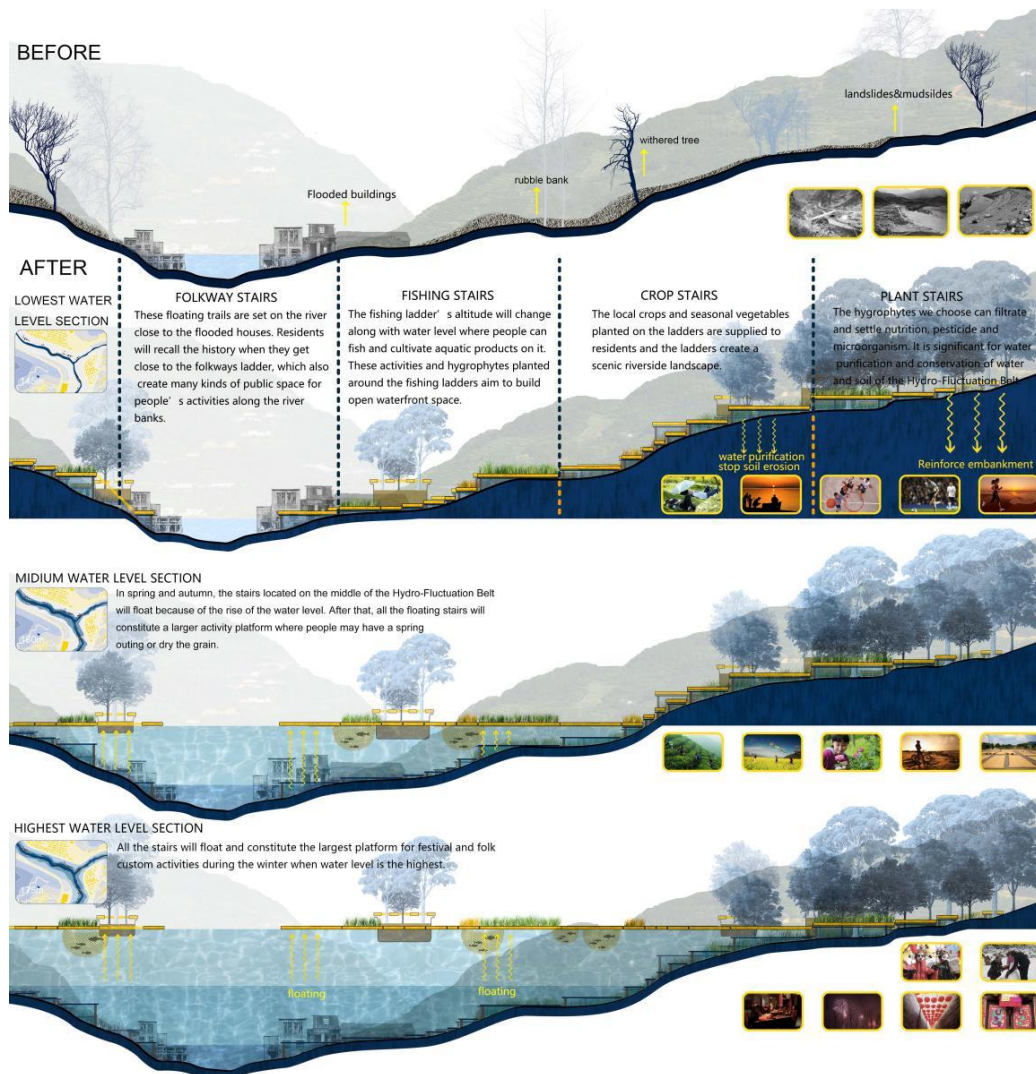


Fig. 6. Before and after elevation design contrast

Primary Study of Renewal Design of Urban Riverside Region —Taking Beijing Zhuanhe Riverside Region Concept Renewal as the Example

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Abstract

The urban riverside region is the area with abundant natural landscape resources and human landscape resources in urban open space. Nowadays, most of the riverside region has problems of unreasonable use of space, lack of features, etc. With the continuous development of the city, the demand for urban open space is constantly improving, the renovation of the city riverside area is imperative. This paper introduces the concept of urban renewal, starting from the factors of land use, function, culture and ecology, so as to draw a set of universal theoretical system in the area of urban river area renewal, and guide the healthy development of urban riverside region renewal activities. Taking the Beijing Zhuanhe Riverside area as an example, the paper hope to make reference for the future renewal of the urban riverside region.

Keywords: City; Riverside Region; Renewal; Urban Design

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1. Research Background

With the development of China, urban renewal has gradually become a hot topic. And as a part of the urban renewal, uniqueness of urban riverside area updated is often neglected. The riverside areas of the city are often rich in natural and human landscapes on account of its nature close to river, which also create the sophistication of their environment. Therefore, how to deal with the various relationships such as traffic, landscape and function in a limited land area during the renovation process is worth exploring.

2. The challenges confronted by the renewal of urban riverside area

2.1. Problems left over by history in riverside region

On the basis of its good water transport conditions, most planners choose riverfront area as an industrial and warehouse space at an early stage of urban construction. So the regional transportation infrastructure is relatively developed. With the development of landway transportation, the riverside area gradually declined, which caused the dilemma of the current riverside area. Firstly, it is the damage to the river ecosystem; Secondly, on account of historical reasons, urban waterfront areas are isolated by main roads, railways or industrial zones, so its purpose is single; the space of riverside region is introverted and relatively isolated organization system lacks close contact and communication with other areas of the city^[1]. However, as the rare scenic resources in the city, how to make the riverside region

[1] Shuang Yu. The Research on Renewal of Transformation in Urban Riverside Region[D]. Tianjin University, 2004.

a place for leisure and recreation of the residents by means of renovation is a huge challenge confronted by renewal of riverside region.

2.2. Absence of riverside area characteristic

In the process of urban renewal, on account of ignorance of the background differences in different regions, most of the riparian areas today exist problems such as weak connection with rivers and poor identifiability. At the same time, the single design method has resulted in slight differences in the landscape of riverside area. How to carry out in-depth excavation of local history, culture and regional features through transformation and renewal is another major challenge for the renewal.

3. The strategy of riverside region renewal

3.1. Renewal meet function

As a whole, riverside regional function should be coordinated with the overall urban functional layout of the city. As a relatively unique area in the city, riverside area is a complete system itself^[2]. Therefore, the upgrading of the riverfront area requires a reasonable functional layout. Dismantle and reconstruct buildings with inappropriate layout such as wasted wharfs and warehouses, increase the public space in the riverfront area and satisfy the residents' daily recreational demands; At the same time, it is necessary to govern intensive urban land traffic, underground transportation and water transportation, alleviate the serious division of the interior sections of the riverside area.

[2] Shanfeng Zhang. The Renewal of Public Space in Urban Riverside Region[D]. Northeast Forestry University, 2005.

3.2. *Improve and upgrade landscape*

As adjust function, the utilization of riverside resources is also very important. Riverside landscape can be shaped by combining riverside landscape belt with landscape nodes. Because of the continuity of riverside landscape belt, different landscape sequences can be formed by combining the landscape nodes. In addition, the whole riverside landscape belt and landscape nodes are connected in series by the means of the slow traffic system to form a complete landscape system. It can penetrate into the interior of the entire riverside area. This enhances the overall landscape while also facilitating the residents in the area.

3.3. *Shape and demonstrate regional characteristics*

The riverside area tends to be the starting point of the urban construction, so the riverside area is also the place where the historical culture gathers. The architecture and landscape with urban geographical features are the embodiment of urban characteristics. However, the traditional forms cannot be simply copied or scaled up under demands of new function and space requirements, we should conduct in-depth research on local history and culture characteristics^[3]. Therefore, when the riverside area is updated, it should be combined with era characteristics to create urban design elements with practical and cultural characteristics.

3.4. *Protection ecological environment*

The renewal design of the old riverside district takes the improvement of the

[3] Qi Zhang. Research on Shaping Features of New Urban Districts in Middle-sized and Small cities[D]. Tsinghua University, 2014.

ecological environment of the riverside area as the precondition. Otherwise, the riverfront area will not attract people and investment and its updated design will lose premise^[4]. Therefore, in the renewal of urban riverside areas, we must make full use of the principles of landscape ecology to restore and manage the ecological environment, including the governance of water pollution, softening of hard revetments and establishment of ecological corridors along the river. Only in this way can we restore and protect the fragile ecological environment of the urban river.

4. **Update content of urban riverside region**

The renewal of urban riverside area includes the contents of general urban renewal: the construction of building with unreasonable function layout and the large-scale renovation of urban roads; Rectification of aging buildings and public service facilities. At the same time, it also needs to pay attention to ecological protection and the construction of riverside public space. Overall, riverside area updates contain:

4.1. *The governance and restoration of water body*

Carry out restoration of water body and govern polluted urban water body; Conduct desilting of water body and restore natural connection and mobility of natural water system; Remould hard bank of the river and restore natural revetment; Plant waterfront plant groups and improve self-purification capacity; Implement construction of sponge

[4] Xiaocong Hu. The Theory and Practice of Renewal Design of Environment in Urban Riverside Old Town [D]. Northwest Agriculture&Forestry University, 2006.

city and strengthen absorption ability on rain.

4.2. Restore and utilize waste land

Carry out ecological remediation on waste and polluted land; eliminate potential safety hazard on site and cultivate plants with high adaptation to restore natural ecology of waste land.

4.3. Improve green space system

Carry out pergola construction along with river. At the same time, increase urban green space by the means of remove and transformation and other methods to form green space pattern of “green dot, green line and green surface”.

4.4. Increase public space

Through governance of illegal occupation of public space and demolition and other methods, increase public spaces in riverside space to satisfy demands of residents’ daily leisure and recreation.

4.5. Improve traffic condition

Tease road system in riverside system to buffer traffic jam. Carry out avenue transformation for those long and lack of shield. Increase public transportation system and parking system.

4.6. Transform old residential areas

Carry out environment transformation on old residential areas; strengthen construction of public service facilities inside areas; improve residential environment and offer ready service for residents.

5. The methods of urban renewal and its application on riverside region

In accordance with definition in the *The old city of Beijing and its Juer Hutong neighbour* authored by Wu Liangyong, renewal mainly includes three aspects of contents as following: 1) transformation, reconstruction or redevelopment refers to completely get rid of certain aspects in current environment and its purpose to expand space and increase new content to improve environment quality; 2) rehabilitation refers to reasonable adjustment and utilization of current environment, generally indicating partial adjustment; 3) conservation refers to protect on current state of owned conservancy value without alteration basically^[5].

In the riverside renewal process, the three means corresponds to three renewal models: demolition and transformation type, governance type and protection type. In the riverside renewal process, the three modes are normally co-existed. The demolition and transformation refers to remove and rebuild buildings and zones unable to adapt to era demands such as industry, warehouse and shack-dwellers to re-motivate vitality of riverside region. The governance type includes governance on water body and improvement of overall regional environment. The protection type refers to protection on historical construction and exploration on history and culture.

6. The concept renewal of Beijing Zhuanhe riverside region

The following part will combine with actual survey on Beijing Zhuanhe riverside

[5] Liangyong Wu. *The old city of Beijing and its Juer Hutong Neighbour*[M]. Beijing: China Building Industry Press, 1994.

region. Targeting at survey results, propose conceptual plan on renewal of this area and hope to provide references to the renewal of urban riverside region in the future.

6.1. general situation of the area



Fig.1. Research scope and location

The survey scale is located in the Zhuanhe riverside area in Xicheng district, Beijing, which was founded in 1955-1963. Zhuanhe river started from Gaoliang bridge in the west to Northern moat in the east. In 1905, when Zhan Tianyou built Beijing-zhangjiakou railway, set up Xizhimen station, which made Zhuanhe river re-channel to north direction and lay the foundation for the current Zhuanhe river. On account of long age of construction, large number of unit compounds existed in the area. On 1st, July, 2014, shutdown of Beijing-Zhangjiakou railway and the holding of Beijing-Zhangjiakou Olympic Winter Games brought huge opportunities for renewal of this region. (Figure 1)

6.2. The renewal of Zhuanhe riverside region

The conceptual renewal this time is to target satisfying comfort level of slow-traffic system, build green network and improve overall regional environment quality. At the same time, in virtue of transportation junction of Xizhimen and regional

advantages of Northern second ring, improve regional internal functions, stimulate regional vitality and form public space with regional characteristics.

(1) Land utilization



Fig.2. The area of dismantle and rebuild

The internal area in this region is dominated by residential areas and it exists large shanty towns. The transportation facilities occupy large floor areas. The Zhuanhe river flow through internal areas and greenbelts are distributed in line along with Zhuanhe river. Therefore, in the renewal design, dismantle areas without historical conservation value as well as inferior building quality such as shanty-towns in accordance with requirements of urban planning. At the same time, rebuild greenbelts with inferior current environment quality and low use ratio. Meanwhile, on account of shutdown of Beijing-zhangjiakou railway and vacancy of Beijing North Station, a part of transportation facilities have been adjusted. By means of reconstruction and re-developments and other methods, it is aimed at making these areas re-play significant role in the overall development in Zhuanhe region, undertake new urban function and become crucial urban areas. (Figure 2)

(2) Combing the traffic



Fig.3. Slow traffic system analysis

The internal road system in Zhuanhe river area is relatively complete. However, on account of existence of Beijing-Zhangjiakou railway, severe segmentation exists in eastern and western side of this region and it failed to form a complete riverside slow

traffic system. In addition, long age of construction, some narrow problems, devoid of shield and severe road occupying phenomenon result in low comfort level and poor cross experience of current roads. It adopts three-dimensional transportation to solve this problem in the design process to guarantee integrity of slow traffic system. In the process of renewal design, initially solve the problem of breaking points in the riverside slow traffic system, because walkway is unable to pass through Beijing-Zhangjiakou railway, Meanwhile, set up riverside sites to enrich level and structure of hydrophilic trail. For problems existed in the urban roads, carry out transformation on green improvement to promote cross comfort level. Moreover, it adopts the method of peaking shift parking to buffer traffic jam caused by on-road parking of vehicles. (Figure 3)

(3) Urban function

The functions of urban riverside area is generally oriented by residence, business, work, leisure and recreation. Among them, residence function is considered as one of the main functions of Zhuanhe river area and owns strong vitality until now, so it should be strengthened. At the same time, this area is the close neighbour of Beijing old town and possess convenient traffic locational conditions, so business function as the main regional function should be developed. What closely related to business is the function of business office. Therefore, in renewal design, install certain quantity and scale of business office function in the riverside area to improve economic values in this area and gather popularity. It is an obvious tendency for cultural recreation function in current riverside area, so build a series of entertainment, popularization of science and cultural facilities as the important means to build the cultural images in this area.

(4) Landscape construction



Fig.4. The partition of updating area

“Water” and “green” are the elements symbolizing nature in the city. The “water” and “green plants” demonstrates strong oneness. The combination of water and green create the landscape of “blue water, green belt and blue sky” so that the riverside



Fig.5. Rendering of riverside ecological section



Fig.6. Rendering of urban leisure section



Fig.7. Rendering of neighbouring residential section

landscape owns more pleasant hydrophilic breath^[6]. Consequently, in the renewal design, pay attention to shaping riverside green belts. In accordance with differences of surrounding environment and landscape style, divide the linear green spaces of entire riverside area into riverside ecological section, urban leisure section and neighbouring residential section. (Figure 4). In addition to this, set up railway heritage park, residential park and so on combining sectional background. (Figure 5,6,7)

(5) Ecological protection

From the angle of landscape ecology, “plaque-gallery-matrix” constitute basic

[6] Chunfeng Luan. The Urban Design and Strategy Research on Renewal of Urban Riverside Area[D]. Nanjing Forestry University,2009.

form of ecological system^[7]. The ecological system in riverside area equals to gallery in the landscape ecology, which tends to be the most frequent intersection between human activities and natural ecological system. Consequently, in the renewal design, it adopts a series method of water body purification, increase phytocoenosium in riverside area and soften original river bank with plant material.

(6) Feature construction

The extraction of regional characteristics is carried out embracing railway culture. From construction of Beijing-Zhangjiakou railway in 1905 to its shutdown in 2014, as its Beijing starting station, Zhuanhe river region witnessed the development of Chinese railway career. With the construction of Beijing-Zhangjiakou high-speed rail, memories on Beijing-Zhangjiakou railway will be reserved as its regional memories. Therefore, in renewal design, utilize space of demolition to set up railway heritage park. Meanwhile, install railway culture museum to commemorate Beijing-Zhangjiakou railway on active service for over one hundred years. It reached the purpose of shaping local characteristics though this simple method and play the active role in improving economic and cultural development of the entire Zhuanhe river region.

7. Conclusion

With urban development, urban renewal is carried out. In comparison with general areas, the riverside areas are normally restricted to more elements. As a result, the renewal of riverside region will take the characteristics into consideration such as natural environment, historical humanism

and economic society, choose renewal strategies and methods suitable for this area to restore vitality in riverside region and re-play its role in the urban development.

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Design methods of Longquan Lake Country Park by Combining Chinese traditional landscape Design and LID system based on low impact development

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Abstract

With the construction of sponge city in China, the limitation and disadvantages of the construction of sponge park are also highlighted. The excessive focus on the LID system and the management of the rain water have contributed to the sacrifice of the "artistic quality" of the park construction. This paper analyzes and summarizes the traditional Chinese landscape design and the LID system and takes Longquan Lake Country Park as an example to discuss a design strategy of effective combination of the two, providing guide for sponge city afterwards.

Key words: China, Landscape Architecture, Resilience, Chinese traditional landscape Design, LID system;

1 Introduction

With the construction of Sponge City in China, cities have accumulated experience of dealing with problems of stormwater from practice. In the process of construction, problems like "excessive reliance on the rain collecting function of the green system" and "the unbalance of art and science" emerged.[1] This reflects that although the construction of the sponge city has achieved fruitful results, our country is still lacking a

set of effective and compatible method of combining it with Chinese traditional landscape design. It is the core of this research that how to meet the function of rainwater management in the construction of sponge city, while meeting Chinese traditional aesthetic standard.

Due to the fact that researches on the Low Impact Development system(LID system) in China are mostly focusing on urban area, the

rain-flood management strategy of green space in the shallow mountain area lacks scientific guidance of the design level. [2]Owing to climate change , urban expansion, disturbance of human activities and many other negative factors, vegetation in shallow mountain area get strongly damaged, which caused a series of water problems such as the overall degradation of the ecological environment, soil erosion, water shortage and water pollution. Therefore, choosing Longquan Lake Country Park which located in the shallow mountain area of Shijiazhuang city, Hebei Province has important research value.

2. Design Strategy Combing Chinese Traditional Landscape Design Method with LID System

According to reports from ministry of housing and urban-rural development, 62% of cities have experienced varing levels of flooding all over the country in 2008-2010. In recent years, heavy rainfall hit Guangzhou, Shenzhen, Nanjing, Hangzhou and many other cities. Especially extremely rainstorm in Beijing on 21th, September, 2012 led to severe water and traffic paralysis in the city and even mountain flood debris flow and other natural disasters in local mountain area. Even so, Chinese classical imperial palaces and gardens were even capable of rapid drainage, surviving from getting flooded, which thanks to its perfect and mature drainage system.[3]

2.1 Overview of Chinese Traditional Landscape Design

Deeply influenced by the geometry stemming from ancient Egypt, western gardens emphasized numbers and geometry, which represents for human's conquest of nature. Different from it, Chinese ancient people learned to dredge rivers, make mounds as well as stone-layout from time to time, forming the theory of 'harmony between man and nature' . It became the general principle of Chinese world view and culture ever since. Chinese literature devote particular care to learning method of ' profound harmony of human inner feelings and the secular world' and 'who excels reads as many as ten thousand books and travels as far as ten thousand miles'. Chinese painting conform to the creation way as 'learning from nature, merge nature with artist's inner feelings' while having 'art is that between likeness and unlikeness' as artistic state and evaluation criteria. Under the influence of literature and painting, [4]Ji Chen summed up the concept and pursuit of Chinese garden in the book *Art of Garden-building*---'Though it is done by man, it looks like the way it is from the very beginning'. This request that the creation of manmade landscape not only needs to take nature as the prototype but also needs to recreate nature on the basis of natural law and merge with poetic idea.

The Summer Palace is a typical example. In Ming & Qing Dynasties, imperial court put forward a series of measures to solve the stormwater problems: built up levees along Yongding River to hold back large floods; regulated floods from shallow mountain area through imperial gardens in western hills area; used river system to prevent waterlogging and so on. Placed in western hills area, the Summer Palace combined hydraulic engineering and gardening together by the excavation of river at the north part. The resulting earth volume was used to make mounds and to extend the real hill in site. Functioning as drainage system for the mountain, the west Taohua gully was expanded at its water outlet part. After completion, the Kunming lake reservoir works as stormwater management facility as well as irrigation water source. Furthermore, it transports landscaping water for the Winter Palace, provides places for practicing navy and also provides entertainment and tourism places for people. Through the test of time and floods, the treasure left over from the Ming & Qing Dynasties is enough to prove its great aesthetic value and its abilities working as stormwater management system.

2.2 Overview of Low Impact Development System

Rapid urbanization has brought great economic development to China, but also brought about a series of urban problems. The impermeable hardscape of large area,

the backward of urban infrastructure such as drainage facility and flood control facility, the depletion of groundwater, and extreme weather brought heavy rains to cities has brought more and more serious floods. To solve this problem, Chinese ministry of housing and urban-rural development compiled the *Sponge City Construction Technology Guide-Low Impact Development of Rainwater System Build(try out)(Guide)*, which referring to American LID system theory and practice experience and consideration of the situation of China.

According to Guide, LID system uses the sunken green space, permeable pavement, seepage pond and seepage to ensure the rainwater seeping into the ground; uses the sunken green space, green roof, water storage tanks, rainwater tanks to store rain water, realize the recycle and reuse of rainwater; uses biological detention facilities, wet ponds and rainwater wetland to reduce runoff and pollution. All of these work as one to form an intact low impact rainwater management dealing measure. Rainwater runoff that exceeds LID system's ability to hold will be discharged into the urban rainwater sewer system, which enables rainwater drainage in off-peak periods and alleviated the pressure of the urban rainwater sewer system. Thus it can be seen that LID techniques of 'infiltration, retention, storage, purification, use, drainage' not only ensure the control of rainwater at the source, midway and end but also restore the natural cycle of water in large degree.[5]

In addition, combining techniques like SWMM and GIS enables us to evaluate and calculate the relevant statistics of stormwater management effectively, which benefits to both the guidance to the construction stage and the analysis and summary after completion.

2.3 Contrastive analysis of Chinese Traditional Landscape Design and LID System

Although both Chinese traditional landscape Design and LID system regulate stormwater, but there are differences in construction objectives, emphasis and technical measures between these two.

‘Harmony between man and nature’ is the core of Chinese culture. Aesthetes Li Zehou summed up the Chinese landscape garden art as ‘naturalization of human and humanization of nature’. The reason why Chinese gardens are called natural landscape garden is that it is an art that being poetic and it takes the natural landscape as its model and combining landscape painting and landscape poetry form into being. Both of them pay attention to ‘feel like’ rather than ‘look like’. They are the product after the observation and experience of nature, combined with the author’s inner thoughts and emotions. After thousands of years of accumulation, simulation of nature led to Chinese traditional landscape Design’s variety. Thus it has a deep understanding of how does nature system works. Chinese

traditional landscape Design pays a lot of attention to comb the landscape structure, make abundant variety of spaces and give it poetic meaning on the basis of site condition. Thus it’s artistic quality is self-evident. In the process of construction, stormwater has already be controlled and managed.

LID system focuses on solving the problem of stormwater. Different from traditional stormwater management system, LID system emphasize that rainwater is a resource, not a waste. Applying LID system techniques of ‘infiltration, retention, storage, purification, use, drainage’ can ensure the control of rainwater at the source, midway and end as well as realize the natural hydrological cycling of rainfall. The construction mode is based on the guidance of scientific evaluating method. It evaluate site and give guide for design at earlier stage and reevaluate after construction for adjustment and design afterward. In a long term, it is beneficial to the progress and development of stormwater management technique. It’s scientificity is self-evident.

But it is not hard to see in practice that it is difficult to control and manage stormwater accurately simply by using traditional Chinese landscape design as the guidance basis; it is guarantee the aesthetic characteristics under the guidance of LID system. Scientificity and artistic quality are the two important attributes of landscape architecture. The artistic quality can’t guide the construction of landscape architecture in

nowadays by itself, while the pure engineering science can not completely represent the whole landscape architecture. This is the starting point of this study.

3. Practice in Longquan Lake Country Park

This paper combines the longquan lake country park project in luquan district, shijiazhuang city, hebei province, research in combining Chinese traditional landscape park construction method with low impact the design of the drainage system of the development of specific methods and patterns. Situated in in urban shallow mountainous areas in northern China, Longquan Lake Country Park takes the the drainage pressure both from unban internal area and urban shallow mountainous areas. In addition, the annual rainfall in North China is less than normal and the rainfall is concentrated. Rainstorms frequently occurs and the annual evaporation is large. This causes serious flood and water shortage. There is a pressing need for applying stormwater management system to the construction of country parks in urban shallow mountainous area in northern China. The site topography East West high low, existing gullies and depressions serve as basic conditions for stormwater management system. Size of 360 ha makes storing massive rainwater possible. The design of this park insists on integrating Chinese traditional landscape Design and the



Fig. 1. Site Context

Stormwater Drainage System based on low impact development, which provides reference for the construction of country park in in urban shallow mountainous areas in northern China.

3.1 Construction of Landscape Structure and Water Circulation on Macro-level

Based on the traditional Chinese landscape theory, the overall structure of landscape architecture of the planning site is done. The design delimit water body and watershed according to the landscape planning, then work with techniques of LID system to realize natural circulation of rainfall.

The project firstly conducts a comprehensive field survey of the site and uses ArcGIS to deal with the site surveying and mapping documents and then designs the topography. The design follows the principle of "adapting to local conditions" according to the traditional Chinese landscape theory, using traditional gardening method to deal with topography and making full use of it's characteristics in site to make

delicate and natural waterscape. Smallest earth volume is used to make various landscape as much as possible.

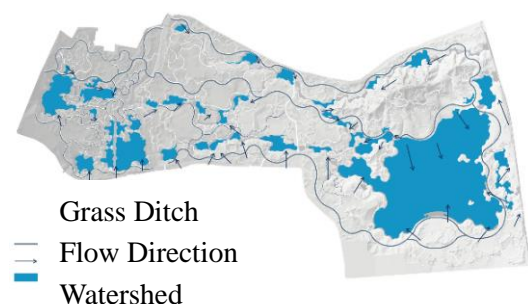


Fig. 2. Planning of Rainwater Storage System

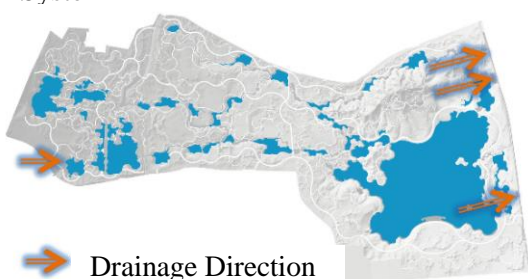


Fig. 3. Planning of Rainwater Drainage System

The site is divided into four district: 1) west district: As the first district to undertake rainwater from shallow mountain, west district faces great threat of flood. Design clears and arranges three gullies existing in site and enlarge part of them to form into water bodies, which has several islands inside. These islands can function as buffers against the flow of water. These water bodies and streams serves as basement of rainwater storage system in west district while serving as flood buffer for the whole park. 2) three gullies district: The gullies are arranged to create a landscape of dry creek.

When heavy rains comes, it will serve as rainwater infiltration and detention system to manage rainfall and floods. When the rain exceeds the load, it works as as a transmission system to transport surplus rainwater to the middle district for further storage. 3) middle district: Gullies are enlarged fully. The resulting earth volume is used to make main hill at north side of this district. The large water body here is not only the basement of rainwater storage system, but also the core water body for rainwater storage for the whole park which holds surplus runoff coming from west and three gullies district. 4) east district: The existing water bodies in the site are kept, and the gullies of the terrain are properly combed to form the wetland landscape.

While combing the landscape architecture, the rainwater circulation can be constructed. Each district has its own water cycle during normal rainfall period while they work as one during heavy flood period to store rainwater coming from inside and outside as super sponge. Planning evaluates the rainwater (table1,2)and adjust the water area of this park. Chinese traditional landscape design also emphasizes the principle of ‘always know where is the water come from and where it goes to’. The water system of the site is connected, and the elevation of water level from east to west gradually decreases. At the end, the water system of the main water body is connected with the eastern water channel by three point water surface. When the amount of

precipitation on the spot exceeds the ability of the site to hold, the surplus rainfall will be discharged into the water channel through the three point water surface and then imported into the municipal pipe network. The rainwater drainage system of the park is established and it effectively avoids the disadvantages of "over-reliance on the rainwater harvesting function of greenbelt system" during the construction of sponge city.

Design Flooding Frequency	Maximum rainfall /24 h (mm)	gross storage capacity (10 thousand m ³)	Maximum of storage capacity (10 thousand m ³)	Amount of collected water's percentage takes in storage capacity
Once a year	104.94	12.96	50.82	25.50%
Once 2 year	133.30	16.46	50.82	32.40%
Once 5 year	170.80	21.10	50.82	41.51%
Once 10 year	199.17	24.60	50.82	48.40%
Once 50 year	265.03	32.73	50.82	64.41%

Tab 1 Rainwater Storage Calculation

3.2 Construction of Landscape Terrain and Rainwater Control on Middle-level

Handling the waterscape and landscape further. Applying LID system techniques of

'infiltration, retention, storage, purification, use, drainage' to ensure the control of rainwater at the source, midway and end.

On the basis of macro landscape structure, the terrain is further combed. The topographic trend and slope changes are arranged to effectively avoid unorganized rainwater flow, and control the flow velocity and flow direction. The surface runoff in the green space is organized and collected through linear negative terrain, such as gully and valley. In the larger part of the water flow, design increases the block stone or even the stone mountain to prevent soil erosion. The adjustment of the water form also combines with the rainwater organization of the green space: For example, in the area where the rainwater is concentrated, the inlet will be enlarged and used as the rainwater alluvial fan to relieve the impact of the flow on the soil. After fully combing the terrain, the road system of the park will be constructed. Using Permeable pavement, the road system will be used as the linear element of the rainwater infiltration system in the whole park. The rainwater after the first infiltration of in the green space will be organized by terrain and flows into the road system. In the process of transport by road it get secondary infiltration.

Rainwater falls onto the site will be absorbed to some degree, and the part that does not being infiltrated will enter into the grass ditch. The grass ditch has a certain

retention effect on the rainwater and can lead the rain to infiltrate again. In the area where the rainwater is collected intensively or connected with squares, the grass ditch will be partially enlarged to form a rainwater garden and the rainwater can be retained to a greater extent. According to the requirement of water catchment, the construction of grass ditch will be combined with road system---along either side of the road or on both sides. The establishment of the grass

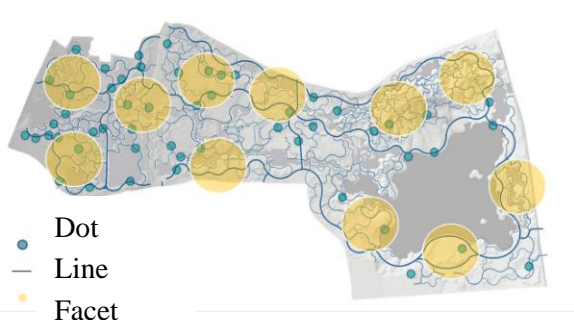


Fig. 4. Planning of Rainwater Infiltration System

ditch has further improved the construction of the park rainwater retention system.

3.3 Construction of Micro-topographical Features and 1235rainwater Management Point on Micro-level

The design of landscape nodes is considered with LID techniques. The microcirculation in the whole system is realized by rainwater garden and sunken green space, which effectively combine the landscape and popularization value of green space.

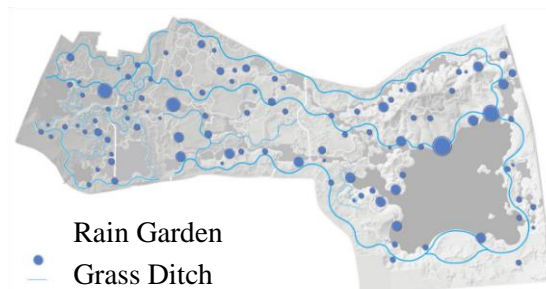


Fig. 5. Planning of Rainwater Retention



Fig. 6. Planning of Rainwater Purification System

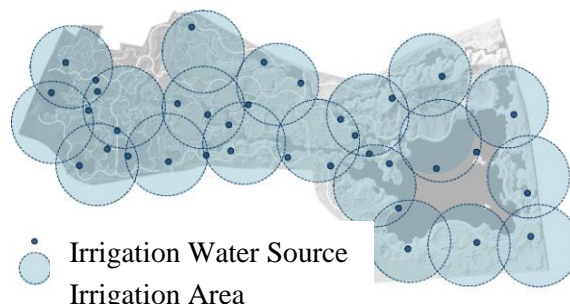


Fig. 7. Planning of Rainwater Utilization System

According to the topographic features of the upper level planning, the location of peripheral functions and so on, different scales of rainwater gardens are set in site. Different rainwater garden has different vertical elevation, paving materials, plant selection and other aspects of specific design. Based on this, they can solve the problem of runoff to some degree and clean up dirty runoff. When the intensity of the

storm reaches the breaking point, the rainwater will be drained into urban rainwater pipe network. At this stage, the rainwater infiltration system and rainwater retention system are completely constructed.

On this basis, the rainwater purification system is constructed. The rainwater purification system chooses suitable purification method and uses physical, microbial and biological method in combination in accordance with their different characteristics and purifying effect. Microbial method is the way that microorganism plays a major role as a decomposer to decompose and absorb in Eutrophication material. But after two months, the effect will significantly reduce. Therefore, microorganisms need to be released regularly for specific water quality conditions. Its advantages are that it is bioenergy and low power consumption and it can absorb in COD, ammonia, total nitrogen, total phosphorus and SS efficiently and effectively. Biological method include aquatic plant planting technique and animal habitat creation technique. Aquatic plant planting technique is the way that plant plays a major role as filter, cleaner as well as major constituent element of a park landscape. In this project, 16 kinds of aquatic plants are selected. The planting area reaches over 30% of the area of the whole garden so that landscape effect can be ensured while acting as an excellent filter for ecological purification. Animal habitat

creation technique is the way that animals function as the moderator of ecological environment. The weakness of this way is that it has slow effect, the choice of biological species should be paid attention to when designing. Through the combination method of 'aquatic plant-animal habitat construction-microbial investment', contaminant like SS, N, P, COD in the water can be reduced shapely. It can even improve the quality of water as V to the quality as VI while improve the level of dissolved oxygen in water. In urban runoff pollutants, SS is often associated with other pollutant indexes. Therefore, SS is generally used as the control index of runoff pollutants. In this project, the total removal rate of SS can reach over 60%. Aquatic plant ponds are put in part of water bodies to purify water while serving as landscape elements that improve the landscape effect of waterscape.

At final stage, the rainwater utilization system is constructed. Water-saving irrigation is used as main irrigation method in this project. Water-saving irrigation is an irrigation measure that maximizes the product of yield using minimize water, which has the characteristics of water saving, energy saving, labor saving and high water quality. The water bodies in this park serves as sources of irrigation and the irrigation area basically covers the whole park. According to the evaluation of precipitation rainfall capacity, water retention capacity and irrigation water capacity, when rain

Tab 2 Rainwater Utilization Calculation

Design Flooding Frequency	Maximum rainfall in 24h (mm)	Storage capacity (10 thousand m ³)	Irrigation water for 30 days in summer (10 thousand m ³)
Once a year	104.94	12.96	10.48
Once 2 year	133.30	16.46	10.48
Once 5 year	170.80	21.10	10.48
Once 10 year	199.17	24.60	10.48
Once 50 year	265.03	32.73	10.48

season comes once a year, the water hold in this park can fulfill irrigation water for 30 days in summer.

Acknowledgments

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4 Summarize

This paper studies Chinese traditional landscape design and LID system and draw a conclusion that there are different emphasis and difference in guiding the park construction. In practice, the combination of the two shows a certain degree of fracture. Thus this paper proposes to a new design method that combines them together which can provide reference for subsequent sponge city construction, guide to create a strategy that conforms to the Chinese traditional aesthetic idea and alleviate urban rain flood pressure. By considering of these three levels, Longquan Lake Country Park effectively avoided the phenomenon of designing first and managing rainwater later. While ensuring the landscape effect and manage stormwater scientifically, it can provides reference for construction of stormwater management system in country park.

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1. Study on the Construction Method of Habitat-Type Urban Forest under the Background of "Keeping White and Increasing Green" in Beijing

-Taking the Hengjiezi Urban Forest as an Example

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Abstract

In order to improve the living environment and build a biophilic city, Beijing Administration began to cancel some non-capital functions. By using the means of “keeping white and increasing green”, illegal buildings were demolished to get a reserved land or for greening and serve as people's livelihood or to leave a flexible space for the future development of Beijing. In this context, Beijing will continue to start a large number of urban forest construction pilot projects to promote urban ecological quality and enhance the public satisfaction of accessing greening areas. This paper takes the Hengjiezi Urban Forest as an example to explore the habitat-type urban forest construction method based on biodiversity researches.

Habitat-type urban forest is built with the purpose of improving urban ecological environment and improving biodiversity by creating habitats for animals and plants and breaking through traditional supremacy of human rights and advocating the idea of equality of life rights. The design will be based on water, topography, plants, travel routes and architecture strategy and will try to create a habitat-type urban forest construction model through the comparison with the traditional greening mode. By means of the dynamic change of water level control, visitors flowrate control, travel routes control and so on to meet the resilient demand.

In the design phase, the animal and plant target species are selected, then the aquatic habitats and terrestrial habitats are classified according to the ecological habits of these target species. For aquatic habitats, the habitats are created based on the food chain system for benthic animals, amphibians, fishes and birds in a stratified pattern. For terrestrial habitats, the habitats are created based on the feeding, nesting, evasion habits of target species in a stratified pattern. Based on urban forest requirements on local tree species, a seedling table is figured out. Then according to the control of plant patch scales and proportions and the collocation of vertical

structure, 27 types of habitats are superimposed, so as to attract the expected target species. Finally, the whole process is digitized and simulated to get a dynamic growth model.

Keywords: Urban Forest, Habitat Construction, Resilience, Biodiversity

2. Introduction

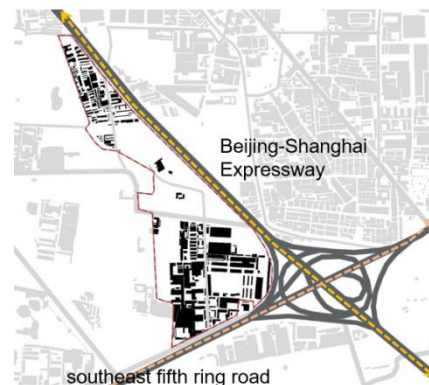
With the constant acceleration of urbanization, it is increasingly difficult to see animals in cities. It is urgent to discuss the new green space construction mode of harmonious coexistence between man and nature under the background of ecological civilization. [1]

As a typical representative of large cities in developing countries, Beijing has to face the contradiction between economic development and ecological restoration. “Keeping white and increasing green” is one of the important measures to relief the function of the capital of Beijing. Referring to other types of land outside the planning green space, after the removal of the illegal construction, it is not possible to determine or implement a permanent plan in the short term, first through the way of greening to improve urban residential environment, reserve space

3. Plot analysis

The research plot is located at the intersection of the southeast fifth ring road and the Beijing-Shanghai expressway, which belongs to the ring belt of Beijing Country Park, with a total area of 62.6 hectares. There are many

comprehensive parks, country parks and



golf courses around the site, and all the functions in the area are relatively perfect. The site is composed of old factories, abandoned buildings and idle land. The whole terrain is relatively flat, and there is a current canal across the land. (Fig. 1)

Fig. 1. Site location picture.

4. Planning strategy

The research aims to improve the biodiversity and create a relatively complete food chain system, so as to create a natural habitat suitable for the survival and development of a large number of animals. [2] To establish and update aquatic and terrestrial ecosystems, to form a resilient and self-regulation mechanism, to play an important role in urban ecology of forest and biodiversity. Finally, create a habitat mode for more living creatures. [3]

4.1. Water strategy

According to the study, there is a positive ratio between the level of biological diversity and the meandering degree of the water system. With the increase of the sinuosity of the water system, the marginal effect will be increased correspondingly, which makes the wetland form more diverse, the wetland function is greater, and the biodiversity will be improved accordingly. [4] The best patch shape is the circular core, the curved boundary and the finger-like protuberance in favor of the propagation of species. The area of the island in the wetland is below 3000 square meters, and the length and area of the island is high, so the island should not be too large, and it is best to control between 0.9 and 1.4 per hectare in the water area. Therefore, the sinuous water system and small scale islands are more suitable for habitat creation.

In the traditional garden design, the hard edge and the bottom of the pot are used, and the water level is constant and easy to manage. The boundary of traditional water body is changed to bending and folding, using soft revetment, combined with the rich underwater topography, change the bottom to the natural type bottom at the same time, to form a hierarchical seasonal aquatic habitat. [5] Finally, create a winding, varied water system. (Fig. 2)

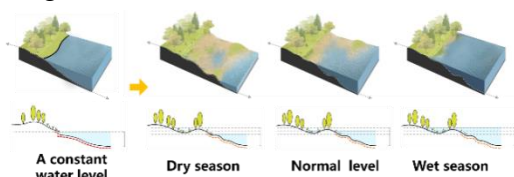
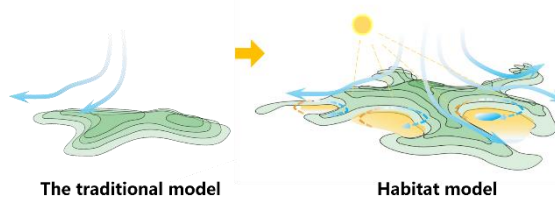


Fig. 2. Water strategy picture.

3.2 Topography strategy

The traditional gardens adopt the gentle terrain, the wind environment is single, and the space is changed. The first starting point is "man". Therefore, the design avoids the enclosed, dark, humid environment, convenient for tourists to visit. This environment is not suitable for biological survival, so this strategy is to create a more complex finger-like terrain in this area, add the terrain elements such as hole and low-lying land, and form the local wind circulation, builds a small environment of complex and diverse. From the point of view of biological equality, it is a safe haven for many species. At the same time, we should consider the experience of tourists, rationally set the terrain trend, and provide a variety of environments with non-interference and harmonious coexistence with other creatures. (Fig. 3)

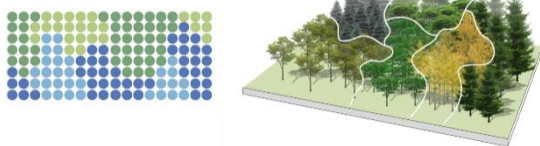
Fig. 3. Topography strategy picture.



3.3 Plants strategy

In the plant strategy, different from the previous methods of artificial afforestation, the size and area of the patch were regulated by mixed mode, tree layer for large patches of 50-80 strains, 20 to 50 strains of medium-sized

patches, small patches of 5-20 strains, build with the same tree with different



age. The shrub layer is 10*20 for large patches, 10*10 for medium-sized patches and 5*10 for small patches. Irregular staggered of the edge of the patches, forming a natural and beautiful boundary. Small patches are used near the edge or landscape nodes. Large patches are used in combination with the background forest, and the rest is the medium patches. The ratio of large, medium and small patches is 3:5:2. (Fig. 4)

Fig. 4. Plants strategy picture.

3.4 Travel routes strategy

In the garden specification, the road density is 200-380m/hm², so the tourist system is relatively perfect, but the animal habitat factors are not taken into account, so that the habitat patch is divided by the park roads, and the patches are relatively broken. This strategy will reduce the density of road to the first 100 m/hm², have at least half area will focus on core habitat for animals reserve, provide habitat for creatures to the greatest extent, and offers visitors must pass the sightseeing tour line.

3.5 Architecture strategy

Building will use the original ecological natural materials decorative

facade, height control in two layers of the following, shall not exceed the height of the tree, and control of building construction, make buildings blanking in terrain backlighting. While satisfying people's comfort in architecture, they avoid the sight of animals, making animals more comfortable in the environment and not being disturbed by artificial facilities.

5. Specific design

Based on the detailed design of the aquatic habitat and land habitat, the planning strategy reconstructs the relatively complete biological habitat, thus improving the biodiversity in the area. (Fig. 5)

Fig. 5. site-plan.



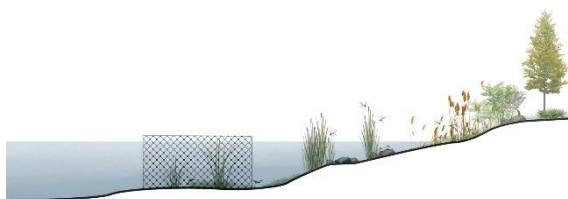
4.1 Aquatic habitat

4.1.1 Habitat creation for benthic animals

Benthic animals are visible animal communities living in the bottom of water bodies. The base should be dealt with first. Except such as silt soft substrate, still need to set up rock and other solid substrate. And plant the aquatic plants that benthic animals like to attached, such as reed and calamus, increased vertically aquatic habitat area,

and plant roots can firm bottom, to provide habitats for climbing and burrowing benthic animals. It also provides important shelter for benthic and small fish to avoid predators.

Proper feeding sources for benthic animals, including suspension and sediment. In order to ensure a good



environment for planted aquatic plants. To some extent, it can reduce the impact of fish crabs on the growth of wetland vegetation by adding some barrier facilities, such as metal mesh. (Fig. 6)

Fig. 6. Benthic animal habitat.

4.1.2 Habitat creation for amphibian

Amphibians is a kind of typical wetland animals, this study will use the dead branches into the shallow water area, is used to control the water flow and provide shelter, shade, climbing media and food source for amphibians and other creatures. For the base layer, it can artificially create some small habitat cave, and improve the richness of underwater topography. Through the understanding of the growth habit, various amphibian species are distributed in different Horizontal layers, with an average depth of about 0.6m. The water system is designed around the different sizes of the mudflat,

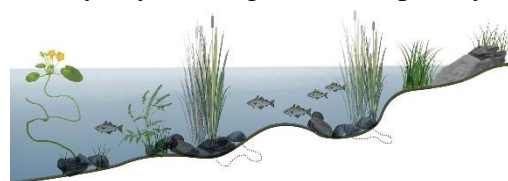


to provide a appropriate land habitat for amphibians. (Fig. 7)

Fig. 7. Amphibian habitat.

4.1.3 Habitat creation for fish

The creation of fish habitat is also an important part of the aquatic habitat. It is mainly by adding the complexity of



water system structure and the diversity of hydraulic conditions by placing rocks or stones in the base. (Fig. 8)

Fig. 8. Fish habitat.

The space between the stones is a shelter for aquatic organisms, often consisting of three to nine boulders, spaced less than a meter apart. At the same time, grow the plants which fishes like to eat, such as hornwort, hydrilla, eel grass, etc. In the end, the fry will be artificially injected into the habitat to enrich the whole fish ecological chain.

4.1.4 Habitat creation for bird

The aquatic habitats are designed for wading birds and swimming birds, According to their habits, the distance between people and targeted are set up

First of all, wading birds are migratory birds, not suitable for swimming, living in marshes and water edge, to get food from the bottom, from the mud, or from the ground. It is usually found in inland lakes, ponds,

estuaries, reed swamps, paddy fields and coastal marshes. The breeding habitat is mainly reed cattail marsh, the viewing distance is 50-100 meters.

At the same time, according to the birds' habits, the plant community types are mainly planted with *Saliz matsudana*, Pagoda tree and other tall trees to form the upper wood structure of the plant community, to provide tall trees for wading birds to reproduce. Select the plant with higher height to provide a foothold for wading birds. For example, birds such as heron and ibis



require a higher proportion of shallow water, submerged plants and Floating plants to cover 40% to 60% is more suitable. (Fig. 9)

Fig. 9. Wading birds habitat.

Secondly, it is very important for aquatic plants to provide food for migratory birds. At the request of the water body, the habitat of the duck species should not exceed 2 m, mainly in the shallow water area (water depth of 10 to 30cm). Open water (canopy density of emergent aquatic plant less than 10%, water depth less than 0.5m) is within 50% of the water area, and the higher the better. [6] The vegetation coverage rate of the habitat between 50% to 75% is better, among which the shrub coverage rate is 30% to 50%, the emergent aquatic plant coverage rate is 40% to 70%, the tree cover is 0-10%, and the water surface is 25%. The water depth of 0.9m is suitable for some

inverted tree trunks. 300-500 square meters pond is more suitable for inhabit.

At the same time, the choice of plant community types and waders classes are similar. Choose *Saliz matsudana* or *populus tomentosa* as the dominant species of trees, with lacebark pine, Chinese ash and other trees. Provide shade for the birds. At the same time, abundant herb layer and aquatic plants provide good habitat conditions for the birds, so as to facilitate the hunting and hiding. For example, the mandarin duck is a typical migratory bird, which mainly lives in rivers, lakes, ponds, reed swamps and paddy fields. A pair of mandarin ducks raised 6 small mandarin ducks for 12 hectares of habitat, including water, direct habitat space and buffer green space 3 habitat types. The watercourse area that attracts the mandarin duck is at least 30 meters wide.

4.2 Terrestrial habitat

Terrestrial habitats are different from aquatic habitats Due to insects, small animals, songbirds, and scansorial birds, they are scattered throughout the park and symbiosis with other animals.[7] Therefore, independent habitats cannot be determined for specific populations.



The target of this research focusing on the most important terrestrial habitat factors, according to the target of the habit of feeding, nesting, avoid, combined with the Beijing native plant resources development list, to obtain the land habitat nursery stock table.

Fig. 10. The tree patches layout picture.

According to the control of patches scale and proportion, the layout of tree patches was obtained. (Fig. 10)

According to birds' habits, the proportion of evergreen and fallen leaves increased to 4:6. [8] (Fig. 11)



Fig. 11. Evergreen and fallen leaves proportion picture

According to the animal's demand for habitat, nine planting patterns were divided, which combined with evergreen leaves to create 27 habitat types to attract target species. (Fig. 12) (Fig. 13)



Fig. 12. Habitat layout picture.

6. Summary

In a word, the actual situation of land and surrounding area should be fully considered in the specific design, and the local flora and fauna, climate, soil and other conditions should be fully studied. Through the rational design of aquatic habitats and terrestrial habitats, the food chain system is well constructed and a stable resilient ecosystem is formed, which is able to cope with the change of external environment and to form a resilient

No.	Habitat Name	Features	Preference of animals
1	Single advantage lawn	Tree coverage < 30%	<i>Passer</i>
2	Managed grassland	The herb height < 0.5m	<i>Turdus merula</i>
3	Wild grass		<i>Phasianus colchicus</i>
4	The evergreen short shrubs		<i>Paradoxomus webbianus</i>
5	The fallen leaves short shrubs	Tree coverage < 30%	<i>Hasianus colchicus</i> , <i>Bee</i> , <i>Rhopalocera</i>
6	The mixed short shrubs	The shrubs height < 1.0m	<i>Dendrocopos canicapillus</i> , <i>Dendrocopos major</i>
7	The evergreen shrubs		<i>Celtis major</i>
8	The fallen leaves shrubs	1.0m < The shrubs height < 1.5m	<i>Turdus ruficollis</i>
9	The mixed shrubs	Tree coverage < 30%	<i>Gamulax canorus</i> , <i>Emberiza tristrami</i> , <i>Emberiza spodocephala</i>
10	The evergreen sparse forest grassland		<i>Stumus sericeus</i> , <i>Corvus macrorhynchos</i>
11	The fallen leaves sparse forest grassland	Tree coverage < 30%	<i>Dendrocopos canicapillus</i> , <i>Hirundo rustica</i>
12	The mixed sparse forest grassland	shrub coverage < 15%	<i>Phylloscopus proregulus</i> , <i>Fringilla montifringilla</i>
13	The evergreen forest grassland		<i>Urocissa erythroryncha</i> , <i>Streptopelia chinensis</i> , <i>Parus palustris</i>
14	The fallen leaves forest grassland	Tree coverage > 70%	<i>Cyanopica cyana</i> , <i>Pica pica</i> , <i>Parus venustus</i>
15	The mixed forest grassland	shrub coverage < 15%	<i>Ficedula parva</i>
16	The evergreen sparse shrubs grassland		<i>Urocissa erythroryncha</i> , <i>Turdus ruficollis</i> , <i>Parus venustus</i>
17	The fallen leaves sparse shrubs grassland	30% < Tree coverage < 70%	<i>Passer</i> , <i>Bee</i> , <i>Rhopalocera</i>
18	The mixed sparse shrubs grassland	shrub coverage > 15%	<i>Turdus ruficollis</i> , <i>Anthus hodgsoni</i> , <i>Phylloscopus fuscalus</i>
19	The evergreen shrubs grassland		<i>Pica pica</i> , <i>Stumus sericeus</i> , <i>Phylloscopus inornatus</i>
20	The fallen leaves shrubs grassland	Tree coverage > 70%	<i>Acridotheres cristatellus</i>
21	The mixed shrubs grassland	shrub coverage > 15%	<i>Cyanopica cyana</i> , <i>Ficedula parva</i> , <i>Eophona migratoria</i>
22	The evergreen multi-layer forest		<i>Pycnonotus sinensis</i> , <i>Corvus macrorhynchos</i>
23	The fallen leaves multi-layer forest	Tree coverage > 30%	<i>Cuculus microplenus</i>
24	The mixed multi-layer forest	shrub coverage > 15%	<i>Cuculus canorus bakeri</i>
25	The evergreen shrubs forest		<i>Pica pica</i> , <i>Streptopelia chinensis</i>
26	The fallen leaves shrubs forest	Tree coverage > 30%	<i>Emberiza pusilla</i> , <i>Emberiza rufia</i>
27	The mixed shrubs forest	shrub coverage > 70%	<i>Turdus pallidus</i>
			<i>Urocissa erythroryncha</i>

habitat-type urban forest with the aim of increasing biodiversity.

Fig. 13. Habitat type picture.

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Suitability of the Conservation and Development of Traditional Villages in Western Zhejiang Province: A Case Study of Shen'ao Village in Tonglu County

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Abstract

Construction of beautiful villages has become sweeping across the whole country in recent years. However, the phenomenon of similar appearance of each village must be avoided in rapid construction. There're many regional traditional villages in western Zhejiang province, which are valuable to explore the suitability of villages' construction. This paper writes from two development stages of villages and discusses suitability of construction taking Shen'ao village in Tonglu county as an example. We are supposed to put forward some valuable inspiration to the maintenance of regional traditional villages in western Zhejiang province with the analysis of suitability both in historical development and process of protection.

Keywords: traditional villages; suitability; conservation; development; regional

1. Research Background

1.1. Historical Background

Village is a basic inhabited form and living unit of human, which has various of morphological characteristics and evolution path under different natural and social environment. China has massive traditional villages with long history and rich cultural remains. Ministry of Housing and Culture of China started a survey on Chinese traditional villages together with other institutions in April of 2012. There have been four batch of 4157 villages listed in the Directories of Chinese Traditional Villages in the nationwide. These villages are not only in wide distribution and different types, but also continue growing and developing today, which have a great research value ^[1].

Regard as precious wealth of the interaction between people and nature, traditional

villages are getting a great deal of attention on their preservation and development with the upsurge of 'beautiful villages' constructions in recent years. However, there comes different kinds of problems. Suffering from a series of impacts on the process of urbanization, traditional villages face the problems of natural disasters, with the internal decay and over-transformation at the same time. Discussing the future resilience and suitability of traditional villages means a lot. We hope to control the trends of development of traditional villages effectively through methods of landscape architecture. Meanwhile, it will contribute to the sustainable development of villages and the large scope of ecological environment through studying on the relationship between villages and the nature.

1.2. Traditional Villages in Western Zhejiang Province

The distribution of terrain in the Zhejiang area has a theory of ‘seven mountains, one water and two fields’. The whole terrain is sloped from the southwest to the northeast. The southwest of Zhejiang is more mountainous and the north is in the plain [2]. The unique geographical conditions form a variety of village types. Zhejiang has 401 traditional villages and the western Zhejiang area has 56 of them [3]. Traditional village of western Zhejiang located in the transition zone between hilly and plain. These settlements have innate good conditions whose geography position fits the natural environment, closely related to water and has good landscape pattern as the basement construction. These kind of villages usually hold significant regional characteristics with profound historical and cultural heritage.

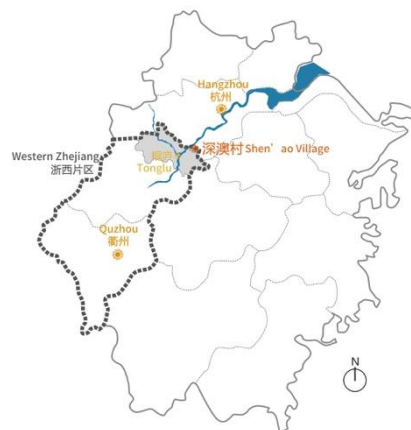
Nowadays research on traditional villages in western Zhejiang province most stays on spatial distribution of large area [2], clan culture [4-5], historical landscape [6], case analysis [7-8] and so on, which are distribution and summary of history one-sided. This article started from Shen’ao village, a typically traditional village in western Zhejiang province, tries to evaluate the development of the village combining the history and status quo of protection and explore the suitability of development process at the same time. Hope to provide reference for the construction practice of protection and development of traditional villages in the western Zhejiang province.

2. Shen’ao Village in Tonglu, Western Zhejiang Province

2.1. General Situation of Shen’ao Village

1. Location

Shen’ao village located in Jiangnan town, Tonglu county in Hangzhou, Zhejiang province. Shen’ao is in the north of western Zhejiang (pic. 1), whose southwest is 15.5 kilometers from Tonglu County, and the northeast is 56.6 kilometers from Hangzhou.



Pic. 1 Location of Shen’ao village

2. Natural Condition

Shen’ao village is located on the south bank of the Fuchun river, at the intersection of the hilly and plain. It has great water source conditions in which the water network is densely distributed. The climate of Shen’ao is mild and livable with rich precipitation. The northeast side of Shen’ao village is Mount Huangshan and the Lion mountain and the southwest side of the village is the Qian mountain, Longmen mountains are in the southeast. Tong Creek and Hou Creek flow through the northeast and the southwest of the village. Tong Creek is a tributary of the Fuchun River, charging with the function of flood discharge and drainage. Hou Creek is also called Zi creek, which is more narrow relatively with good scenery of pastoral [9]. The water system in the periphery of the village is superior obviously, and landscape view is totally different of the two stream.

Moreover, it is convenient for the usage of water on both sides of the village (pic. 2).



Pic. 2 Relationship between Shen'ao village and surrounding mountains and water system

3. Cultural History

Shen'ao village is a clan settlement of Shentu's family. The family of Shentu has a long history with vast branch. South of Tonglu is one of them in a tributary of Zhejiang. Shentu's family moved to Tongxi (Today's Shen'ao) in the early Southern Song Dynasty according to the records^[10].

3.2. The Research Value of Shen'ao Village

Settlements in western Zhejiang area have a long history, in which some counties like Tonglu, Chun'an, Jiande, Quzhou were established tracing back to the previous of the Three Kingdoms. Lots of buildings remain intact in some villages of western Zhejiang because of the long history and safe geographical location. Shen'ao village is famous for its abundant remains of ancient buildings and techniques of water control by the wisdom of old people in the area. As the first batch of villages which is included in the national directory of traditional villages in

western Zhejiang, protection work of the village carried out earlier, discussing its suitability and resilience of construction and development in the future have certain guiding significance (pic. 3).



Pic. 3 View of Shen'ao traditional village in 《Geographical Names in Tonglu County, Zhejiang Province》 (1984)

3. Suitability of Conservation and Development of Shen'ao Village

3.1. Suitability of Conservation and Development of Traditional Village

Construction of traditional villages is a result of taking multiple factors into account such as natural conditions and social conditions, which is an important part of the developing history of them. Traditional villages are not stagnant. Their protection and development should conform to the needs of villagers' daily life, bear the important task of economic development in villages and towns. Therefore, villages cannot be separated from the continuous construction process. At the same time of social progress, urbanization and industrialization have brought new problems to villages, such as the loss of population and culture, the blind construction and so on. We propose the suitable construction helping to maintain the unique regional features of traditional villages in the historical flood under such a situation. The develop process of traditional villages is summarized to two stages, historical construction and future utilization. How to build the village, repair the environment and make a long-term planning reasonably in these two stages is the key of 'suitability', to

balance the relationship between nature, human society and the land in the development.

The 'suitability' in the process of historical construction of traditional villages means adapting and respecting. The traditional villages are usually good in Fengshui, because their location and construction following the local conditions to some extent, respecting the nature and using the nature properly at the same time. Their development complies with the change of society, however, it needs to be discussed whether it is appropriate to adapt to the society all the time.

The 'suitability' in the process of development and utilization needs more 'moderate'. The current study tends to attribute the present problems of village protection to similarity. However, some villages have a certain similarity in both culture and environment within a specific range of area, coupled with the limited of development conditions and engineering ability, will be easy to form a similar visual experience at last. Therefore, planners have to learn the situation correctly. Appropriate development of the traditional villages should be moderate, respecting the growing track of villages themselves and rationally expanding the structure and texture of predecessors' work, so as to maintain regional characteristics of traditional villages.

3.2. Suitability of the Process of Historical Construction in Shen'ao Village

1. Construction Adapts to the Environment

1.1. Adaptation of the Site Selection

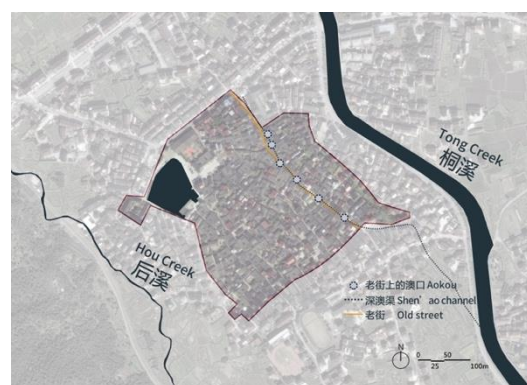
People have been in awe of nature since ancient time, as the site of the settlement is adapt to natural environment. There is a

proverb called 'high and do not close the hill with enough water, low and do not near water with ditch prevention ^[11]', using the nature rationally and defending the safety of human themselves.

The development of Shen'ao village is typical. People can't control effects of natural disasters in the absence of high construction ability those years. High water levels of Tong creek during the rainstorm period will inevitably bring security risks. The early Shen'ao village located in the southwest where is the highlands, and then gradually expanded to the northeast because of social development and growing population.

From the perspective of the current development form, Shen'ao village is located in a relatively gentle land between lowlands and hills. The site selection following the traditional Chinese geomantic omen theory, which called "negative Yin Yang, facing the water and against the mountain". These kinds of topography and water conditions are also conducive to the healthy development of villages.

1.2. Adaptation of the Construction

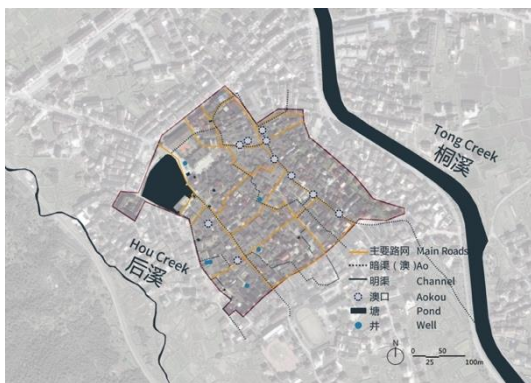


Pic. 4 Shen'ao Old Street, Shen'ao Channel and the Aokou in the Old Street

Shen'ao village is surrounded by two creeks. The southwest one called Hou creek is

excavated at the early stage of the village construction, which can divert the flood properly. The existence of these two streams basically controls the development scale of the whole village.

It's inconvenient for villagers to deliver water by open channel because Shen'ao village is higher than the surrounding water system in altitude. The villagers excavated an 800-meters underground channel in the upstream side of Tong creek, guiding water into the village. The culvert is arranged with a certain interval "Aokou" (generally 3-4 meters deep), providing water for residents. People started building their houses along this underground channel and gradually came up with the first street in Shen'ao (Pic. 4). The water system and its facilities guided the formation of the village structure in Shen'ao directly. The location of the water facilities in the village such as drainage ditch, wells,



ponds and the structure of buildings and streets are all interrelated (Pic. 5). Shen'ao village is a model of Chinese traditional settlements construction. The theory of planning water system at first and then conducting construction is still of significance.

As for the project of house construction, it's easy to get the based building materials like

wood and stone because Shen'ao is located in the hills and near the mountain. We can find the left beam structure of buildings in the Ming and Qing Dynasties, which are usually big with beautiful carved (Pic. 6). Stone is also very common being used in the building facades and street paving (Pic. 7).



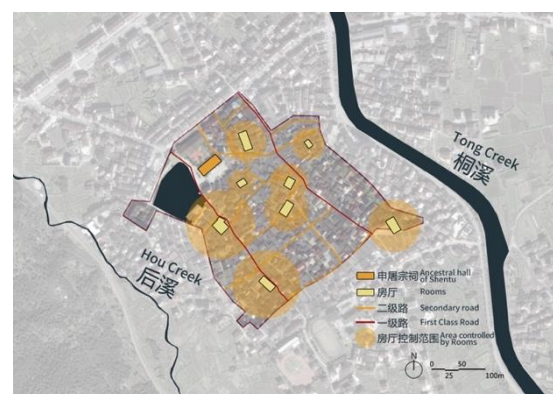
Pic. 6 Large amounts of wood material and fine wood carvings inner the buildings



Pic. 7 Stone in the building facades and street paving

2. Construction Adapts to the Culture

The traditional Chinese local society is connected with blood ties [12], and the geo is an expression of blood. Shen'ao village is an example of it. The patriarchal clan system



Pic. 8 Relationship between the layout of the ancestral hall and the village structure was the basis of residence and city

construction system in the long history as the mainstream of each system in ancient China. Ancestral hall of Shentu has a prominent position in the settlement, the village of blood ties of Shentu. It controls the volume of the settlement on the plane, the architectural form and orientation around the ancestral hall together with other rooms, and determines the layout of the street space (Pic. 8).



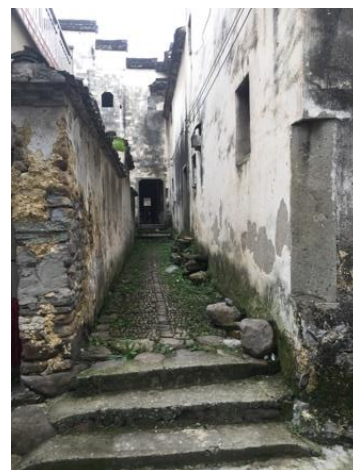
Pic. 9 Anhui Architecture with white wall and grey tiles, corbel-steps above the roof

Ancestral hall of Shentu which also called Youxu Tang is the most important building in the whole village and located at the pond near the entrance to the village. Front square of Youxu Tang became the most popular public space of the village. Room is a place for family members holding big events and storing the farm implements, and also a symbol of the development and strength of the family ^[1]. Shentu's family has eight Rooms (Room1 is centered on the Front Room while Room2 is centered on the Rear Room). We can find that all the Rooms are distributed along the Old Street first. The reason may be that the infrastructure of the Old Street is the earliest and the most completed of the whole village. Although Room6 and Room7 have many people, they are mostly located next to another main street called Houju Road because of the late development.

These eight rooms and their respective control ranges determine the regional scale of ancient village. The patriarchal clan system is the intangible planner of this kind of traditional village. The formation of the settlement is adapted to the clan culture.

In addition to the overall control of the patriarchal culture, the village will be affected by the surrounding existed regional culture in the process of development. With the development of society, the social culture in different periods will be reacted to every corner of the village.

Shen'ao is in the ancient Yanzhou area, near Anhui province. Prosperous merchants from Anhui in Ming and Qing Dynasties made Huizhou culture greatly influenced Jiangsu and Zhejiang area. Buildings of the village are most with white wall and grey tiles, corbel-steps above the roof (Pic. 9). The form of settlements space leading by surrounding buildings is similar to Huizhou architecture, which usually has a closed courtyard and tall walls enclose a family (Pic. 10). The internal space is open and public space is centered on the courtyard (Pic. 11).



Pic. 10 A narrow, closed street space



Pic. 11 A courtyard inner a building

Architecture is the embodiment of village construction's adaptation to the social culture as a living fossil. The existing buildings in Shen'ao are the combination of Anhui architecture and mountain residential buildings in western Zhejiang [13]. Architectural features of different periods are clear and easy to find, including the modern village built by rural residents.

3. Value to the suitable construction in the future

In modern society, the so-called "social and cultural adaptation" has been abused. With the expansion of village construction, the increasing self-consciousness of villagers and their demands for life lead to the low quality spontaneous construction, which is difficult to control and undermine the overall appearance of whole village. Therefore, the suitable construction of future village should learn from the advantages of historical construction, planning before extending the range of village, respecting to the natural landscape pattern and the original village texture, arranging infrastructure and public

space reasonably. What's more, people should also extract cultural elements of Zhejiang architecture and use them into the future construction.

3.3. Suitability of the Process of Development in Shen'ao Village

According to the statistics of the yearbook data of Shen'ao village, the population of the village declined significantly in 2012 over the past ten years and reached the minimum in 2013 [14]. It is also in this time that the government carried out a series of protection and renovation projects for Shen'ao village, and started the future plan of traditional village protection and utilization. People can see the benefits immediately. The suitable protection and utilization of villages directly led to the return of human.

1. Suitable Position

The background of villages' development in western Zhejiang are similar. Although every traditional village has its own characteristics, the difference is very small. Marketing highlights which added forcedly by people are contrary to the moderate planning rules of traditional village, destroying regional characteristics of villages.

Good family in Jiangnan, which is the position of Shen'ao village, seems simple but appropriate. The protection and utilization works used their own strengths, respecting for the history and renovating the ancient architecture, ancient water system as much as possible. These old structure is the basis for villages' own development and tourism for ancient village in the future. The protection works firstly meet the needs of the daily life and production of the villagers in the function assignment, and then the new format. Although there are lots of visitors all the day in the village, the atmosphere of life is strong

and dynamic. The protection and utilization of traditional villages is working for people living in villages. Children are the future of villages and towns. We can see the future of Shen'ao village through the bustling scene of the village library during holidays.

2. Suitable Renovation



Pic. 12 The ancient village and skyline after the control of appearance

Traditional villages have been destroyed in different degrees during the long history, so the restoration project is the most important part of the develop process. Shen'ao village is reasonable and appropriate in the repair project, which is mainly reflected in the renovation of buildings, water system, paving, walls and so on.

Classify the current buildings according to their quality, which could be concluded into three development modes, service, culture and benefit^[15], and each one adopts different repair measures. In addition to the restoration of ancient buildings, Shen'ao village is not forced to transform the built farmhouse into an archaize building, but it takes the way of overall style control to make the village remain the mark of every social development stage (Pic. 12).

Shen'ao village is like a micro Jiangnan. People can see ponds and wells while walking in the village, reminding them of the

underground flow. In order to maintain such geographical features, restoration of river system seems to be important. The ancient water system in Shen'ao village consists five parts, which are creek, pond, Ao, canal and well. The water system of "two creeks, one Ao and three canals" remains to this day^[9]. The most important thing of water system restoration is the protection of water quality, repairing nodes and the management of the whole system.

The street space is composed of street and building facade, which is the most direct space to experience a traditional village. The protection and utilization planning restored the original pavement pebble of several streets. As for the building façade, planners adopted different measures of restoration according to different periods of construction and building materials, neither seeking for the new things nor imitating the ancient (Pic. 13, 14).



Pic. 13 Repair of building facade at the entrance of Xingsu



Pic. 14 Comparison of old street before and after restoration

3. Suitable Landscaping

The landscape here mainly refers to the design of plant configuration, landscape elements, structures and so on. The traditional village has formed a mature vein of landscape itself and it is not suitable for excessive addition. Shen'ao village focus on the public space around Aokou and Tang to enhance the original landscape. People use stacked stones as planting bowls planted with native plants, creating a pleasant landscape environment. The structures in the site are basically retained, and people repaired the wooden structure of the original gallery frame in the meantime. Material of new landscape elements are also using local materials as far as possible (Pic. 15).



Pic. 15 Gallery frame after the renovation

3.4. Suitability maintains regionalism of Shen'ao

The protection and development project of Shen'ao village is the model of the combination of 'protection of original authenticity and inheritance of living state^[16]'. The suitability is mainly embodied in the adaptation of the village construction, suitable for positioning, moderate repair and development and so on. Respecting for history and inheriting from the historical

experience, adhering to the "endogenous development" internal growth theory, people protect the village context of growth ultimately and maintain the regional characteristics of traditional village.

4. Summary

Western Zhejiang is hilly, there are nearly half of traditional villages' altitude less than 150 meters, and mostly located in the mountain plains like Shen'ao village. The location of Shen'ao village is adapted to the natural environment. Its ancestors took methods wisely towards water system, which adapts to the geographical and geological conditions of ancient villages. Moreover, the development of ancient villages is suitable for multiple cultural evolution. As a traditional village, Shen'ao village has taken a moderate restoration and landscaping plan under an appropriate target, the protection and utilization of the project is very effective. Through the analysis and summary of Shen'ao village, suitable construction will be an effective and sustainable development mode to maintain the regional characteristics of the west Zhejiang area.

The two aspects of "historical construction" and "protection and utilization" appear to be time oriented. However, they interact and restrict with each other in the practical process, so as to achieve the harmonious unification of material environment and traditional culture.

Suitability is actually a combination of adaptation and moderation. For the "historical construction", it is more like a process of summary and learning, and the suitability focus on adaptation. Utilization is the theme of the development of traditional villages. As the social background of modernization and industrialization in recent

years, we can always find similar elements from various practical cases, thus the "suitability" principle focus more on moderation, respect, conform to the historical site, and maintain the growth force of old villages.

The problem of "hollow village" is very common in the current rural development. Proper restoration and construction will let people come back to those areas, which will also bring the growth of construction land, and new suitable construction is needed again. In this respect, the analysis of suitability will play an important role in the process of historical construction in Shen'ao village. For new construction, the social and cultural background are sustainable growing in inheritance. We cannot blindly build as the old mode or the extremely new in order to be different, people need to make a connection between the history and future. That's also called the construction of the landscape between the past and the future in the space-time continuum, protecting each unique landscape unit and taking it as a cultural reference attribute^[17]. The proper protection and development of traditional villages should respect the history, conform to nature, undertake the future, and contribute to the sustainable development of the earth's ecosystem.

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Research on Botanical Garden Planning Based on Green Infrastructure Network

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Abstract

The connotation of botanical garden has been expanding with the developing process of urbanization in China. It's an effective way to define the new role of the botanical gardens by Green Infrastructure theory. This paper summarize the planning and designing methods for Chinese botanical gardens combined with infrastructure system. It elaborate the botanical garden planning and design methods on the basis of green infrastructure system from the macro and micro views.

Keywords: Green Infrastructure(GI); Botanical Garden; Low Impact Development(LID); Biodiversity

1. Introduction

In late 2017, the country's urbanization rate has reached 58.52%^[1], with more than half of the total population living in towns, cities or suburbs. The city sprawl leads to a fragmented and isolated natural system and the dotted city pattern surrounded by pasturelands is sliding into reverse. Those are bringing numerous city problems^[2]. Therefore, for a long period to come, how to build a poetically ideal inhabitation will become the primary concern. As an effective solution, Green Infrastructure is playing a crucial part in city construction. Botanical garden, an important part of urban green space, serves the function of scientific

research, science popularization, and recreation etc.^[3]. The distant urban space forces people to consider how to integrate botanical garden into Green Infrastructure and how to optimize its diversified functions.

2. Green Infrastructure

Green Infrastructure means a net made by connections between natural space and other open spaces. The net contributes to preserving ecological value and function, keeping air and water clean and doing good to humans, wild animals and plants. It is a natural life support system as well as an ecological framework which serves environment, society and economic health^[4].

2.1. *The Origins of Green Infrastructure*

In the 1860s, Olmstead's connection thoughts about park and open spaces and the idea of establishing ecological protection and management network to decrease the fragments of ecological areas had a significant influence on academic field. Based on the two thoughts, two new theories were formed. One is to build connected parks and integrated green space system to protect human's profits. The other is to establish a natural protection net to protect biodiversity and species' habitats^[5]. The two new theories evolved the lead wire of modern western Green Road Campaign and ecological framework of Green Infrastructure.

In 1984, UNESCO put forward the idea of establishing ecological infrastructures resembling Green Infrastructure in Man and The Biosphere. In 1990, during the Green Road Project in Maryland, Green Infrastructure firstly appeared as one of sustainable development strategies. In May, 1999, PCSD issued the work report named *Creating A Sustainable US in 21st Century*, in which the concept of Green Infrastructure was brought forward^[6]. Since then, the concept of Green Infrastructure was spread across the US, the UK, Canada and many other countries.

2.2. *The Components and Functions of GI*

2.2.1. *The Functions of Green Infrastructure*

The principal function of Green Infrastructure is ecosystem service. It means humans attain profits from eco-system. The profits could be concluded as supply service, support service, adjustment service and culture service^[7].

The supply service includes food and material resource supply, fresh water supply, groundwater formation, biological genetic resource supply, erosion prevention and soil fertility protection, noise prevention and biological control etc. Support service includes urban wildlife habitat support, the biodiversity production and protection, the soil formation, photosynthesis and nutrient cycle. Adjustment service includes regulate local climate, decrease drought and flood disaster, air therapy regulation, carbon sink, water purification and circulation, pollination, pest control, detoxification and decomposition of waste. Culture service includes recreation, keep physical and mental health, provide tourism and local scenic spots, aesthetic experience and inspiration, cultural values, provide information, adaptive management, stress free life and urban agriculture etc.

2.2.2. *The Components of Green Infrastructure*

Green Infrastructure is composed of hubs, links and sites. Hubs mean large natural areas without external interruption. provides starting and destination points for wild animals and plants. The size of it varies with hierarchies. It mainly include large ecological protection reserves, large public land, working lands, and large parks etc.

Linear ecological corridors collectively refer to links, which forms an integrated system by connecting hubs and sites. Links has a crucial impact on the stimulation of ecological cycle, the guarantee of eco-system health and preserving biodiversity. It mainly includes landscape link corridor, eco-protection corridor and natural greenbelt etc. Sites means niches and recreation sites in a large natural area. Its size is smaller than hubs

but could provide habitats for animals and ecological nodes for humans in case hubs could not connect links. It not only supplements hubs and links but possesses ecological and social value.

3. Botanical Garden and Green Infrastructure

The concept of botanical garden originated from western in where people make scientific researches, science popularization and take a rest by means of collecting and protecting numerous internal and external species^[8].

3.1. The Development and Construction Status of China Botanical Garden

3.1.1. The Development of Chinese Botanical Garden

There were a long history of plants-collection in ancient China, but strictly speaking, the botanical gardens that conform to the scientific definition have only begun to be constructed under the influence of western countries in modern times. Until the founding of PRC, there were only 8 botanical gardens in China. After the establishment of the PRC, on the initiative of Chinese Academy of Sciences, government renovated and built total 36 modern botanical gardens. After the reform and opening up, the construction of China's botanical gardens has been booming. Up to now, there has been more than 200 botanical gardens in the whole China, which are affiliated with different departments such as gardening, forestry, agriculture, pharmaceutical, and scientific research etc.^[9]

With the development of Chinese society and scientific technology, botanical gardens present different features in different periods.

In general, the development of modern Chinese botanical garden could be divided into four phases: before 19th century, mid-19th century to mid-20th century, after 20th century and nowadays. Because of the change in social needs at each stage, botanic gardens have adapted to the functions of the times under different mainstream thinking.

Table1-1 Development of Chinese Botanical Gardens (author-drawing)

Periods	Social Demands	Added Functions	Mainstream Ideologies
Before 19th Century	Varieties Collection	Collect crops and herbs	Functionalism
Mid-19th Century ~Mid 20th Century	Varieties Collection and Horticultural Development	Plant research; Explore new beneficial plants; Science popularization	Ornamental Horticulture
After Mid 20th Century	Social culture and demands for scientific research	Species conservation, scientific research, science popularization, tourism, new plant material industry	Ecological planning
21th Century	Sustainable development	Guarantee and promote biodiversity; regulate Regional Eco-system	Sustainable development and ecological civilization

3.1.2. Current Situation and Inadequacy of Contemporary Chinese Botanical Gardens

Currently, except most large and medium size cities, many prefecture-level cities have begun to build botanical gardens. The development of the Chinese Botanical Garden has not been more than 100 years,

shorter than most western countries. It's difficult for China to obtain the achievement, but there are still many problems as follow.

1) Self-enclosed system fails to maximize eco-efficiency

Constructed as an independent ecological patch, the traditional botanical gardens have not formed a well relevance with the surrounding natural systems. The exchanges of matter, energy and genes only occur within the park for its relatively closed system and has little impact on the regional ecosystem. As an isolated ecological plate, ecological performance has not maximized, and it is not conducive to the improvement of regional ecological pattern^[10].

2) Focus on own functions singly

The diverse and complex functions play an important role in improving the status of green space in urban development^[11]. However, the functions carried by most botanical gardens still remain in a series of traditional functions such as collection display, popular science research, and leisure recreation^[12]. And these single traditional functions have not formed a perfect system for each other and cannot adapt to the rapid development of urbanization.

3) Imperfect popular science system and outdated display mode

At present, the popularize knowledge activities of botanical gardens in China mainly include the following types: festival activities with the theme of seasonal flower viewing, various kinds of popular science exhibitions, lectures, and practical training that are held in indoor venues. These activities have a single and outdated pattern and do not form a good integration with the park's natural landscape environment. As a result, the interactive activities of popular

science activities are reduced, and the subjective initiative of visitors cannot be fully mobilized.

4) Similarities in form and lack of own characteristics

At present, most of the Chinese botanic gardens do not have their own characteristics except the geographical position of natural climate characteristics reflected by the floristic characteristics and garden style, and the primary and secondary relationships between the affiliated parks and scientific research^[13].

5) Low biodiversity

Currently, China's most botanical gardens only display 300-500 species of plants. A few of the parks can reach 6000-8000 species, and there are only 39 botanical gardens with more than 1,000 species (including varieties). The total number of planted and cultivated plants in the Botanic Garden of China is about 20,000, while the UK Kew Garden has 55,000 plants. Plant types are the basis of botanical gardens, and its richness or not reflects the level of botanical gardens. Therefore, enriching plant species is a top priority for the construction of Chinese botanical gardens^[14].

3.2. *Integrated into the Green Infrastructure System—Functions Extension of Botanical Gardens*

3.2.1. *New Requirements for Botanical Gardens with Contemporary Social Development*

Sustainable development, environmental protection, and the coexistence of man and nature, these important topics have brought significant development opportunities for the construction of today's botanical gardens.

The botanical garden has become a hot spot for urban environmental construction and has risen to a strategic level. It has gradually developed into a comprehensive urban park integrating plant collection and display, popular science education, nature protection, and recreation^[15].

However, with good opportunities in external development, the construction of botanical gardens is also facing many challenges. It overtakes more social attributes and needs constant adjustment to meet the needs of modern urban cultural life^[16]. This article argues that the role of botanical gardens in the current rapid urbanization process should meet the following requirements:

- 1) Fully integrate into the regional green infrastructure network.

The botanic gardens, as a region with high diversity of species in the city, should pay attention to the connection with the urban green space during construction, and enhance the connectivity and integrity of the urban green space system, and use the Links as part of the regional ecological chain^[17] to improve regional ecological efficiency and the regional green infrastructure system.

- 2) Improve the functions of leisure and recreation.

The particularity of the botanical gardens in terms of base sites, management systems, etc., allows them to have a great advantage in the basic research of plants and cooperation. However, with the change of public demand and aesthetic awareness, the botanical garden, as part of the urban park green space, should enhance its ornamental nature and provide the public with adequate recreational functions.

- 3) Advance science popularization system.

The science popularization system mainly consists of two aspects. The ways of popular science display and popular science facilities. The ways of popular science display should be flexibly set according to the tourist groups of different ages, including gardening theme activities and exhibitions, and online popular science education^[18]. The science popularization facilities should keep pace with the times on the premise of guaranteeing complete facilities, and introduce emerging technologies, such as the construction of digital botanical gardens^[19], adapting to social needs with the process of innovation.

- 4) Highlights regional features.

The botanical gardens should reflect the regional landscape features and the urban features. The exhibition will focus on the display of native plants with regional features and will not blindly introduce foreign plants. It should pay more attention to the traditional landscape pattern, space composition and plant community collocation, express the local plant landscape and spatial characteristics.

- 5) Enhance the biodiversity of urban ecosystems.

While ensuring the diversity of plants and animal and microbial are enhanced, and consideration should be given to creating habitats for birds and other animals. The stability of plant communities provides a stable living environment for animals and microorganisms. As the same, animals and microbes also provide guarantees for the healthy development of plant communities^[20]. The construction of habitats also enhance the popularization and appreciation of the botanical gardens.

3.2.2. The Roles and Functions of Botanical Gardens as Green Infrastructure

The new requirements raised by urbanization process for the construction of botanical gardens coincide with the appearance of green infrastructure in contemporary China.

Botanical gardens are diverse in scale and form, and cloud play an important role in the construction of a green infrastructure network. Large-scale botanical gardens can serve as hubs for ecological protection in areas such as conservation of biodiversity, providing recreational space, and alleviating negative effects in cities. Liner botanical gardens can be used as Links connecting green spaces to form regional green space network which further improve the urban ecosystem. Small botanical gardens can serve as sites for enhancing biodiversity and recreational functions.

4. Botanical Garden Plan Based on Green Infrastructure System

Two dimensional analytical programmes are put forward in this paper to achieve the integration of botanical gardens into GI system . One is that botanical gardens are planned as macro constructions and designed as micro constructions between hubs and links. The other is to make botanical gardens as micro construction of sites, part of GI system.

4.1. Botanical Gardens as Hubs and Links

4.1.1. Botanical Gardens Built as Hubs and Integrated into GI Network (as a Part of Macroscale)

In general, only larger botanical gardens could play the role of hubs and each such botanical garden covers in excess of 200

hectares. The crucial to make these botanical garden hubs influential is the construction of links. Three methods are usually adopted to construct links.

The first is to choose proper sites where natural linear elements could be used to make links. Rivers, forests and farmlands are the most common natural linear factors. Shanghai Chenshan Botanical Garden is the typical botanical garden constructed with such method. It covers an area of 207 hectares. To make linear connections throughout the garden, designers use the natural riverways in the garden center and form an open space network which makes botanical garden connect DianShan Lake east and She Mountain west(Figure 4-1).

The second method is to build artificial links to connect external hubs or natural links. Artificial links refer to streams and forest belt which connect surrounding natural areas in the garden.

For example, Bai Caopo Forest Botanic Garden covers 350 hectares and is located in the center of the regional green circle. The green circle system covers Taiyuan City, the ecological barrier in the north of Jinzhong City, Xiashan Suburban Forest Park, Tian Longshan National Forest Park, Wu Jinshan National Forest Park, large forest and farmlands. Bai Caopo Forest Botanic Garden is a key joint in it. Designers form a regional open space by connecting approaching natural forest landscape and other surrounding landscape patterns (Figure 4-2). In addition, greenways in the garden are regarded as important part of city greenways. City greenway system is perfected by integrating garden greenways (Figure 4-3). It makes greenway system as a way to create

links among botanical garden, regional nature system and open space.

The third is to make botanical gardens as external part of hubs. It needs designers to consider the overall city green land system fully, such as Beijing Botanical Garden, which was regarded as the extended part of Xi Mountain to Beijing ventilation corridor (Figure 4-4).

4.1.2. Design Botanical Gardens as Links and Integrate into GI Network (Macroscale)

The botanical gardens which serve as links are rare in China. The most typical one overseas is Chicago Botanical Garden, part of the northern branch corridor of Chicago River (Figure 4-5).

4.1.3. Design Botanical Gardens as Hubs and Links in Microscale

Serving as hubs and links, the microscale of botanical gardens promotes self eco-service function by a series of measures such as perfecting original functions and composite functions, promoting biodiversity and so on.

1) Improve the original function & Develop the composite function.

Once enhance the popular science function and regional characteristics, the functions of botanical gardens serving as green facilities can be strengthened. For instance, Chenshan botanical garden in Shanghai uses new measures like opening interactive experiential science activities for different crowds and Xianhu botanical garden in Shenzhen constructing digital garden acquiring great social impact. In addition, botanical garden will overtake some new functions adapting to the city development, such as the function about water system. Chenshan Botanical Garden pays attention to collect the natural precipitation,

comprehensively manage the waters for building recycle waters, purified and rational system.

2) Cultivate Biodiversity

Biodiversity includes landscape diversity, species diversity, and genetic diversity. It could be realized by means of cultivating various habitats, application of native species and few interferences from humans.

In the case of BaiCaopo Forestry Arboretum in Jinzhong, Shanxi province, the site belongs to unique loess erosion landform, there are many loess hill, platform, ridge and tableland (Figure 4-6). Therefore, we can take full advantage of various terrains to cultivate a multiple ecotype on the basis of the forest and analyze the landscape pattern to design the functional layout and leisure place. These layouts reflect the design principle that respect the characteristics of the site (Figure 4-7). The vegetation selection has formed relatively stable forest structure through the construction of local native plants.

4.2. Botanical Garden as Sites

Affiliated to different apartments, the botanical gardens used as sites mostly belong to education, medicine and forestry with small size^[24]. Constrained by outer environment and the scale, the botanical garden can't involve too much biological processes while connecting with central control point and links. So the key of bringing into green infrastructure network for sites turned into making the full use of every functions and overtake more functions to sustain the system. Sites just like the botanical gardens used as central control point and links, mainly constructed by

comprehensive functions, science-capacity building, local characteristics and biodiversity.

5. Conclusion

It's an effective way to define the new role of the botanical garden by Green infrastructure theory. This paper summarize the planning and designing methods for Chinese botanical gardens bringing into infrastructure system. It elaborate the garden planning and design methods on the basis of green infrastructure system from the macro and micro views. It is hoped that this research will provide a new idea for the planning method of Chinese botanical garden and provide a reference for solving the existing problems in Chinese botanical garden.

Acknowledgments

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Appendix

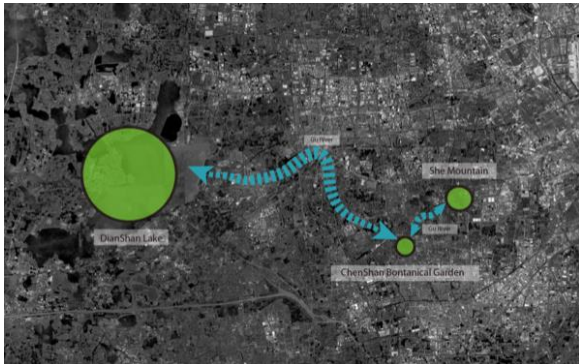


Fig. 4-1 Natural riverways in Chenshan Botanic Park are used to connect with surrounding environment

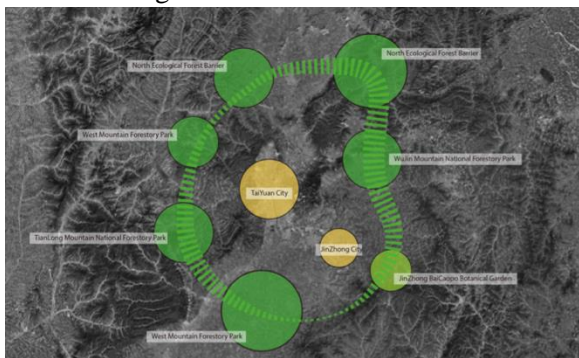


Fig. 4-2 Forest belts in Bai Caopo Forest Botanic Garden are used to connect with surrounding environment



Fig. 4-3 The Greenways which connect Bai Caopo Botanic Garden and city open space



Fig. 4-4 Beijing Botanical Garden, the extended part of Xi Mountain to Beijing



Fig. 4-5 Chicago Botanical Garden, part of the northern branch corridor of Chicago River



Fig. 4-6 Undeveloped Forest Arboretum



Fig. 4-7 Proposed Sections of the Park

How to Construct Country Parks with the Aim of Improving Biodiversity—Taking the Planning and Design of Longquan Lake Country Parks as An Example

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Abstract

With the acceleration of urbanization, cities are facing ecological imbalance and environmental crisis. Artificial habitats are a serious threat to the existence of natural habitat, resulting a rapid decline in biodiversity. It is necessary to consider how to improve this serious situation through landscape architecture design to improve the urban ability of self-restoration. After expounding related concepts such as natural and habitat construction. Taking the planning and design scheme of Longquan Lake country park in Shijiazhuang City, Hebei Province, China as an example, this paper discusses the ecological mode of country parks with the aim of improving biodiversity in the elastic range of the transition between cities and nature, and constructs a relatively complete ecological chain. It provides some practical experience for the formation of stable and diversified urban ecosystem.

Key words: Biodiversity; Naturality; Habitat Creation; Longquan Lake

1. Introduction

Urban biodiversity is the material basis for the sustainable and stable development of the city, and has an important significance for the sustainable development of the city. City is a semi-natural ecosystem dominated by human beings, and its biodiversity characteristics are different from those of natural ecosystem.

As urbanization continues to heat up, biodiversity rapidly decreases. According to surveys, more than 15000 species worldwide are on the verge of extinction, faster than

any previous geological period.^[1] Artificial habitats (such as concrete roads and buildings) destroy natural habitats that are suitable for wildlife survival, and the area of habitats for organisms to depend for survival is extremely reduced and habitat conditions are severely destroyed. This is one of the important reasons for the loss of biodiversity in urban cities.^[2] In addition, environmental, pollution, alien species invasion, simplification of agricultural, forestry and animal husbandry varieties, global climate

change etc. Are threatening the survival and development of organisms. This series of reasons are closely related to the interference of human activities. Therefore, in the urban ecosystem, how to solve the human development and biodiversity protection is the general problem discussed by a lot of planning and design workers and ecological researchers.^[3]

2. Relevant research

Some scholars have studied urban biodiversity from the perspective of theoretical framework and problem causes. Qizheng Mao is discussing the problems of urban biodiversity research in "Progress of Urban Biodiversity Distribution Pattern". Miller Jr. analyses the causes of homogeneity of biodiversity in his paper "Thinking about Biodiversity and Experiences of species Extinction". Yirong Deng puts forward the ideas and strategies of biodiversity restoration in a regional scale in the "Approach and case study on Urban Diversity Restoration", which takes Haizhu Ecological City in Guangzhou, China as an example. Patrick Mooney selected birds as ecological objects in the study of Bird Habitat use in Lower Fraser River Basin of Canada, to study whether habitat types and habitat groups will affect the local bird species level. In the exploring of regional biodiversity restoration and experiment research, Hui Liu made a relatively complete experimental study on the improvement of biodiversity on a small scale in the Experimental study of Habitat Construction.

To sum up, the previous researches, on the one hand, a lot of attention has been paid to the pattern of urban diversity and the problems on a larger scale. On the other hand, the study of the urban regional scale and biodiversity of small scale itself is

deeper. However, the exploration of the transition part between different scales is very rare. It is difficult to know how to realize the relative integrity of the control system in the actual process, and the transition region between the city and the nature is less explored. The author will discuss the related contents below.

3. Research ideas

If the process of moderate and orderly development of biodiversity is understood as the complete adaptation to the natural process without artificial interference, there will be no way to discuss to improve biodiversity. Planning and design is a man-made process, we should regard man as a factor in the natural system. Based on this understanding, to increase biodiversity to an appropriate and more stable level is either to choose the operational process that humans respect nature to limit human negative impacts on the environment to a smaller extent, or through guidance, to promote the natural system towards a benign cycle of planning and designing.^[4]

Based on the above discussion, the author discusses the combination of two ways to promote the biological diversity in the medium and micro scale. The two main objects of urban biodiversity decomposed are plants and animals. In order to study the systematic and correlation between them, the concepts of naturalness and habitat construction are introduced here.

3.1. Naturalness

Means the degree of naturalness. The concept of naturalness refers to the distance or similarity between real vegetation and their natural state. The greater the human interference, the greater of impact or destruction of vegetation and sites, the lower

of the degree of their naturalness and the farther away from their "climax community" or "potential natural vegetation". The difference between the current vegetation status and the primary (or potential) forest vegetation status in a given region can be evaluated and quantified by an assessment of naturalness.^[5] On the basis of correctly recognizing the regional naturalness grade, it is hoped that the purpose of promoting succession can be achieved by planting a suitable number of specific tree species to lay the foundation for the improvement of biodiversity for the status quo of vegetation in different succession stages.

3.2 Habitat creation

Habitat (or biotope) often refers to all the environmental factors required for all activities such as the survival and reproduction of a species. For animals, it is a place to provide food, shelter, protection and other necessary living conditions for their individual, groups or community in a certain stage of life, which promote their various life activities.^[6]

The creation of biological habitat is a complex process, creating and regenerating high-density living space in the object environment, especially considering the bottom living environment of "ecological pyramid". To create a diversified living environment, that is, to preserve the most basic living environment on the biological chain, which makes the advanced organisms have a rich food base. Therefore, habitat construction needs to consider all levels of components in the food chain. Only by building an elastic system with self-regulating functions can achieve the stability of the biodiversity environment and promote the appropriate communication between human beings and nature.

Combining the definition of habitat in ecology and from the angle of landscape

architecture design in microscopic scale, the author defines the connotation of habitat construction. That is, through the spatial elements of water, terrain, vegetation to affect ecological factors which influence the survival of animals and plant growth, such as water, light, heat and so on, to create a spatial organization displaying the natural internal order, to provide suitable site conditions and growth succession space for living organisms.

Combining the planning and design scheme of Longquan Lake country park in Shijiazhuang City, Hebei Province, this paper will expound the ecological strategy and construction mode for the purpose of improving biodiversity during the process with medium control and micro design.

4. Planning and Design of Longquan Lake Country Park in Shijiazhuang City, Hebei Province, China

At the beginning of the project, according to the actual situation of Longquan Lake area in Shijiazhuang (Longquan Lake area locates in the shallow mountain area of West Mountain), referring to the relevant practical strategies and experiences and the comprehensive analysis, the design team draws the objectives and requirements that should be met in the planning and design of Longquan Lake country Park in Shijiazhuang City.1) On the basis of mastering the natural succession law of the zonal plant community in Shijiazhuang, taking the catalysis succession as the means, the plant diversity in the region can be directly improved, and the animal diversity can be promoted indirectly.2) Creating a relatively complete food chain system in the design area, creating natural habitats suitable for the survival and development of a large number of animals, establishing and renewing aquatic and terrestrial ecosystems,

and forming a flexible and sustainable self-regulation mechanism. Make the forest and biodiversity play an important role in urban ecology. Then, I will select the typical links and sections of the project to make a key statement.

4.1 Plant planning strategies for generating succession

The site belongs to the regional geography and climate conditions: located in the eastern edge of the Eurasian continent in middle and low latitudes, close to the Bohai Sea, of the Pacific Ocean, and belongs to the temperate monsoon climate. The seasonal variation of solar radiation is remarkable, the ground high and low pressure activity is frequent, the four seasons are distinct, the cold and heat are distinct, the rainfall is concentrated in the seasons of summer and autumn. The dry and wet period is obvious, the summer and winter is long, while the spring and autumn is short. The regular succession process is shown below.



Fig. 1. A Natural succession Picture.

Design team analyzes naturality of site status based on GIS technology. The site naturalness is divided into five grades, the roads and villages without vegetation layer did not enter the succession process for the greatly interfered of artificial intensity; the part of cultivated land and the residential area with higher green quantity also belonged to the stage of not entering the succession process at all for the greatly interfered of artificial intensity. The third layer is grass and shrub stage, and the present situation is in the middle and late stage of the shrub community succession. The xeric *Bothriochloa ischaemum* is dominant, and the shrub is sparse in the

community, and the main is chain, lespedeza and wild jujube. The current succession stage of artificial forest is in the early stage of tree stage. Seedling afforestation and sowing afforestation are included, while the species is relatively single, the artificial side cypress, cork oak, the young tree forest of acacia in domain, the main shrub is chain, lespedeza and wild jujube. The herbaceous plant is dominated by the *bothriochloa ischaemum*; Finally is the natural secondary forest, in the middle stage of trees succession, partly by artificial seeding forest succession, and mainly for *platycladus orientalis*, associated with cork oak, acacia, pistacia, main shrubs for thorns chain, lespedeza, and herb for Chinese wildtype. It is hoped that the site status stage which is not completely in succession stage, middle and late stage of shrub community succession and the middle and late stage of Arbor succession stage will be guided to the middle stage of Arbor stage succession. It is suggested to supplement *quercus variabilis*, *robinia pseudoacacia*, *populus davidiana* (Arbor) leaves white wax, thin bark wood, *amorpha fruticosa*, yellow prickly rose, *cotinus coggygria*, clove (shrub) big awn oil (herbaceous) and so on.

For the present stage of Arbor stage, it is suggested to be guided to the last stage of Arbor stage and to supplement *quercus variabilis*, *robinia pseudoacacia* (*aracia pseudoacacia*) leaflet white wax, yellow thorn rose, *cotinus coggygria*, clove (shrub) big oil awns (herbs) and so on.

In the above way, aiming areas with different succession stages, the species and quantity of plant communities are controlled, which to some extent catalyze their relatively natural growth, which is a long-term process that needs intermittent operation. According to different regional conditions, different types of living environment for different species can be guided and to shaped, which has a far-

reaching impact on the subsequent planning and design.

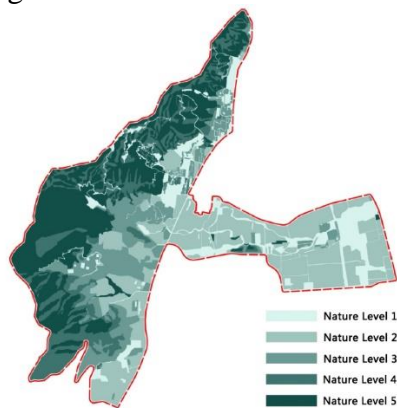


Fig. 2. A Natural level picture.

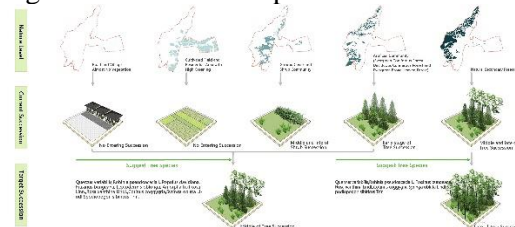


Fig. 3. A Natural Succession Schematic diagram.

4.2 Habitat planning and design strategies for biodiversity enhancement

In order to improve biodiversity, a relatively complete food chain is needed. Firstly, based on the common species of animals and plants in Shijiazhuang, and combined with some rare species, target species are identified. Biodiversity is based on habitat diversity. Therefore, according to the ecological habits of the target species and the types of space to be constructed, the designer, according to the preferences of different species, forms a flexible material space through the controlling design of the natural elements such as water body, topography, plant to construct habitat environment with varieties. As the east of Longquan Lake, (100.6 hectares) is planned as a wetland area in the upper part, which is the most abundant biodiversity, with comprehensive ecosystem function and highest productivity ecosystem in nature that is chosen to elaborate in detail.

According to the common species of animals and plants in Shijiazhuang and some rare species, the target species are determined, and then the habitat is created layer by layer according to the food chain system. Limited by space here, birds are selected as the research object to be focused on for narration. Birds are at a higher level in the ecosystem, and there is evidence proving that bird diversity can represent the overall biodiversity.

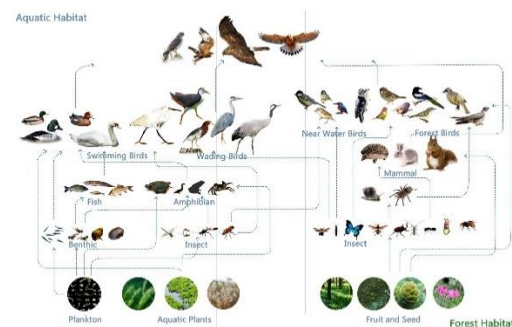


Fig. 4. A network diagram picture.

Based on the study of common birds in Hutuo River wetland section of Shijiazhuang, the birds were divided into waterfowl and non-aquatic bird after the sufficient study on original habitat birds. From more than 80 species of water birds and 63 species of non-water birds, 20 species of waterfowl and 15 species of non-aquatic birds, which are most suitable for survival in the eastern wetland, were selected as target species. They will be expounded separately in the below.



Fig. 5. A aim birds picture.

4.2.1 Aquatic bird habitat construction

The construction of aquatic bird habitat is considered deeply from two aspects: habitat range and planting design.

The determination of habitat range is affected by many factors. For example, the target species of game birds, represented by the Duck family, are mainly foraging in shallow water areas with a depth of 10-30cm, and are active in waters with a depth of 1.5-2m, while the target species of wading birds, represented by Crane family, are mainly taking meadow activities within 15m offshore, nesting and resting in the shrubbery. General waterfowl can bear the distance of 50m from the outside disturbance. Finally, the design team selected the depth of water, the range of coastal activities and disturbance distance as the selection index of the habitat range of waterfowl, and selected 11.4 hectares of habitat area of the eastern waterfowl by the superposition of the three indexes.

Secondly, considering the related indicators of planting design, after a period of investigation and research, designers found that aquatic plants will provide food and necessary rest and hiding space for waterfowl, and its coverage will determine

the livable degree of waterfowl in the water area. Waterfowl require a higher proportion of shrubs, herbs and low tree coverage to provide an environment for nesting and rest on shore within a range of 15 meters of inshore activity; Waterfowl require less floating leaves and floating plants in the waters. Otherwise, it will affect its take-off and landing. The inshore plants should be able to provide shelter for the waterfowl and provide visual guarantee for the bird. To sum up, aquatic plant coverage, Arbor and shrub coverage of inshore activity and plant height were selected as the main influencing factors.

According to the area of habitat distribution of waterfowl after screening, combined with the function and landscape layout of the park, we divided the habitat of waterfowl into the following six regions and controlled the coverage of aquatic plants, the coverage of Arbor and shrub, and the height of plants as follows.

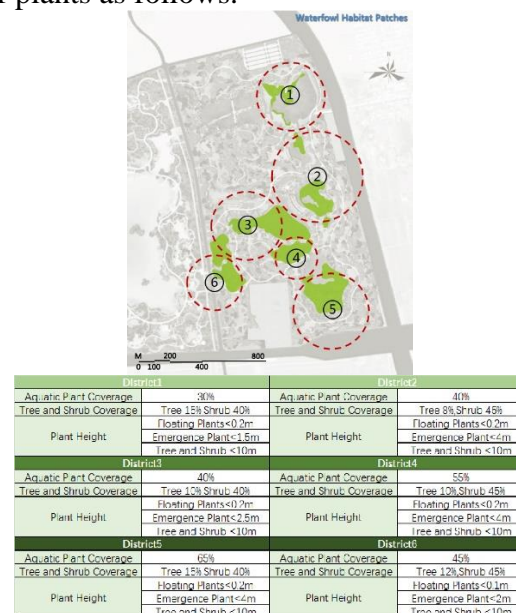


Fig. 6. An aquatic bird habitat construction picture.

4.2.2 Establishment of habitats for non-aquatic birds

Similarly, the construction of non-aquatic bird habitat will be discussed from two aspects: habitat range and planting design.

The design team studied a series of relatively microscopic conditions, such as terrain slope changes can also cause plant species and community structure changes, thus affecting the bird's habitat, of where require a certain slope of 30-40%, terrestrial bird requires 15% -35% as preferred; Selection of non-aquatic bird habitat influenced by disturbing distance mainly by road; Wetland water margin planted at least 30M wide waters connected of formed plaques, which provide channels from terrestrial habitats to aquatic habitat through a variety of plants grouping for birds. Therefore, the terrain slope, disturbance distance and water access patch are taken as the selection index of the habitat range for non-aquatic birds, and the three indexes are superimposed to screen 8.9 hectares of habitat for non-aquatic birds.

The planting design selected soil richness, community structure, tree height as indicators. The abundance of ground cover plants will affect animal activities (including insects and soil microorganisms), ground moisture and bird feeding sources, which are important factors affecting the habitat of birds. The community structure of bird habitat was divided into Arbor shrub herbaceous type, Arbor herbaceous type, shrub herbaceous type and herbaceous type according to different collocation of Arbor and shrub. The proportion of different community structure and community structure in habitat affects bird life; the proportion of different height trees in habitat greatly affects the suitability of bird habitat.

Through the control of the above indicators, the designers divided the non-

aquatic bird habitat into the following six areas.

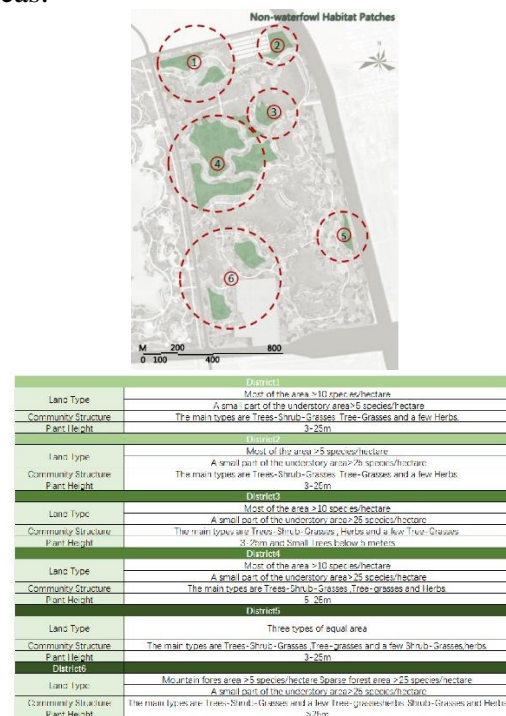


Fig. 7. A non-aquatic birds habitat construction picture.

5. Summary

On the basis of quoting and discussing related concepts, this paper takes the planning and design of Longquan Lake country Park in Shijiazhuang City, Hebei Province, China as an example to discuss the ecological construction model of country parks with the objective of improving biodiversity in the elastic range of the transition between cities and nature that is, respecting the laws of natural succession and speeding up plant succession by appropriate catalytic means. At the same time, create a relatively natural habitat as much as possible. According to local conditions and the biological needs, especially the birds, put forwards the corresponding zoning construction indicators, set reasonable allocation of animal and plant species and disturbance control to build a complete

ecological chain and to form a stable and diversified urban ecosystem as well as provides some practical experience. However, the restoration and protection of biodiversity is a gradual process, which requires long-term unremitting efforts to achieve positive results.

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Study on Landscape Construction Strategy in Urban Piedmont Area

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Abstract

China is mountainous and watery. Traditional Chinese urban planning emphasizes the layout and relationship of mountain, water and city. The idea layout of city is surrounded by mountain and water, which make city and the natural environment can take advantage from each other. The piedmont area is a special region of the city, which is the boundary and transition zone between city and natural environment. The land use of piedmont area is diverse, including urban construction land, rural settlement, farmland, woodland, water systems. The piedmont area of city is an important space of living, production and recreations with outstanding landscape and ecological values.

At present, rapid urbanization leads to the urban expansion and the area of residential and industrial land in the piedmont area increasing. However, the vegetation is reduced, the natural hills are destroyed, the traditional villages and farmlands are gradually disappearing, the landscape characteristics and ecological functions are impaired. The piedmont area need specific measures and means to restore its landscape and ecological value.

The paper take the piedmont area of Mount Qingyuan in Quanzhou, Fujian Province as an example, to analysis its landscape change process; to summarizes the landscape pattern, landscape structure and landscape characteristics of each stage; to analysis the landscape decade and ecological destroy problem led by urbanization and industrialization. Furthermore, this paper put on the landscape development strategies: (1) According to the characteristics of the environment, restoring landscape security pattern in the piedmont area; (2) Based on the historical characteristics, protecting the piedmont area historical landscape heritage; (3) combined with the development needs, renewing the landscape of urban and rural in the piedmont area.

Keywords: landscape architecture; the pediment area ; landscape ecology; landscape heritage; landscape renewal

1. Introduction

1.1. Definition of Urban piedmont area

China is mountainous. Topographically undulating areas such as hills, mountain and plateau account for approximately 66.7% of the land area. Alluvial plains between mountains with flat terrain, fertile soil, and abundant water resources are the common sites for urban development and development. The construction and development of the city will inevitably interact with the surrounding natural hills. There is a certain transition area between the city and the natural mountain. It belonging to the 'Piedmont Area'. This area has a topographical characteristic that gradually transitions from the plain to low hills and mountains.

1.2. Traditional Chinese Landscape City System

The rich mountains and waters in China have given birth to traditional landscape aesthetics and culture. Ancient Chinese literati admired nature mountains and water landscape. Nature environment were places where they healed depression and felt physical and mental freedom. In the past thousands of years in China, most of the local officials were literary men. They brought their profound inspiration of nature into the cities that they created.

At the same time, Feng Shui theory also have significant influence on location and construction of ancient Chinese cities. The idea Feng Shui Pattern is a basin-shaped landscape unit that is oriented mainly from north to south and surrounded by the four

sides with triple mountain enclosure(Fig.1). The Feng Shui planner chose the location and layout of the city based on the location, layout and direction of the mountain and water system. It has created a relationship of 'symbiosis, coexistence, co-prosperity and co-pleasure' of mountains, water, city and people. The Feng Shui pattern has a positive effect on agricultural production and



ecological balance. [1]

Fig. 1. The ideal Feng Shui structure
 Source: Yang Liu, The research of Fengshui Theory And The Building of Ancient Shanshui Cities.

1.3. The relationship between city and nature

Urbanization and industrialization has caused changes in the relationship between urban and natural landscape, leading environmental problems. In recent decades, China has undergone rapid urbanization. Traditional urban-rural relations have changed. Construction land in urban have a significant growth, eroding the natural and

rural land around city. The open space and green space in piedmont area has decreased. The landscape heterogeneity and biodiversity has decreased, the ecological environment is destroyed and the beauty of traditional landscape has disappeared.

The relationship between urban area and natural space is one of the important research topics in urban planning, landscape architecture, landscape ecology. Howard E. put forward the idea of ‘garden city’, a multi-core system that cities surrounded by rural and natural area in this pattern. The transition area between urban and rural areas consists of low-density residential and garden belts. He hoped to integrate nature and agricultural area with city organically, to solve the urban development problem, such as environmental pollution brought by industrialization and urbanization, the uneven distribution of population and jobs, and the income gap between rich and poor.[2] Olmsted F L. A believed that the natural environment in city was a necessary condition for alleviating urban congestion after the industrial revolution and people could relieve their emotions in beautiful natural space. He planned and designed the Boston Emerald Necklace Park System to bring nature to city.

In the middle and late 20th century, urban ecology has developed and provided valuable spatial planning principles. Ecological restoration measures such as urban ecological networks could improve the degraded nature in cities. Urban ecological networks consisting of patches and corridors have been valued. Green corridors could link up large-scale forest or greenways, active woodland and natural patches, large parks, river

corridors, green belts marginal habitat, small urban parks, and agricultural lands within and outside urban area [3]. This might help enhance the city landscape and ecological functions. In 1996, the United States issued Charter of New Urbanism against urban sprawl, eroding farmland and green space and advocated smart growth city. It has inspired urban zoning control planning which divide planning area into natural zone, rural zone, sub-urban zone, general urban areas, urban center zone, urban core zone and special districts(Fig.2). The control guidelines were proposed by special characteristics and land use for each division and emphasized the use and control of transition areas [4]. In 2013, Singapore government put up their urban planning goals as ‘the city in a garden’. The implementations have involved increasing the natural protected areas and parks within and around the city, and enhancing urban biodiversity [5].

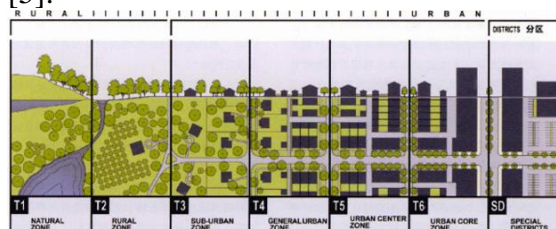


Fig. 2. Smart code zone

Source: Parolek D G, Parolek K, Crawford P C, Form based codes: a guide for planners, urban designers, municipalities. and developers[M]. John Wiley & Sons, 2008.

2. Site Analyses

2.1. Overview

The study site is in Mount Qingyuan, Quanzhou. Quanzhou is a well-known historical and cultural city in China, with a developed culture relating to ocean communication. The traditional culture there have originated from the integration of different countries and regions. There are various religions competitively developing in Quanzhou.

Quanzhou has maintained its historical landscape elements, such as ancient city of Quanzhou, Mount Qingyuan, Ming River, Luoyang river, traditional architectures and villages, etc(Fig.3). Quanzhou also fully embodies the spatial pattern landscape characteristics—a city surround by the rivers and mountains, also facing to the bay.[6]



a. Anping Bridge b. Confucian Temple c. Qingjing Temple d. Kaiyuan Temple e. Tianhou Temple

Fig 3 Quanzhou historic landscape
 (Source: a and b from Quanzhou ancient architecture)

b. Mount Qingyuan

Mount Qingyuan is a Scenic and Historic Area of China because of its magnificent natural and cultural landscape, with a long development history. The rich number of stone carvings and the multi-religious displays coexisting in the landscape. It reflect the spatial characteristics of the ancient city's famous mountains that are blended and developed by traditional geographical

culture, inhabited culture and religious culture[7]. In addition to the variety of natural.



a. Laojun Rockb. Lingshan Holy Tomb c. Wu Suwang Mausoleum d. Tiger Milk Spring Tea Village Fig

Fig4 Mount Qingyuan scenic and historic area
 (Source: the first two photographed by author, the latter from the cellular network)

c. Study Site

Study Site is located in the Mount Qingyuan Scenic and Historic Area. It borders on the ancient city of Quanzhou in the west and Mount Qingyuan in the east. It is located in northeast area the Mount Qingyuan Scenic and Historic Area and belongs to tertiary protected area and closes to the core area of the park. It is the transition zone between the city and mountains(Fig.5).

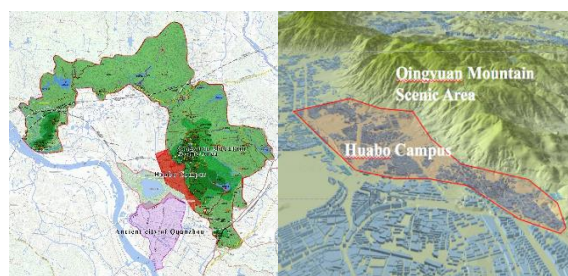

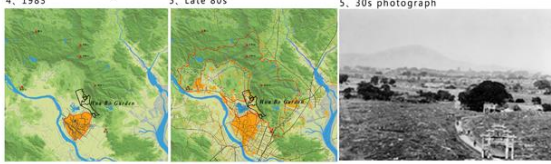



Fig 5 Bitmap of study area
 (Source: Left-bottom map from the Master Plan of Mount Qingyuan Scenic and Historic Area.)

2.2. Evolution of urban landscape of Quanzhou

The landscape pattern of city has undergone three phases (Tab.1) [8]. In this process, the study area has changed from a purely natural landscape into the semi-natural landscape, and eventually into a urban-rural landscape.

Tab 1 Evolution of city- scenery pattern

<p>Phase I Old City facing to famous mountains</p> <p>The Pattern of City mountain The Tang Dynasty The Song Dynasty in the first generation The Song Dynasty and The Yuan Dynasty</p>  <p>After many times of city expansion, Quanzhou, as an existing ancient city, has turned into such a situation --- facing mountains across the field. The Hua Bo Garden area is dominated by nature-idyllic landscapes, with scattered villages throughout. A landscape painting of crisscross footpaths between fields and that of a red wall and cooking smoke are presented. The combination of the city and the landscape has formed the landscape features of this famous city with the famous mountains, in a relatively independent status.</p>
<p>Phase II Cityscape Connected</p> <p>The Pattern of City mountain 4. 1983 5. Late 80s 5. 30s photograph</p>  <p>In the 1990s, with the rapid economic development of Quanzhou, the urban and rural construction volume rapidly increased and its scope continued to expand. The city has already developed to the foot of Mount Qingyuan. The villages around the scenic area, including the Hua Bo Garden area, have expanded outwards in an unordered manner, crowdedly within the mountains and forests. The unreasonable architectural heights within the Hua Bo Garden area and the modern means of transportation like railways have disrupted the natural sequence of "mountains, fields, and cities" between the ancient city and the scenic spot, and cut off the landscape connection between the mountains and the city.</p>

<p>Phase III Surrounded by the City</p> <p>The Pattern of City mountain 6. 2002 7. 2014 7. 2018</p>  <p>After the 21st century, with the rapid development of the Beifeng Group, the pastoral scenery area of the original ancient city surrounded by three mountains gradually changed into the Mount Qingyuan three-facedly enclosed by Quanzhou City. Due to the unique geographic location of the Hua Bo Garden area and the improvement of traffic conditions in recent years, towns and villages have shown a jointing trend. The uncontrolled spread of villages has further squeezed the ecological area, and the traditional city-mountain structure is facing to a huge impact.</p>

2.3. landscape changes of the study site Area

Stage I Natural Landscape

Since the Quanzhou government moved to site known as today during Tang Dynasty, the study site was initially developed, which was based on natural landscape.

Phase II Nature-Rural Landscape

After the Tang Dynasty, the Study Site area was further developed. Several natural villages were built alongside the mountains along with the initially development of agriculture. The Study Site area gradually evolved into a nature dominated landscape [9]. This change added to the spatial level of the urban landscape, and changed into a city-field-scenery landscape pattern.

Stage III urban-rural Landscape

After the 1990s, the process of urban sprawl was accelerated. The establishment of the Mount Qingyuan Scenic and Historic Area led to a development of the Study Site area. The original villages rapidly expanded, and modern transportation facilities flooded into the area, leading to such a condition where the pastoral community is constantly

suffering from operation, forming a contiguous development of the city-village and a fragmented landscape pattern of ecological area. As shown in Fig 6 of Evolution of the Study Site from 1921 to the present



Fig 6 Evolution of the Study Site area (1921-2017)

(Image source: the bottom map from Google Maps; the picture self-made)

2.4. Site Analysis of the study site

a. Low natural ecology and poor quality

Ecological area is fragmented: patchy forest land scattered along the western side of the Qiyunshan Highway, weed lands mainly distributed in the open space around the community, and no contiguous large areas of grassland within the planned area. (Fig 7)



Fig 7 Ecological Area Distribution of Study Site

(Source: Baidu Street Scene and the rest self-painted)

The quality of large agricultural area is low. The garden is mainly distributed in the north-eastern side of the Tianbian Community, and is mainly dominated by longan orchards. The farmland is mainly

distributed on the west area of the Tianbian Community and on the northwest area of the Huanqing Community in which there mainly grows fruits and cash crops. The nurseries are mainly distributed on both sides of Huabo Road. (Fig 8)

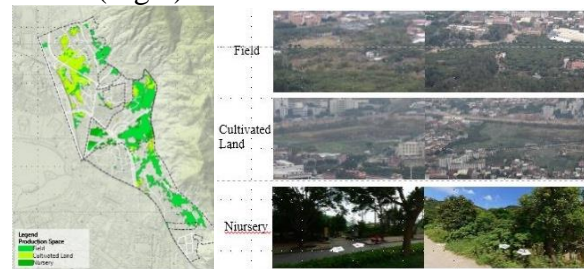


Fig 8 Eco-spatial area distribution of Study Site

(Source: Baidu Street Scene and the rest self-painted)

Unordered construction and land use the construction of the study site area is considerable confusing. Village land, urban land and scenic land are mixed together. There are large-scale factory buildings, communications facilities and other large base stations inside the village. In the communities of Houmao and Huanqing, there are driving schools and other urban sites. The original traditional buildings were replaced by modern three-story buildings and various large-scale factories. The disorderly factory expansion continued to swallow the communities and the surrounding natural landscapes, which resulted in the destruction of the original landscape style of the villages and the deterioration of the overall landscape quality. (Fig 9)



a Tianbian Community b Huanshan Community

c Huanqing Community d Houmao Community e Renfeng Community

Fig 9 Current Statuses of Communities in Study Site

(Source: Photographs from Baidu Street View, others self-painted)

b. Disorder development of the community and lack of public space

There are relatively few lands in different types, such as public venues, social welfare land, and kindergartens. Slow pace of retrofitting led to the lack of internal infrastructure and the inability to meet the daily needs of residents. The internal public space in the community is affected by the compact layout of the original buildings, by the small building separation, and by the lack of rational planning for the newly-built buildings. As a result, the public space within the community is squeezed and residents have less space for their activities. At present, there are two types of public space within the community, namely, the space before the ancestral hall, the former land open space, and the newly built public facilities. But a small area and little recreational facility are the problems. (Fig 10).



a Former land open space b space before the ancestral hall c Village committee space d Street style

Fig 10 Aerial view of Study Site

c. The landscape of the community cluttered in low quality, and lack of integrity

Community settlement landscape is more natural with many changes in street space. Their scale is pleasant, but the biggest problems are that the relatively narrow space and their flat style landscape. The Study Site buildings retain relatively complete ancestral halls, and its old buildings still retain the traditional style and interior features. However, due to the roughness of the later renovation and maintenance, the new building styles are not uniformed. That is to say, the form of facade is disorderly, and scale is out of control. The open space of the Study Site area is packed with area in various dimensions and forms such as the space before the ancestral hall, a square, a green space, farmland, and water channels. However, because of traffic and facilities, the public functions of the site are not prominent, and the unused space is not fully utilized. Community plant landscapes have been investigated and found to be rich in species and especially outstanding in native tree species. However, due to the lack of green space and the lack of corresponding plant designs, plant communities and their levels are monotonous, so it is lack of landscape appreciation. (Fig 11)



Fig 11 village landscape

3. Strategy for development of piedmont area in Mount Qingyuan

3.1. Protecting the ecological-agricultural area and Improving the ecological environment of the community

As a rigid boundary between the core preservation area and the three-grade preservation area of Mount Qingyuan Scenic and Historic Area, the tourist road is also a clear boundary between the ecological area and the agricultural area. The strict protection clauses of the key preservation zone ensure the ecological safety of natural secondary forest and other important historical sites. The area outside the road includes a small amount of woodland, farmland, longan orchard plots, nursery plots and the urban and rural areas.

According to the defined policy space and the land use status in the piedmont area, constructing the area's ecological security pattern based on the anti-planning theory [10] is the basic research of defining ecological protection space. In term of the characteristics of Mount Qingyuan's piedmont area, the study of ecological security pattern includes two aspects: water system and catchment corridor protection and biological habitat protection. Water system and catchment corridors protection area consists of the existing rivers and the reformed catchment corridor, which is simulated and modified on the basis of DEM elevation model, and the safety level is determined according to the different ecological functions. The analysis of biological habitat protection is studied in two aspects: vertical analysis and horizontal analysis. Vertical analysis, which can be calculated by the spatial superposition

technique of GIS to get the histogram of the suitability evaluation results, includes the analyzing of elevation, surface cover, slope and other factors to determine the habitat, distinguishing the most suitable habitat for the species, and use it as the "source" for the next step analysis [11]. Horizontal analysis is based on the law of spatial movement of focal species, and establishes resistance range to simulate the movement range to determine the ecological safety space outside the source. Ecological security pattern of piedmont area is superimposed the analysis results of water system and catchment corridor protection and biological habitat protection. The result shows that the low-level ecological safety area mainly contains the southeast side of the study area and the buffer area of the catchment corridors, canals and ponds. The mid-level ecological safety area mainly contains the orchard plot in the middle of study area. The high-level ecological safety area mainly contains the farmland, the small grass land, the orchard plot and the constructed area of some villages.



a. Analysis Result of Water System and Catchment Corridor Protection b. Analysis Result of biological habitat protection c. Analysis Result Ecological security pattern

Fig 12 Ecological Security Pattern of piedmont area

The corresponding ecological protection strategy can be made according to different levels of ecological security pattern:

1. Setting up the negative list of construction project and activity in low-level ecological security area, and strictly prohibits all construction and development activities.
2. Definiting the positive list of project types in mid-level ecological safety area, controlling the total amount of construction, guiding local residents to grow special economic crops, increasing amounts of plant species and improving species diversity.
3. In high-level ecological security area, encouraging local residents to grow trees, grass enhance the proportion of ecological area and agricultural of piedmont area.
4. Encouraging local residents in built-up area to build gardens and three-dimensional afforestation at their roof and balcony to improve the quality of residential environment.

3.2. *Shaping public space, formulating policies and guiding style recovery.*

The village streets are small and the public space, as the only open space besides the ecological and agricultural area, is the key point of the restoration of the traditional style in village. In research site, the main village public space is the temples and the ancestral halls. The temple space in the traditional settlements in Southern Fujian is the substantial carrier of the folk belief culture. As a social form, the temple sacrificial organization affects the organization and production of the settlement space by the way of the residential integration [12]. There are dozens of temples and the ancestral halls in the piedmont area of the Mount Qingyuan,

and the temples and the ancestral halls have an inseparable relationship with public spaces. The typical forms are the ancestral hall - the stage type and the ancestral hall - the square (or basketball court) type.



a.b. The Ancestral Hall - The Stage Type b. The Ancestral Hall - The Square (or basketball court) Type

Fig 13 The Typical Public Space Forms in research site

(Source: photographed by author)

The frequency of using public space by village residents is closely related to the spatial quality. Taking the public space of Tian Bian community as an example, the front square of the village committee attract many villagers due to the banyan as the center with tables and chairs. Almost no villager stays at the western stage and basketball court in the community owing to no trees and facilities. There are plenty of rain for all the year around and hot summer, which leads that residents' spontaneous activities around the fig is very common in the research area. In addition, public facilities are an important to the residents' activities. According to the different types of public space and the needs of residents' activities, it is necessary to transform public space. The corresponding strategies are as follows:

1. Planting shade trees with tree box set seats and tables and other furniture, Meeting the needs of the elderly villagers.
2. Increasing different types of sports facilities, including fitness equipment and amusement facilities to provide space for young people and children.

3. The pavement and decoration need to match the colors and symbols of traditional style in Southern Fujian.

By transforming and reshaping, the public space, as the core of the village, will take the lead in restoring the traditional style and providing more high-quality activity space.

3.3. Activating historical relics and making flexible use of historical buildings in various ways.

There are very rich natural and cultural heritages in Mount Qingyuan Scenic and Historic Area, but there are no high-level historical relics in this study area according to the resources investigation of scenic spots. However, through the site reconnaissance, there are dozens of historical buildings in Southern Fujian style as well as the temples and ancestral halls that is the center of village's public space. Due to the urbanization process, many residents migrate to the city. Residents no longer repair old houses, so that some historical buildings are in an abandoned state.



Fig 14 abandoned historical buildings

Southern Fujian culture is an important part of Chinese traditional culture, which has great influence in Taiwan and Southeast Asian countries. Mount Qingyuan, as an important natural and historical cultural heritage in China, deserves more attention to protecting the historical buildings in the piedmont area.

Historical buildings are distributed in every village of study area, establishing

flexible and diverse protection policies and promoting the operation mechanism of protection in every villager is necessary. The corresponding strategies are as follows:

1. Delineating a certain protected area according to the scale of historical buildings and the condition of the surrounding sites as a historical and cultural area.

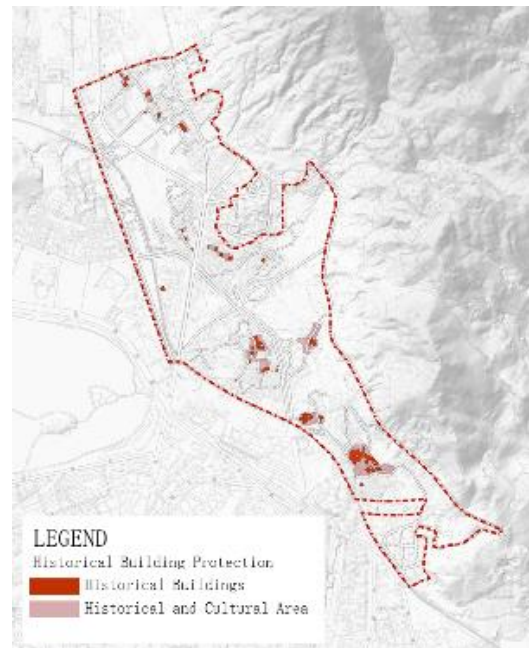


Fig 15 Historical Building and Historical and Cultural Area

2. Enterprises and individuals are encouraged to protect, renew and redevelop historical buildings and historic cultural areas under the premise of a village style guidance clause, so that operators can get long-term benefits, which can upgrade the industrial and commercial diversity of scenic area.
3. On the premise of retaining the architectural characteristics of South Fujian and not destroying the original appearance of the building, the abandoned buildings are encouraged to be rebuilt and

developed creative industries and tourism industries under the premise of a village style guidance clause, which are able to enhance location value to achieve profitability and achieve self-balance of project funds.

4. Searching for way of combining protection and development that the environment of historical buildings and cultural features can be more effectively protected and utilized, showing the artistic value of historical buildings.

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Promoting resilience, liveability and sustainability through landscape architectural design: A conceptual framework for Port Louis, Mauritius; a Small Island Developing State

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Abstract

The world is witnessing an unprecedented acceleration in climate change. Enhanced global warming is disrupting climate patterns across the world leaving Small Island Developing States (SIDS) particularly at risk. Demographic patterns are changing and there is an inexorable movement of people from rural to urban areas across all countries of the world, including SIDS. While cities are therefore becoming denser, research and literature points concludes that few are sufficiently resilient to cater with changing climate patterns; an example is Port Louis, the capital city of Mauritius in the Indian Ocean.

In last 20 years, Port Louis has witnessed flash flood episodes that have claimed human lives. While upgrading has been undertaken to Port Louis' drainage systems as a response, the city is still heavily plagued by rainwater accumulation. Other cities in SIDS have also witnessed similar drastic events, and moreover face the dilemma of how to promote sustainable development while aspiring to pro-actively enhance the future liveability of their cities. Environmentally-responsive landscape architectural design offers the promise of renewing ties between people and nature. This paper examines this scenario, and proposes a conceptual framework to promote resilience, liveability and sustainability in the city of Port Louis through design. The paper explores principles, key dimensions and drivers of landscape architectural design and how they can be integrated within the existing structure and planning framework in Port Louis. The findings of this research, presented in this paper, contribute to addressing the dearth of literature and research on this topic pertinent to Port Louis and Mauritius, offering an exemplar for resilience and liveability scaffolding in cities of SIDS. This paper also offers policymakers and stakeholders with an extra dimension to consider for future urban development planning in SIDS cities.

Keywords: Small Island Developing States; Mauritius; Liveability; Sustainability; Biourbanism; Landscape architecture

1. Introduction

The world has entered a new urban era where the planet's ecology is being significantly influenced by human activities. A core agent is cities whom cause

significant environmental impacts triggering a real need for eco-friendlier systems capable of scaffolding sustainability, liveability and resilience [1]. Although urbanization brings unique challenges, it is evidenced that other serious challenges and concerns arise. Improving the ecological

functioning and resilience of urban systems remains therefore central. As posited by Elmqvist *et al* [2], urban investments in ecosystem-based adaptation and green infrastructure can contribute positively to human and animal well-being and liveability in cities.

The city of Port Louis, the capital of Mauritius, recently witnessed flash flooding episodes and has been plagued by rainwater accumulation and ponding. This environmental pattern is increasingly commonplace in all Small Island Developing States (SIDS) [3], which are vulnerable due to their lack of preparation and logistics to deal with such situations.

SIDS were first recognized as a distinct group of developing nations at the United Nations' *Conference on Environment and Development* in June 1992 [4]. The *Barbados Programme of Action* was adopted in 1994 to assist the SIDS in their sustainable development efforts [5].

For Mauritius, enhancing sustainable development and enhancing future liveability in its cities is therefore a primary concern.



Figure 1: Location of Mauritius. Source: <http://ontheworldmap.com/mauritius/mauritius-location-on-the-indian-ocean-map.html>, accessed 1 March 2018.

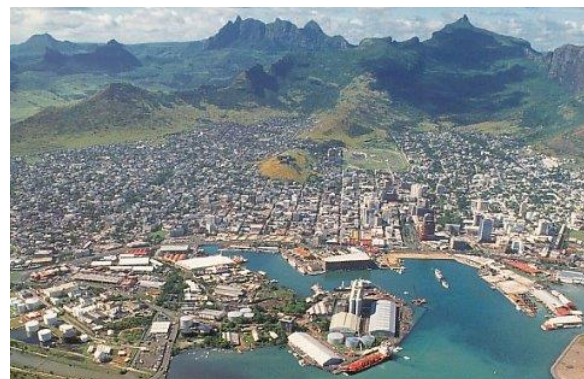


Figure 2: Port Louis, Mauritius. Source: <https://ports.co.za/portlouis.php>, accessed 1 March 2018.



Figure 3: Flooding in Port Louis, Mauritius in 2013.

Source:

<https://emmaozsen.wordpress.com/2013/04/01/482/>, accessed 1 March 2018.

Urban ecology evolved internationally in the 20th century as being a potential solution for improving sustainability and liveability in cities [6]. Authors like Steiner [7] and Ndubisi [8] have asserted that ecologically motivated landscape architecture and site design, such as the Sustainable Sites Initiative [9], is good practice.

Port Louis has attempted to respond to this theory by seeking to enhance sustainability and reduce flood concerns through contemporary design and landscape management mechanisms and initiatives. The flood episode of 2013, being one major effect of climate change experienced by Mauritius so far, demonstrated the urgent need to address sustainability, liveability and resilience nationally.

2. Background

When Mauritius was first colonised by the Dutch between 1638-1710 they established a harbour at the southern village they named ‘Grand Port’. Urban planning for Port Louis, the capital city of Mauritius was led under French colonisation from 1715-1810, and then under the British until independence in 1968. The French approach was to favour large alleyways and to maintain a lush canopy. Their designed infrastructure satisfactorily sustained the Port Louis population of around 6,779 inhabitants in 1968. However, today Port Louis accommodates a population of

155,226 being a demographic increase of 2,290%. The city witnessed this exponential increase in population without expanding its basic infrastructure services. Coupled with the effects of climate change, sandwiched between the Signaux Mountains and the Indian Ocean, this rapid urbanisation has brought forth numerous concerns in terms of city planning. Key climate change risks and impacts for Mauritius are summarised in Table 1 of which Port Louis is located in the Marine ecosystem type (as seen in Figure 5) wherein all impact factors are pertinent.

Ecosystem types	Climate change-related impacts					
	Sea level rise	Acidification	weather events	Extreme species	Invasive c pressure	Anthropogeni
Forest plantations		✓	✓	✓	✓	✓
Natural Forests			✓	✓	✓	✓
Agriculture ecosystems – Grassland			✓			✓
Agriculture ecosystems – Cropland						✓
Wetlands	✓			✓	✓	✓
Marine (fisheries, mangroves, and coral reefs)	✓	✓	✓	✓	✓	✓
Islets	✓		✓	✓	✓	✓

Table 1: The main climate change-related impacts on the main ecosystem types in Mauritius. Source: [10].

The contemporary post-independence government response to Port Louis' urban planning has been haphazard with little comprehension of the historical drain and creek system in the city and their capacity to handle the huge volume of runoff because of the major urbanisation adoption of non-porous surfaces.

With urban sprawl, there has been a rapid reduction of the French-established green areas in the city. Today it is showcased by the PORLWI Collectif that Port Louis encompasses around only 16m² of green space per capita, a figure well under the 35m² as recommended by international standards [11].

Green space loss in favour of built fabric expansion has brought forth numerous issues specific to Port Louis including:

- an increase in the urban heat island effect that is also affecting Port Louis' economic footprint [12];
- a reduction in air quality [13];
- a reduction in physical and accessible public open space; and
- a reduction in the natural rain water absorption potential contributing significantly towards flash flooding [14].

3. Resilience

With rapid urbanisation in Mauritius, urbanization has amplified the sealing of the drainage basins and conventional engineering work in river valleys (eg. riverbed straightening and narrowing) there increasing the threat of urban floods throughout Mauritius [15], as seen in Figure

4. Port Louis particularly experienced this situation in 2013, as seen in Figure 3. The 21st century has witnessed augmented flood threats due to global climate change with intensified urbanization and extreme weather events [15]. Majewski [16] has argued that extreme meteorological and hydrological events are increasing in frequency. However, the manner in which cities and towns have planned, used and developed land is also another cause exposing populations to coastal and river flood risks.

The European Union Floods Directive (2009), introduced alongside a requirement of integrating flood risk management and hence the coexistence with water, is one of the preferred approaches. Some of these measures include the implementation of:

- flood protection efforts;
- sustainable rainwater harvest approaches; and
- application of underground and surface water management in drainage basins.

Majewski [16] has claimed that other measures should include:

- warning systems and hydrological and meteorological prediction;
- educating how to decrease risk of property damage in flood-prone areas; and,
- evacuation and protection plans.

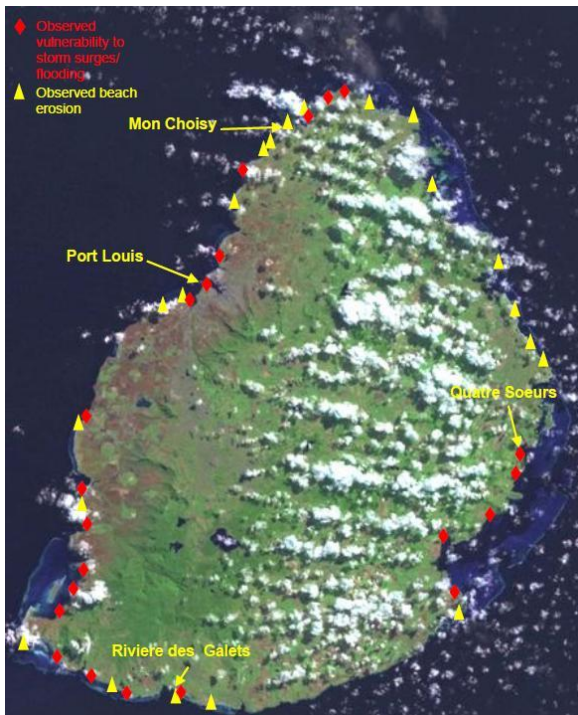


Figure 4: Mauritius observed vulnerability to flooding and beach erosion. Source: United Nations Development Programme - Mauritius (UNDP Mauritius), <https://www.preventionweb.net/english/professional/maps/v.php?id=32259>, accessed 1 March 2018.

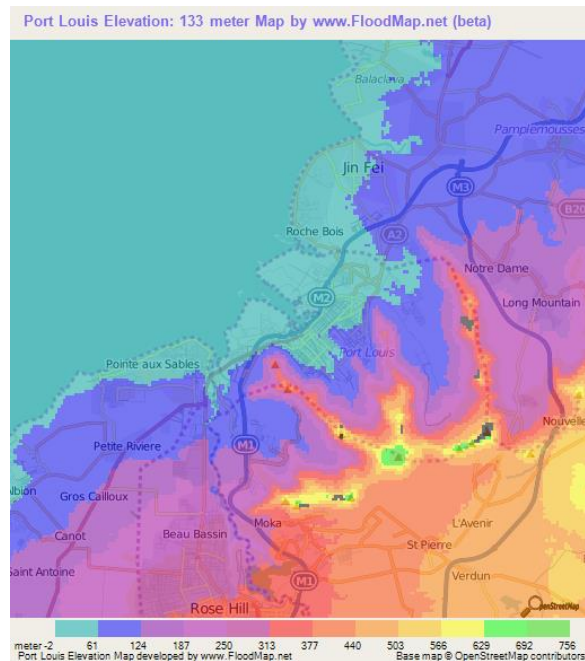


Figure 5: Elevation of Port Louis, Mauritius, by [www.FloodMap.net](http://www.floodmap.net). Source: <http://www.floodmap.net/Elevation/ElevationMap/?gi=934154>, accessed 1 March 2018.

4. Liveability

The separation of city and nature was previously a predominant characteristic of urban architectural designs [17]. This philosophical approach is hazardous and costly because it disregards a city’s natural processes and separates human living from nature. Allam [14] and Grant et al [18] argue that the more the disconnected humans are from nature the more individuals do not understand the link between healthy cities and healthy ecosystems. Today, it is acknowledged by scholars that landscapes associated with infrastructure and buildings can accommodate multi-functional layers of vegetation and soil controlling surface water, providing wildlife habitat and food,

and keeping the city cool as contrast to its long-perceived ornamental and Gardenesque values [18]. Grant [18] further argues for the need for panoramic, trans-disciplinary thinking and co-ordinated action to enable a grey-to-green transformation of cities, to enhance the liveability of these places to its citizens.

Numerous researchers are increasingly trialling new methods to analyse cities to assess and measure their liveability [19]. However, it remains difficult to define ‘liveability’. While some researchers’ claim that liveability is tied intrinsically to physical amenities such as green space and parks, others supports its connectivity to economic dynamism, career opportunities, cultural offerings and human safety for a family to co-habitat in. However, the most important conclusion is that liveability is connected to infrastructure and sustainability issues [19].

The decision of forming a balanced relationship between the city and nature is crucial.

5. Sustainability and Maintainable Solutions

Because of the larger flood threats in the European Union, the member states have responded in implementing strategic programs and such should also be the case in

Port Louis. For instance, the programs of Making Space for Water (2005) in the United Kingdom, and Room for the Rivers (2006) in The Netherlands, seek to increase river valley retention capacity as well as improving drainage basins together with enhanced co-ordination of spatial planning and flood protection. These strategies emphasise integrating sustainable water management and urban planning in areas far from simply the riverbanks (improved rainwater retention for decreasing flood threats) and urban waterfront zones (which offers direct protection from floods).

Three primary trends currently dominate management of urban waterside areas which include [20]: riverbank urbanization and urban revitalization of downtown waterside areas; sustainable land management allowing enhanced retention capacity and using construction forms which adapt to changing water levels; and, environmental revitalization of river valleys.

Table 2 offers a synthesis of key ecological design strategies that could be applied in Port Louis to better negate climate change risks and threats as well as increasing the urban liveability and built environment quality of this rapidly growing urban landscape.

Principle	Aspects
Climate and context	City’s climate conditions, density, landscape, available resources
Renewable energy	Development of renewable energy source, energy efficiency planning, cogeneration, intelligent building management
Zero-waste	Reduce, reuse, recycle
Water	Reduce consumption, efficiency of use, water quality, underground

	water catchment area, storm water retention and flood management, rainwater harvesting, local treatment of waste-water, integrated urban water cycle planning, water management during drought
Landscape and urban biodiversity	Local biodiversity, wildlife rehabilitation, forest conservation, urban vegetation, inner city gardens and urban agriculture to counteract UHI effect, tree planting, restoring stream and river banks, de-pavements and rehabilitation of canals
Sustainable transport and good public space	Easy access to green public transport, promotion of bicycle use and safe bicycle alleys ways, smart vehicles, walkable city
Density and retrofitting	Densification of the city, retrofitting inefficient building, better land use planning, public space upgrading
Passive design for buildings and districts	Low energy, zero-emission design, reduce energy use, compact solar architecture, bioclimatic architecture, solar architecture, energy generating buildings
Liveability and mixed use	Affordable housing, healthy community, social inclusion, flexible housing typologies, diversity, integrating a diversity of economic and cultural activities,
Local food and short supply chains	Local food production, regional supply, urban farming and agriculture, allotment gardens, roof gardens, urban market garden, paper bags, recycling
Identity and sense of place	Public health, cultural identity, urban heritage, air quality, grassroots strategies, creativity of government and citizens, health, activities and safety
Urban governance and leadership	Evolutionary and adaptive policies, participative decision making, and responsibility shared with empowered citizenry, enabling citizens, updating building codes, improve planning, legislating controls on density and urban sprawl, certify urban development projects
Education, research and knowledge	Knowledge and capacity development, scholarships for areas relating to sustainable urban development
Resilience	Provide for free first aid courses, training for support team to the fire brigade, communicate all emergency measures to the citizens and carry city wide rehearsals on exceptional situations

Table 2: Key Ecological Design strategies pertinent for Port Louis, Mauritius. Source: adapted by the authors from [21].

5.1 Planning guidelines and regulations in Port Louis

While there are numerous documents outlining parameters for urban development in Port Louis, the enforcement of guidelines remains a local challenge. The contradictory nature, or difficulty of clear interpretation,

of planning codes across various planning documents further accentuates this issue.

This creates a leeway for haphazard development, and provides opportunities for developers to maximise their land use for increased economic profitability while disregarding the development's impact on

their immediate surrounding. Allam [22] confirms that there is a mismatch between planning documents and the demographic boom of 330% in the last century.

The confusing guidelines coupled with a lack of guidelines enforcement has enabled approval of various projects that contributed to the flash floods of March 2013; namely the construction of buildings on classified rivers and streams; the KFC building, Air Mauritius Parking, Rogers Parking, Garden Tower and Hawkers Palace [23]. Those developments however do not abide by the Mauritian *Forests and Rivers Act 1984* river buffer requirements [24]. Figure 6 illustrates development along the Ruisseau du Pouce Stream where the capacity of drains has been reduced.



Figure 6: The Hawkers Palace at Ruisseau du Rouce. Photo by author (Allam, 2018)

6. Landscape Architecture and Ecosystem Functions

Five principles of ecosystem functions include recognition that: urban areas or cities are ecosystems; cities or urban areas

are heterogeneous; cities or urban areas are dynamic; cities or urban area biophysical and human components interact; and, biophysical processes are crucial in them [25].

The first principle provides the basic theory of contemporary urban ecology. It indicates what needs to be included for explicitly addressing urban systems. The urban ecosystem concept embraces the deepest urbanization levels and the addresses the function and structure of exurban fringe [25]. The other principles relate to the specific implications of the first principle. Hence, the first principle has been discussed in this paper.

6.1 Cities are Ecosystems

Cities and urban areas are ecosystems as they have interacting physical and biological complexes. Therefore, one should not consider that ecosystems are stringently homeostatic, self-maintaining and fundamentally closed entities [26]. These assumptions are not invoked by the definition of core ecosystem. In simple terms, an ecosystem relates to the interaction between a physical complex and a biotic complex [27]. This definition remains the core motivating contemporary research and application by Jax [28].

Cities contain organisms, people and light, water, soil, air and physical regulators as day length and temperature. Biotic complex are also present in cities which have complex social structures [29] and these include institutions [7]. Machlis et al. [30] claim that the sumptuousness of social interactions and structures are the heart of

the inclusive conception which they refer to as the ‘human ecosystem framework’. In the same vein, a cities’ physical complex is not only made up of native soils and substrates and existing or emerging non-managed animal populations and vegetation, but contains covered or highly modified soils, introduced or maintained vegetation, paved surfaces, utility infrastructure, roads and buildings as well. Hence, in contrast to agricultural or wild ecosystems, the urban ecosystem has additional complexities [31].

The precise scenery of the novel structures contributing to the biotic and physical complexes in a city may be perceived as conservatories to the concept of basic ecosystem [27], rather than violations to the definition [32]. Because urban ecosystems comprise new human artefacts such as infrastructure and buildings and new land forms, an additional complexity layer is emphasised as the ‘built’ component. Therefore, cities are human ecosystems with built, physical, social and biotic components that interact with one another ([33; 34]. Any spatial arena containing interacting biotic and physical complexes is an ecosystem. In addition, smaller ecosystems may be found in larger ecosystems and this remains important in the application of ecological insights in landscape design [7].

6.2 Implications for Ecological Design

The interactions of the built environment, social structures, physical conditions and setting and organisations happen through information flows, organisms, energy and matter [25].

Van der Ryn and Cowan [35] define ecological design as ‘any form of design which reduces the environmentally destructive impacts by integrating itself with living processes’. It assists in connecting the scattered efforts in ecological restoration, ecological engineering, sustainable agriculture and green architecture and other fields. Urban design, technologies, buildings, transportation system and land uses are some of the reasons that give rise to ecological problems. Ecological design should be able to understand patterns which connect to nature and hence it remains important to work outside mainstream disciplines for seeing matters in larger contexts. Landscape architects need to foster integration between urban ecosystems and designs to save scarce resources for future generations [2].

Malaysian architect Ken Yeang [36], argues that there is a need to: apply ecomimesis being designing by imitating ecosystems; include environmental bio-integration; imitate the functions, structure, and processes of nature as in their ecosystem; not misled by technology; not assuming that if a building yields a high rating in green-system rating it is successful; and, recognizing that ecosystems contain both abiotic and biotic constituents acting in the biosphere.

These principles help in creating a sustainable city by reducing waste, creating healthy social relationships, decreasing noise pollution, increasing accessible open green spaces, enabling healthy and greener buildings, decreasing indoor and outdoor pollution, ensuring fewer toxic

transmissions, and increasing energy efficiency [36].

7. Potential Solutions

7.1 *Urbanization of riverbanks and urban revitalization*

The main argument for revitalization was that areas had become a barrier separating cities and towns (humans) from water spaces as well as negating visual and emotional access to rivers in providing breathing space in swarming cities. Januchta-Szostak [37] have highlighted that successful revitalization projects in port districts demonstrate the social and landscape potential of riverside regions. The primary aim of urban waterfront transformation was to reintegrate riverbanks with the urban fabric (with respect to their function and composition) and scaffolding investment zones with outstanding landscape attributes. The sudden rise and interest in waterside parks, squares and boulevards being a showcase for cities and towns prompted a need to invest in active flood protection systems in profoundly built-up downtown zones that could be turned into attractive areas for residential and recreational integration, such as London's Thames Barrier Park [30].

7.2 *Construction attuned with the changing water levels*

The necessitation of new types of flood-proof land management and construction techniques and practices to allow infiltration of flood water has been acknowledged as enabling the need for ensuring space for increasing flood water and inevitable expansion of cities [38]. There is a need to

establish safe evacuation routes while considering the dynamics of rising waters. In addition, the need for quality zoning to enable adaptation to the rising water and intensity and direction of flood water flow based on planning of flood risk maps that would simultaneously allow shaping landscape architectural designs closely with water [20]

Pilot projects, such as in Littlehampton and Peterborough in the UK, demonstrate innovative rainwater management systems in urban areas enabling flood protection as part of Long-Term Initiatives for Flood-risk Environments (LIFE) initiatives [38]. In these cases, flood risk maps were the foundation for new urbanized shaping approaches enabling periodic floods mitigating and acceptance of the need to enable natural environmental processes and engineering.

7.3 *Urban rainwater management*

The key to preventing urban floods is to reduce surface runoff since its volume increases considerably when large urban surface areas are sealed. The USA and several EU member states have recommended adoption of the Sustainable Urban Drainage Systems (SUDS) that mimics environmental processes that occur naturally including infiltration, detention and retention [39]. These Systems help to decrease pollution levels and rainwater runoff from the urbanized zones.

Rainwater management in SUDS may be classified into 3 stages [20]: collecting and transporting water; water distribution and retention for reuse; and, evaporation and

infiltration. SUDS stages stress the purification of rainwater runoff via natural properties of the vegetation and ground. Thus, water needs to be clean in any composition so as to be socially and visually attractive [20]. Therefore, there is no need to conceal purification processes from the public. Moreover, the water-plant ecosystem serves as a recreational purpose and help in ecological education of the inhabitants [40].

7.4 Recommendations to local planning guidelines

Based on the review of current guidelines and regulations in Mauritius, it is noticed that guidelines are outdated, and addendums do not cater for environmental impacts of climate change. For example, the *Design Guidance Policy*, part of the *Mauritius Planning Policy Guidance 1* [41], is more than 14 years old. It is also recommended that guidelines are designed in a more contextual fashion for both Urban and Rural areas. The *Planning Policy Guidelines 6* [42], does this well by imposing strong regulations on Heritage. This needs to be expanded outlining desired activities, development and regulations at street block level. Further, there is the strong need for enforcement of urban guidelines and regulations. Numerous bodies across various Mauritius ministries currently issue clearances, which work in conflict from each other. There is a need for a centralized committee at municipal level for the review of all developments prior to the issuance of development permits at municipal level.

8 Conclusion

This papers explored sustainability and liveability through the five principles of the ecosystem. The first principle which showcased urban areas as ecosystems and the implications for ecological design were emphasized. This was particularly important for Mauritius, as being part of the SIDS which hosts a unique fragile ecosystem.

The need for a resilient fabric was emphasized due to the local challenges of Port Louis through the advent of climate change; and its impacts on weather patterns. The issue of flash floods which impacts on both economy and society were discussed and solutions were offered that tallies with ecological and sustainable methodologies.

Urban planning policies and guidelines relating to Port Louis was reviewed and recommendations were made to decrease the risk of flash floods. It was further argued that urban ‘green and blue infrastructure’ could play a fundamental role in enhancing the adaptive capacity of coping with climate change [2].

Altogether, the proposed recommendations are aimed to ensure that appropriate policy anchors into governance and practice to ensure urban densification to prevent urban sprawl; conserve and enhance nature; ensure proper planning for climate change mitigation; and, support a more efficient policy for urban disaster management.

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LOW (TECH) ISN'T SMART ?...

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Abstract

Is it possible to envision the city today without sustainable development?

In Western Europe, we put a large part of our energy in the protection of resources in order to reduce the effect of climate change, especially the extreme heat in the city centers, and to develop resilient cities in the face of natural disasters. We also work hard on social development and on generating melting pots between generations and origins. With these goals in mind, we, as landscape architects, with our large scale projects, are part of the solution. But, as nature has proven, large impacts on our environment often come from the sum of a large number of little simple changes. Nature provides 'low tech' answers, so, what can we learn from it? Fighting high level summer temperatures in our living spaces today is simple with smart *technological* solutions. But, it is just as simple and efficient with low tech *natural* solutions, like storm water management, evapotranspiration, wind use? These solutions represent no energy costs. And they are reliable, even during a large power failure, this type of design continuing to function no matter the circumstances. Scientific experimentation in Lyon, France (but also elsewhere), has already proven that a planted street (trees and bushes) is 4° Celsius cooler than a mineral street nearby.

In each project, we have to choose between the use of "pre-invented" industrial solutions, often with a high need of technical maintenance, or the use of locally adapted solutions, needing little maintenance, except observation, cleaning and gardening. In order to answer the city's needs and be as efficient as industrial products, we must dedicate more time to designing our public spaces, adapting solutions and designs to the spaces being refurbished. Using these "natural" solutions will change the face of our cities, the atmospheres, the social networks, as well as the way we organize / share work. We will need more and more 'city gardeners'. These new 'gardeners' could be local citizens, just as they could be members of the city's extended garden department. In any case, more 'gardeners' also mean more social exchange and more social appropriation of public spaces.

This thinking is illustrated in projects developed in the Lyon suburbs, where a number of projects are being renovated. The refurbishment of large settlements from the seventies (associated with social housing) in the North of Lyon, integrates as basic design requirements, green infrastructure, storm water management and biodiversity strategies, wind orientation studies, as well as a structural analysis and thermal scan of all existing buildings. This doesn't forego the economic or the mobility analysis of the project. In another neighborhood, East of

Lyon, raingardens and green spaces colonize the city center further preparing the area to climate change.

The question is not to confront a smart life for smart cities, with a 'slow' and simple life for sustainable human installations, but just to choose the best solution for each situation.

Keywords: climate change, low tech design, storm water management, green infrastructure, city gardeners, Lyon

1. Introduction

The projects presented hereafter, all of which are located in the Lyon suburbs (France), stem from the will to first and foremost review the urban, as well as the social organization, planning and design of a commonly found constructive typology in France: the 'grands ensembles'. These 'grands ensembles', projects developed mainly in the 60's and 70's, are large scale social housing projects that were spread over entire sections of unused or abandoned city areas, outside main city centers.

Today, they have become matrices for an urban and social renewal, accompanied by a strong drive for inner city landscaping, that take into account future global warming questions and rainwater management. In the last years, these 'grands ensembles' have met with a large increase in their population (due to higher demography, real estate speculation, etc.). But most thankfully, they also benefited from the existence of 'vacant' spaces, yet to be constructed.

The original urban configuration of these 'grands ensembles' is precisely what can be used today to adapt new urban refurbishment, reconciling natural space and density demands, automotive and soft traffic infrastructure, social and residential housing. This reconciliation of interests and functions is mainly possible through the introduction of a mixed typology of spaces. For example, streets and avenues invariably integrate trees, rainwater gardens or ditches as well as

melliferous plants, where there were none, or new urban constructions are built with the obligation to integrate central and permeable planted patches or even green roofs.

A part (more or less important, each according to individual city's political policies) of these newly created public spaces are today submitted, in France, to public consultation and are followed either by local residential action (public space management taken over by actual residents or future newcomers), by educational team management from surrounding schools, by the use and handling of spaces for non-profit associations or even artists within the scope of a biennale or other artistic manifestation. For these reasons, these spaces must remain, despite having to be of easy upkeep, a source of collective well-being and of sharing (sharing stories, experiences, uses and functions, even production (allotments for vegetable or fruit growing), etc.).

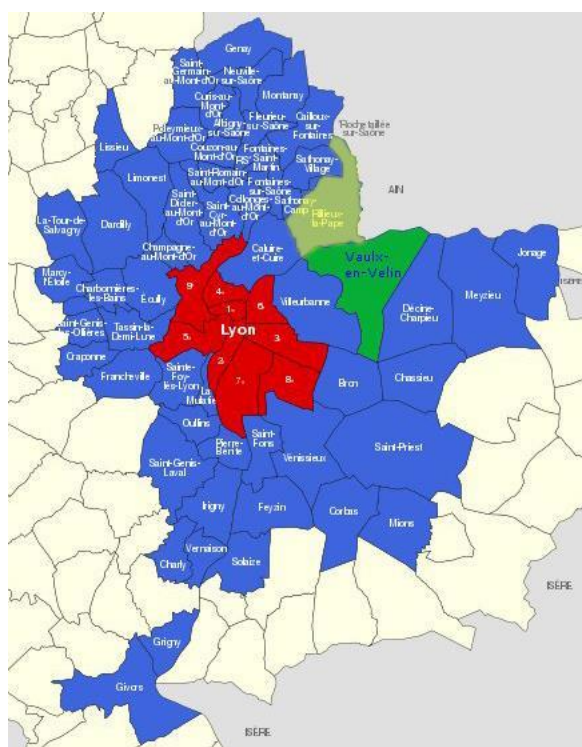
The following examples illustrate the history of the evolution/transformation of existing 'grands ensembles' neighborhoods, through the implementation of major green infrastructures, mostly (but not always) managed by local authorities but always adapted to each context, each area (streets, avenues, parks, central green spaces, fruit and vegetable patches, etc.).

These major transformations are made possible by the French Agence Nationale pour la Rénovation Urbaine (ANRU), a national public aid and subsidy program to

help various cities deal with the renovation of whole sectors of their inner cities.

Shared wisdom (*sensus communis*): term initially used by the Romans, meaning humanity and sensibility as well as common sense. Indeed, wisdom can be translated as the common sense of the common folk. It is the wisdom born from immediate and practical knowledge. This is a common and collective cultural heritage. Our work in Vaulx-en-Velin and Rillieux-la-Pape, suburban residential cities, Northeast of Lyon (the Greater Lyon conurbation accounting for around 1.5 million habitants) aims to reclaim this notion of “shared wisdom”.

Fig 1 - The 55 municipalities of the Greater Lyon area. In green, city of Vaulx-en-Velin. In yellow, city of Rillieux-la-Pape.



2. VAULX-EN-VELIN _ THE EVOLUTION / TRANSFORMATION OF DIFFERENT CITY NEIGHBORHOODS USING SHARED PUBLIC SPACES

Since the 1960's, Vaulx-en-Velin has been expanding from an old rural community to a residential suburb complete with working factories. Pressed by the urgency of housing shortages, the 60's urban planners applied rather typical mainstream theories to all of France's developing territories, unfortunately, regardless of context, cultural or historical preoccupations. This period saw the introduction of “platform” urban planning, consisting mainly of social housing, surrounded by large empty “green spaces” built on old orchards, farmlands and wetlands. Today's designers and planners are most likely to search for all remaining traces of this past, both historical and social, in order to elaborate the city's new urban landscape. The goal being to reintroduce and reinterpret different aspects of the old landscape through new public spaces but with a shared vocabulary (orchards,

vegetable patches, meadows, rain gardens, etc.)

Three examples successfully demonstrate this process within the city, a city which has grown from 21 000 habitants to more than 47 000 habitants since the end of the 1960's.

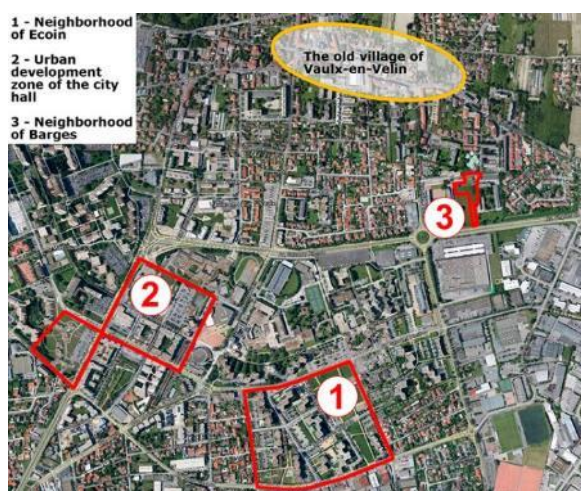


Fig 2 – The location of 3 urban renewal projects in Vaulx-en-Velin

2.1 The Ecoin Neighborhood (2001–2009) – 10 ha. Project management: Latitude Nord landscape architects, Atelier sur les Quais architects, Cap Vert engineers.

This neighborhood's refurbishment included the design and construction of new streets, squares and urban parks, as well as parking lot reconstructions, the creation of communal gardens and the arrival of new shared common spaces, etc.

The project's renewal was based, throughout, on a strong partnership between the different territorial protagonists.



Fig 3 – The building of a garden shed in the Ecoin neighborhood communal gardens

Two squares in the heart of this neighborhood (each of 3 000 and 1 600m²) now offer new public spaces devoted to conviviality as well as allow for the planning of community events and activities.

A new urban park now provides multiple answers to space sharing: children's playgrounds, mini sporting grounds, specific theme gardens, multiple use large green spaces, and more intimate green spaces, etc.

The non-profit association "Vaulx Jardins" manages garden allotments that remain at the inhabitants' disposal through a 'Management Service Agreement' signed with the Vaulx-en-Velin local authorities.

The association considers these garden allotments as community meeting places and relaxation areas with the primary aim of respecting all users and the environment.

Using agro-biological gardening methods, the residents participate in the embellishment of their own living environment contributing to their neighborhood's newfound identity.

The association informs and educates local gardeners, and at times, the public, on all types of natural techniques enabling the development of many cultural and educational activities for all ages.



Fig 4 – The Ecoin neighborhood community gardens, their sheds, their water barrels and their vegetable gardens.

2.2 The City Hall Urban Development Zone (2010–2022) – 11 ha

Project management: Marc Pelosse architect, Eranthis landscape architect, François Gschwind lighting specialist, Sitétudes engineers.

To answer growing concerns in the fast growing environments of our cities, France, as early as 1970, put in place new urban legislation allowing for large zones to be developed with public or private funds (or both) for the betterment and the renewal of all city territory. Still largely the model in use in today's public urban planning, Vaulx-en-Velin's City Hall sector is but another example of the implementation of an Urban Development Zone.

Began in 2010, the project consists mainly of green infrastructures and rain gardens (small and large units, as well as large units with overflow outlets), using permeable materials (evergreen pavement for parking spaces, water treating rainwater gardens, etc.).

Novelty of the project: most of the underground water treatment is made through the tree substrate.

Early on, in researching the future design for this new zone, it was found that existing plants growing on the nearby riverbanks had an inherent capacity to support droughts as well as floods. These plants were capable of surviving in polluted environments by means of a rainwater filtration process. It became obvious that this knowledge would mold the future neighborhood's landscape and the plant order within the project. The plant selection was then based on the physical properties of the substrate and the plants' root filtration capabilities.

Plant nurseries and universities were associated with one another. Piezometers (instruments needed in the fine water pressure measures) and probes were installed at the same time as the vegetation was planted. The aim of these water pressure surveys was, and are still today, to study the water cleaning results of the plant species as well as their growth.

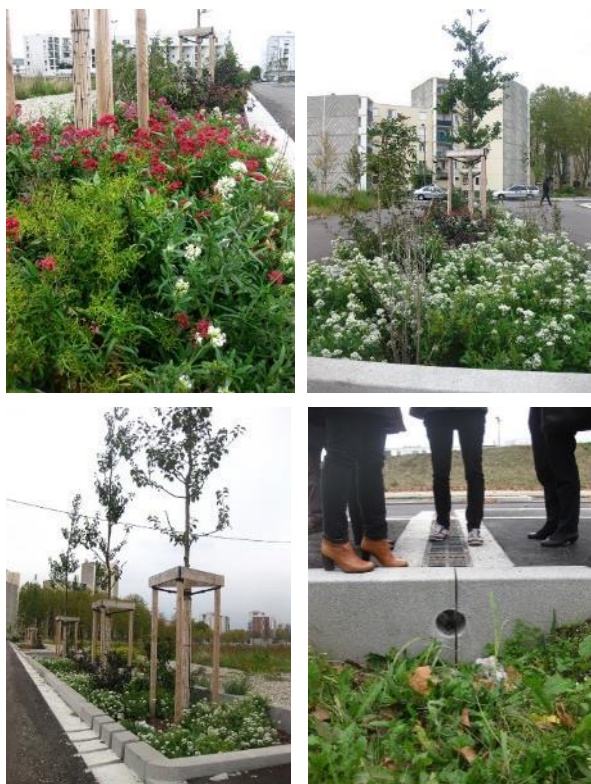


Fig 5 – Blooming rain garden plants



Fig 6 – The rainwater management of all local streets in the urban zone is exclusively alternative via rain gardens or ditches. This sector’s construction ended in 2015.

2.3 The Barges neighborhood (2011–2017) – 0,5 ha. Project management: Eranthis landscape architects, Sitétudes engineers.

Not far from the City Hall Urban Development Zone, stands another renewal project, the Barges neighborhood. This project stands among other smaller projects in the city with similar ambitions: these are ‘warn out’ areas that have outgrown their initial functions and need to open up again to new urban populations and uses.

As often in occupied areas, the Barges renewal project was the object of a public inquiry and dialog sessions with the local residents early on.

Adjoining the newly designed public spaces, a center for Youth and Sport activities secured a certain amount of use for these new public spaces, located far from the more

urban city center. The sports center's users and the local residents were at the heart of all concerns while designing the project.

The desire to densify our urban areas for sustainable development purposes need not only touch large agglomerations. When opening up a neighborhood such as the Barges, it must be associated to concrete development projects that reinforce the initial political will to create new functions and uses in these areas. Timid as they may be at first, these development projects, whether housing or public facilities, need to be backed. This was the case with a neighboring lot construction. An auto-building project, for residential use, was introduced in the Barges urban landscape, built by the 'Chamarel' association, a group of retired seniors searching to live in a shared coop building with shared principles. Among these principles, one finds certain common needs:

- **Cooperation:** Collective and regulated management of all aspects of the project, and later, the living spaces.
- **Ecology:** Construction and operating rules in compliance with sustainable development norms.
- **Civic rights:** Open living spaces, available to all groups, in keeping with the pursuit of a locally active lifestyle (associative, cultural, etc.)
- **Respect of individual lifestyles:** Controlled relationships between private life and collective life in respect with secularism.

As for the vegetation choices, the plants here are reminders of Vaulx-en-Velin's past involved in fruit and vegetable farming, and are at the heart of the project. A drawn shape upon the square's new concrete surfaces represents a huge thistle to remind the inhabitants of their city's past. This floral motif is reused in the street furniture.



Fig 7 – Corten steel screens engraved with the thistle motif



Fig 8 – Rainwater garden

This project aimed to implement specific plant species to allow the development of biodiversity. The introduction of bird houses also contributed to reclaiming biodiversity. The general maintenance of the project is incumbent upon the city but the nearby activity center also plays a role.

The reintroduction of a small tree-filled grove (representing the historical forest of this site), of rain gardens and swales, planted for rainwater management purposes and made up of permeable materials (evergreen pavement for parking), and plants like native tree species and blossoming hedges of mixed varieties, recall a rural image for the new square.



Fig 9 – Mini sporting ground in the foreground, and in the foreground, the

Chamarel auto-building project under construction



Fig 10 – Planted street with permeable surfaced parking. End of project construction: 2015

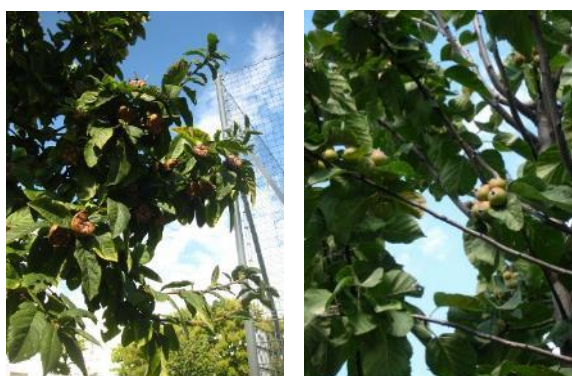


Fig 11 – Planted fruit tree varieties: meddler tree, apple tree

3. RILLIEUX-LA-PAPE – THROUGH A NATIONAL URBAN RENEWAL PROGRAM, GREAT UNIFYING GREEN INFRASTRUCTURES

The New City of Rillieux-la-Pape, built in 1960, is today one of many registered municipalities in France’s national Urban Renewal Plan, a plan which includes numerous housing rehabilitations but also

demolitions and future constructions. The establishing of this sort of territorial Urban Renewal Plan allows cities to rethink the ‘grands ensembles’ neighborhoods and their city’s own framework in general, most notably through the prism of the city’s urban nature.

At the same time, Rillieux also wishes to develop an Eco District Label within this program, as well as a Cit’ergie Label (the Cit’ergie Label being the implementation of certain measures destined to municipalities that are willing to continually improve their policies concerning sustainable energy consistent with ambitious climate targets).

Two examples to illustrate the evolution/transformation of a city, having gone from 10 000 residents to more than 30 000 residents since the late 1960’s:

**3.1 The Linear Park (2016-2022) – 10,5 ha.
 Project management: Eranthis landscape architects, Notus architects and scenographers.**

The city of Rillieux-la-Pape is stretched over many different districts that, with time, have stopped being connected. It is especially the case with its New City district, a ‘grand ensemble’ neighborhood dating back to the 60’s and 70’s, concentrating within its territory most of the city’s population. Rillieux suffers today from these divisions among its neighborhoods, whether they be physical or social. An Urban Renewal Project such as this one, with the help of public funding from state or local government, offers new opportunities for this city to face its two major challenges: the

renewal of ties between the different districts and the transformation of an old city into a new sustainable one, that will counter urban heat islands, reintroduce urban biodiversity and work to better its public spaces.



Fig 12 – City of Rillieux-la-Pape: a green belt to surround the city’s differences in altitude – a New City district constructed halfway between a natural balm and farmlands



Fig 13 – City of Rillieux-la-Pape: Local Urban Masterplan – In red, the former reserved area for a future roadway



Fig 14 – The location for the future Linear Park

The basis for the ‘Coulée Verte’ or Linear Park : a reserved area indicated in the city’s local urban masterplan, devoted to become a future roadway stretching from East to West.

An urban study, covering the entire city of Rillieux-la-Pape in 2014 (Study team: Eranthis/Notus), and the Urban Renewal Project, under way since 2008 (and prolonged for the another 15 years), concluded with the suggestion to overlap a new green infrastructure framework atop the city’s actual urban frame, the main component, at the heart of it all, being a large ‘Coulée Verte’. This ‘Coulée Verte’ was renamed the Linear Park: a large park

that would cross the city from East to West, using the image of a flowing river with areas expanding into varied spaces for different uses.

The park was thus conceived to become a grand unifying space. It offers on one hand a large scale meeting space for residents, and on the other, playing areas, sporting areas, and easy access kitchen gardens.

It is the foremost component of the new green space policy, mixing green infrastructure, natural green spaces and/or nearby proximity spaces. If these green spaces’ main mandate is to cater to leisure or recreational activities, they also serve as a biodiversity reserve or even a fruit and vegetable garden.

Non-motorized transportation options are reinforced: a bicycle path, today partially existent, is completed and redrawn across the southern stretch of the park (1,4 km), while a pedestrian walkway is entirely created across the northern stretch of the park (1,3 km).

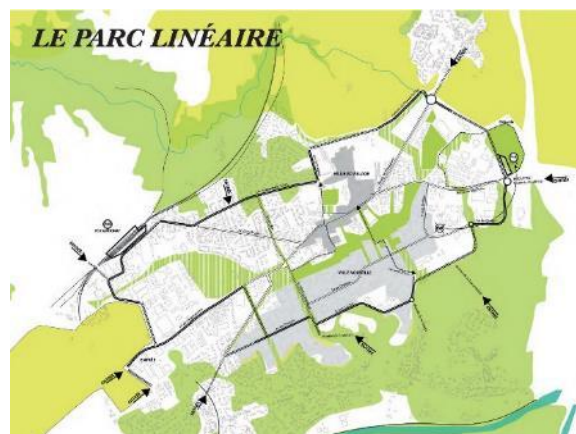


Fig 15 – General urban study for the City of Rillieux – plan established in 2014

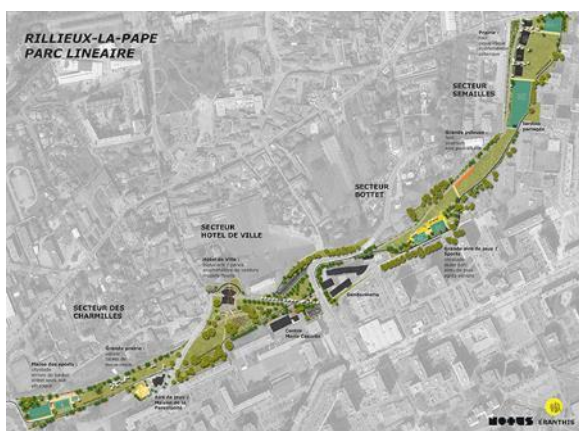


Fig 16 – General key plan for the Linear Park

The park’s first steps in its construction in 2017 coincided that year with the Lyon Contemporary Art Biennale. As a marker for its debut and a way to involve residents beforehand, a local artist was able to take temporarily over parts of the park, his intervention consisting mainly in planting Damas rose bushes.

The idea was that at a further date he would be able to produce and collect the rose water once the rose bushes would attain a certain maturity. It is through a residents’ association, in charge of pruning and caring for these bushes that his work goes on each participant already invested in the park’s future.

These new ‘city gardeners’ are very much the different neighborhood’s habitants. They meet regularly around a common activity: the caring of the rose bushes.



Fig 17 – The planting of rose bushes, as part of the contemporary art biennale in 2017

On the park itself, specific actions were sought in order to recover cooler air in the city, to reinforce urban biodiversity, to manage rain water and to federate citizens’ gatherings, at little cost.

This concerns:

- the peeling off of existing ground top surfaces made of a bituminous mix (parking areas, streets, access roads, etc.) to replace them with grass covered zones, bush and perennial areas, trees, a bicycle path, etc.
- the planting of an additional 250 trees (to add to the 150 existing

trees), a great variety in plantation species (30 different in all), some flower varieties, some fruit varieties, to attract, as much as possible, birds and bees.

- the introduction of sporting plains, playgrounds, community barbecues, green amphitheatres and natural solariums
- the expansion of existing kitchen gardens (a total of 2 500m²) to unify collective sharing actions, to ensure the caring by the habitants of public spaces, etc.
-



Fig 18 and 19 – Phase 1 of construction on the Park: a before shot (2017: a parking area with asphalt surfaces) and an after shot (2018: a prolonged tree filled park with secured bicycle path)



Fig 20 et 21 – Phase 2 of construction on the Park: a before shot (2017: an abandoned bike park and path) and an after shot (2019: a new sporting plain, large grassy areas with community barbecues, an exterior bowling track and a secured bicycle path)

3.2 The Alagniers neighborhood (2014-2030) –40 ha.

Project management: Eranthis landscape architects, Notus and JASP architects and city planners.

Developing green and blue infrastructures, searching for civic participation.

In 2014, the newly voted in municipal team wished to hold a holistic discussion at a communal scale particularly concerning its green framework. It was on this notion, the green framework, that their territorial project was based upon, putting forth the landscape as founding principle, a transformation instrument for spaces and practices, a levy to change the city ‘s New City image.

The Urban Renewal Project searches to put forward natural and recreational environments forging ahead on the existing green framework in order to develop a true network of theme related parks (urban, natural, agricultural, sporting, recreational, etc.) with one logic in mind: a structural human flow for the municipality’s identity and its economic development.

The city’s changing image and the social and urban diversity

The Alagniers neighborhood is the oldest part of the New City District. It suffers from a negative image due mainly to its poor architectural development (dilapidation, strong morphology issues, etc.), to its increasing impoverishment and to its absence of social diversity. When coming from Lyon, it is the gateway to Rillieux. In this geographical context, the renewal program is a benediction for any image changing initiative.

The river and its ‘affluents’ / the structural nature

The Alagniers neighborhood is restructured around three North/South ‘green affluents’ (the ‘river’ being the earlier cited Linear Park, chap. 3.1), and constitutes the first foundation in the implementation of new functions and uses.



Fig 22 – The new city scaled green frame...



Fig 23 – And at the Alagniers neighborhood’s scale...

These affluents constitute a certain continuity between the city’s natural balms and the Linear Park. They insert themselves, and actively participate, in the new green transportation plan: bus, bicycles, etc.

They allow for a better enhancement of area buildings and main public facilities in the urban landscape (newly renovated existing tower, etc.).



Fig 24 – The green ‘affluents’ that irrigate the Alagniers neighborhood

Civic participation from local residents to deploy Urban Renewal Projects, to set up urban experimentation zones.

The city’s political project team put in place an intervention methodology adapted to each type of project and to the desired degree of participation.

They applied for each sector:

- ‘walking’ general diagnosis and exploratory walks to account for daily management and environment needs
- street level publics consultations in front of buildings, or door to door consulting, to gain information on uses (questionnaires concerning public recreational facilities for example)

- resident workshops (exchange times, brainstorming and debates)
- residents’ association brainstorming workshop (work done on collective memories, change adaptation, etc.)
- other urban renewal project visits and an exchange network between residents at the Greater Lyon scale
- friendly exchange moments between district associations and public housing authorities. These rather festive moments are ideal for everyone to exchange concerning the Urban Renewal Project and to materialize short term actions.



Fig 25, 26, 27, 28 – City ‘gardeners’!

4. Conclusion

Our city's new 'intelligent' urban planning and designs are today conceived in terms of the more essential criteria, more basic, simple to put in place. Among these criteria, one may find:

- The planning and designing of cities while anticipating and adapting to risks and climate change
- The preservation of water resources and the guarantee of quality and efficient management
- The preservation and enhancement of soil biodiversity and natural environments
- The promotion of heritage sites (architectural and natural), of regional history, of city and neighborhood identity
- The implementation of urban, landscaping and architectural quality projects
- The favoring of active mode transportation (bicycle, skating, etc.), community transportation and all alternative means of transports
- The implementation of common guidelines for mutual coexistence and solidarity

Soil and Water Bioengineering as Natural Based Solutions

The ECOMED Project

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Abstract

Soil and Water Bioengineering: is a discipline than combines technology with biology, making use of native plants and plant communities as construction material for protecting soil and contribute to restore degraded environments.

It can be summarized that initiation of vegetation is a good way of providing various ecosystem services such as erosion protection, aesthetic value, habitat provision and balanced local climate without neglecting water management issues. Soil and Water Bioengineering are Natural Based Solutions offer sustainable solutions to cope with climate change mitigation and adaptation challenges and are effective not only in normal but also in extreme situations. In this context we are working on the ECOMED Project.

The ECOMED project aims at supporting and promoting the specialization level of the Soil and Water Bioengineering sector in the Mediterranean ecoregion. The Mediterranean particularities are related to the aridity of the climate and the selection of both plant material and planting techniques.



Canal Artia Irun-Spain-One of the works to be analyzed by SCIA SL in ECOMED Project G. Vasco P. Sangalli AEIP EFIB

The ECOMED project is co-funded by the Erasmus+ project of the European Union and the project consortium includes academic entities and enterprises, from 8 different countries (Italy, France, FYROM, Greece, Portugal, Spain, Turkey and United Kingdom). The use of the accumulated experience within the sector is a featured element into the sector specialisation process strategy.

Keywords: Type your keywords here, separated by semicolons ;

1. Introduction

The ecological crisis issued from the human activity and its risk push us to find solutions that go through the understanding of the laws of nature and its principles, the stop of the ongoing degradation and the mechanisms of restoration. As a society, we are experiencing a period of uncertainty, in which we perceive that the solutions could come from finding a balance within our environment based on the sustainable management of our ecosystems, the restoration of their functionality and services, and the use of nature-based construction systems such as soil- and water-bioengineering techniques.

Soil and Water Bioengineering: is a discipline that combines technology with biology, making use of native plants and plant communities as construction material and erosion control in degraded environments. The term "Engineering" refers to the use of technical and scientific data for constructive, stabilization and erosion control purposes and "bio" because the functions are related to living organisms, mainly **native plants** with **biotechnical characteristics** and with the purpose of **restore ecosystems** and increasing the biodiversity.

There is growing recognition that nature can help provide viable solutions that use and

deploy the properties of natural ecosystems and the services that they provide in a smart,

engineered' way. These nature-based solutions provide sustainable, cost-effective, multi-purpose and flexible alternatives for various objectives: Technical, ecological, landscape integration and socio-economics. It can be summarized that initiation of vegetation is a capable way of providing various ecosystem services such as erosion protection, aesthetic value, habitat provision and balanced local climate without neglecting water management issues. In this context we are working on the Ecomed Project.

The ECOMED project aims at supporting and promoting the specialization level of the bioengineering sector inside the ecoengineering in the Mediterranean ecoregion. The Mediterranean particularities are related to the aridity of the climate and the selection of both plant material and planting techniques.

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strategy. This strategy can be articulated from different perspectives:

- By analysing the sector current needs, strengths, weaknesses and opportunities.
- By analysing existing soil and water bioengineering works.
- By improving the existing design routines and protocols.
- By reinforcing the sector by a know-how transfer strategy (generation of new interactional schemes and dynamics within the sector).
- By generating an improved syllabus and sector specific training modules.
- By generating a plant database adapted to the bioengineering Mediterranean sector and needs.

2. Methods and Materials

2.1 Study Area

The Mediterranean ecoregion in Europe should be a priority in the efforts implemented in mitigating soil and land degradation (Cerdan et al., 2011). The ecoregion is extremely susceptible to erosion, floods and landslides because of its natural characteristics that include the semi-arid climate, sparse vegetation, many dry lands

and steep topography (Davidson 1991, Palmer, 2017; Zaimes et al., 2012). The Millennium Ecosystem Assessment (2005) estimated that 10–20% of drylands are already degraded. Furthermore, scientists have stated that approximately 12 million hectares of drylands are degraded each year (James et al., 2013).

This ecoregion has been inhabited by humans for thousands of years. The impacts of the human activities in the region are evident with the many unsustainable agricultural lands and the few remaining patches of natural ecosystems (Pearce, 1996; Tal, 2010). The natural and frequent wildfires of these ecosystems should also be a major concern (Shakesby 2011). Burnt bare areas have very high erosion rates especially after torrential rains (De Luis et al., 2003; Pausas et al., 2007).

The socio-economic changes of the past century in the ecoregion have led to the frequent abandonment of agricultural fields that have also increased susceptibility to soil loss (Ries, 2009). Finally, the forecasted changes in climate for the ecoregion that are increased precipitation intensities along with prolonged droughts should be considered in management plans and in the use of vegetation. Increased soil erosion, floods and landslides in the Mediterranean ecoregion should be expected in a region where these phenomena already cause serious socioeconomic problems (Giupponi and Shechter, 2003).



Vegetated Crib wall in the Mediterranean area- Slopes
 Sardegna, Italy. P. Cornellini AIPIN EFIB

Overall the soils of this ecoregion have been developed under unique natural and anthropogenic drivers. This uniqueness means that to achieve soil sustainability the strategies used need to be suitable and adaptive to the region. The Soil and Water Bioengineering should be adapted, and are likely to fail soil sustainability in Mediterranean (Lagacharie et al., 2017).

A set of soil and water bioengineering works scattered over the Mediterranean ecoregion are being selected for their analysis. This is a crucial feature within the Ecomed project strategy. The scenarios or work typologies included within the set of selected works are slope scenario, fluvial scenario and coastal scenario. Besides, some failed works will be selected for their analysis and discussion. The collected information both from the field work and the analysis of bioengineering projects and works will allow an effective proposal of improvements at different levels of analysis which are design,

construction, monitoring and training. The preceding scheme will support the specialization process of the soil and water bioengineering sector in the Mediterranean ecoregion.

2.2 Materials

To promote and specialise the soil Bioengineering sector for the Mediterranean ecoregion new material and tools need to be adapted or developed. For the new material and tools to be applicable in the Mediterranean, the accumulated experiences of the ecoregion within the soil bioengineering sector need to be identified, analyzed and utilized. These experiences are the basis of the new material and tools being developed and are being mined with four different ways: a) understanding the know-how transfer within the sector, b) analyzing existing soil bioengineering works, c) generating new interactional schemes and dynamics within the sector and d) by improving existing design methodologies and developing new design routines and protocols.

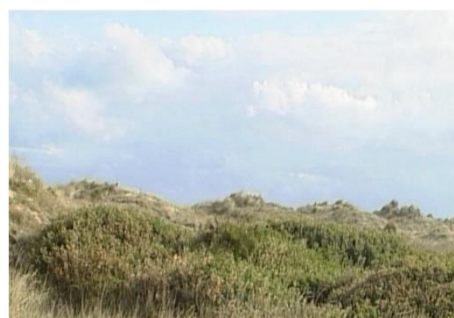
A survey of the existing curricula related to soil bioengineering of the educational institutions in Mediterranean was conducted that was followed by a thorough analysis. Another survey of specific enterprises related to the soil bioengineering and geotechnical sectors was conducted on the major current needs to improve the sector specialization level. Specifically, 2-3 experts from big companies were asked questions in regard to how to best specialize Soil and Water Bioengineering in the Mediterranean. These surveys provided the feedback on the know-how transfer of the soil bioengineering sector currently in the ecoregion.

2.3. Results

One of the advantages of soil bioengineering works is the use of plants and/or parts of plants. As these materials grow, they further enhance the protection of soil loss and erosion that is provided initially by the inert materials (e.g. soil, rock, timber) that are used in combination with the living building material. The growth of the living plant material ensures the long-term sustainability of these works. As the living material is heavily dependent on the climatic condition, bioengineering structures are characterized by their semi-empirical nature. This is why it is necessary to compare between the original and the current state and the different stages of the construction site in terms of biodiversity, soil evolution, plant anchorage, ecosystem resilience, etc. The work analyses should also be complemented with the additional comparisons with two reference scenarios. Initially a site without any soil bioengineering intervention will be used as a pre-operational site. Afterwards an end-point reference where the targeted restoration objectives are well reflected will be utilized. With the first comparison we will be able to assess the intervention benefits and the work performance. With the second comparison we will be able to assess the progress of the restoration objectives fulfilment and the pace at which the restoration objectives are being achieved. This is carried out since pre- and post-construction evaluations can measure the change or the impact of the intervention, but the level of success can be judged only relative to a reference system (USDA-NRCS, 2007).

In addition with most experiences, examples and methodologies originating from different ecoregion (primarily the Atlantic and Continental) testing and examples from the Mediterranean ecoregion

are necessary. With the Mediterranean climatic condition substantially different from the Atlantic and Continental condition successful ecoengineering interventions from the ecoregion are analyzed. Therefore, the ECOMED project is reviewing existing soil bioengineering works from the entire Euro-Mediterranean region with some being selected to be further analyzed. The idea is to provide successful case-study engineering interventions but also “failures” that could be transferred and utilized in different areas of the ecoregion with similar problems. This type of information is currently missing for this ecoregion and the generated and analyzed case-studies will provide information required to meet the needs for the professional specialization and to better understand its effective and efficient applicability in the ecoregion.



Restoration of Dunes. El Saler . Spain A. Vizcaino AEIP EFIB

The apparent gap between universities and enterprises in many scientific fields requires the better and more effective collaboration of the two. Therefore, the ECOMED project is generating new

interactional schemes and dynamics within the academic and professionals of the sector. The first step was to invite the companies, enterprises, agencies and organization that work or deal with soil bioengineering for each country of the partnership to participate in the online questionnaire that addressed the needs and existing gaps in the soil bioengineering sector to further promote it in the Mediterranean ecoregion. This allowed to evaluate the opinions of the enterprises in regard to the design, construction, maintenance and monitoring of works but also the educational and professional expertise in the sector. Additionally, after the completion and analysis of the questionnaires the partners in each country hosted Focus Groups to further discuss the results of the questionnaire. These activities will fill the current scientific gaps and generate a knowledge transfer network involving the Mediterranean stakeholders. The development of such a network will promote soil bioengineering in the ecoregion.



Practical Workshop by AEIP and EFIB – Technical trip with Agebio, AEIP, EFIB and Ecomed

Soil and water Bioengineering are sustainable tools to improve resilience against soil loss and soil degradation.

2.4 Conclusiones

The Ecomed Project want:

- To promote an innovative and more effective teaching and learning in Soil and Water Bioengineering in Mediterranean Areas.
- To generate a sector specific theoretical and practical syllabus essential for the specialization process of the Mediterranean Ecoengineering sector and more specifically the soil and water Bioengineering sector.
- To create new alliances and dynamics between Mediterranean research and education centers and Soil and Water Bioengineering enterprises.

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Experiments on Flowscapes

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Abstract

For the last five years, graduates within the master track of Landscape Architecture at TU Delft's Faculty of Architecture and the Built Environment have been working on the theme of "Flowscapes". In the graduation guide the theme is explained as follows: "Flowscapes, explores infrastructure as a type of landscape and landscape as a type of infrastructure. The hybridization of the two concepts seeks to redefine infrastructure beyond its strictly utilitarian definition, while allowing landscape design to gain operative force in territorial transformation processes. Through focusing on landscape architectonic design of transportation, green and water infrastructures, the studio aims to develop innovative spatial armatures that guide urban and rural development and represent their civic and cultural significance. With movement and flows at the core, landscape infrastructures facilitate aesthetic, functional, social and ecological relationships between natural and human systems. The studio seeks a better understanding of the dynamic between landscape processes and typo-morphological aspects; here interpreted as flowscapes. Flowscapes projects put Landscape Architecture Education Delft at the interface of Urbanism, Architecture, Civil Engineering, Environmental and Spatial Planning."¹

In this paper the theme will be discussed by comparing two graduation projects situated in two different deltas: "The Haringvlietdam, a beautiful coastal landscape, part of the Rhine-Meuse delta" in the Netherlands and "The Living Estuary, a study to develop landscape spatial adaptive strategies by integrating water, ecosystem and anthropomorphic-dynamics in the estuary of the Volta Delta" in Ghana. The focus of the paper is on the method developed and applied in the graduation work. What do these projects have in common? In what way are they different and what can we learn from them in terms of understanding landscape architecture as an integral design discipline, in relation to the theme of flowscapes? A discipline that relates space to place and uses design as an operative force to steer adaptive and sustainable territorial transformation processes.

Keywords: Flowscapes; dynamics; integrating natural and human systems; biodiversity; climate change; flooding; a living delta, future resilience.

1. Introduction

Deltas are dynamic areas where river branches meet the sea. These rich ecosystems, have attracted, and still attract humans as deltas provide food, water and a good trade position from which to conduct trade. According to Meyer [2014] four-evolutionary phases for delta regions can be distinguished. First, the phase where land-formation is dominated by natural forces. Second, human interventions and settlements begin to influence the natural dynamics on a modest level with the help of technology. Third, water management knowledge developed by the state which enables large scale structural interventions to regulate the delta system. And fourth, a delta in which a new balance between the different layers (natural, cultural and urban) of the delta system is introduced, creating a sustainable living delta.

Most of the delta's in the western world and in Asia are urbanised and refer to phase two or three. Only a few delta's in the world, especially in Africa, are still intact even though people live there. They can be categorized as belonging to phase one. The degree to which urbanised deltas are managed and how high the safety level is, differs substantially. In all cases, exploitation over years of urbanisation, intensive farming and industrialisation causes land subsidence, loss of wetlands, coastal erosion, salinisation and loss of biodiversity. Subsequent to this path of exploitation, more measures are required to maintain or increase the established safety level. A better appreciation of the damaging impacts of climate change requires amending this traditional, exploitative approach. Controlled urbanised

deltas need to transform towards a more open system, balancing urban, cultural and natural dynamics in order to create a sustainable, living delta landscapes. In other words there is a need for measures that minimise anthropogenic impacts of coastal protection structures on ecosystems and that might even offer possibilities to enhance ecosystem functioning. [Borsje, 2010]

Since landscape architecture is the discipline which works and thinks with processes, landscape architects should get involved to and guide coastal engineers in again making living in the delta attractive and inclusive. As stated by a colleague from Delft: "The landscape is considered as a process rather than as a result. Natural and social processes constantly change the landscape, making the dynamics of the transformation a key issue in research and design. The design is considered to be an open strategy, aimed at guiding developments, no blueprint design. Projects play a role as an open-ended strategy, as in staging or setting up future conditions." [Nijhuis, 2013].

In this paper two students projects, both situated in a delta are discussed. Both projects work on the idea of transforming an existing delta to a living delta (phase 4). One project deals with the Dutch delta, probably the most regulated and safest delta in the world and the other project is about the Volta Delta in Ghana, a scarcely cultivated African delta. Both delta's face large changes in the coming years. The Rhine-Meuse delta needs to move towards the fourth evolution step to regenerate dynamics and enhance the delta as an ecosystems. Concepts such as 'building by or with nature' that utilizes the forces of nature to strengthen natural, economic and living conditions are discussed.ⁱⁱ Building with nature not only implies that ecosystems

should suffer as little as possible from flood protection measures, but also that natural processes should be incorporated to strengthen the coast. [Brand, 2014] In the end the building with nature approach looks for integrated and flexible solution by making use of natural processes in such a way that meets the need for infrastructure while creating the opportunities that benefits both, for the economy and ecology sectors. [De Vriend and Van Koningsveld, 2012] The transformation of the Volta delta towards the forth step is needed not so much because the delta lost its natural dynamics but due to serious coastal erosion problems and rapid, uncontrolled urbanisation.

The approach of the two projects to reach the goal of generating a sustainable living delta is different. Not only due to the different starting points of today's delta, but due to economic and political differences as well as access to water management knowledge. In the Dutch case the state takes more or less the lead, there is an awareness and funding to change the delta towards phase four. In the Ghana case, nothing is certain, measures for coastal reinforcement are taken without an awareness of the full consequences for the region and informal urbanisation is occupying more and more of the delta's terrain. The awareness of the need for change towards a more sustainable approach is not yet present in Ghana, though the potential of the Volta delta as a living landscape is better places than the Dutch delta.

2. The Haringvlietdam, an operative landscape

The delta works in the Netherlands are world renowned for their construction of dikes, dams, sluices, and storm surge barriers that shortened the coastline of the Rhine-Meuse delta by 700 km. The works were declared finished after almost fifty years, in 1997. During the construction it was realised that by building the delta works, the natural system was drastically altered. During the process of building and in response to public pressure, the idea of a closed structure which restricted the sea was already altered.



Fig. 1. Oosterscheldekering, an open barrier construction (sea on the left of the barrier) photographed during flood tides, The Netherlands. © maritimnieuws, RWS

The Oosterscheldekering, a 4 km long barrier, one of the elements of the whole plan was changed into an open construction, that only closes under adverse weather conditions. In this way, the saltwater marine life behind the dam is preserved and fish can continue, while the land behind the dam is safe from the water when needed. The Haringvlietdam, an earlier build part of the Delta construction and subject of one of the discussed projects, consists of a closed dam which divides the water flow into fresh and salt water and can be considered a linear technical structure, a typical engineered element.



Fig. 2. Haringvlietdam, river water (on the right of the dam) can flow into the sea. The Netherlands. © maritimnieuws, RWS

Maria Potamiali explores in her graduation project how the Haringvlietdam dam can be transformed into an operative landscape infrastructure. To get a grip on the site and to understand the processes she mapped the natural dynamics and processes of the tides, the wind, the waves, the erosion, the sedimentation and the biotics in the area. Followed up by understanding and drawing their interrelations and the changes in the system due to the construction of the dam. From this research, design principals for the Dutch coastal zone were formulated. The forces of wind, waves and tides could be used for the creation of barrier islands to protect the coastline were the dam to be opened. Making islands could be achieved by placing an underwater barrier and stimulating natural processes to redistribute sediments towards desired locations.

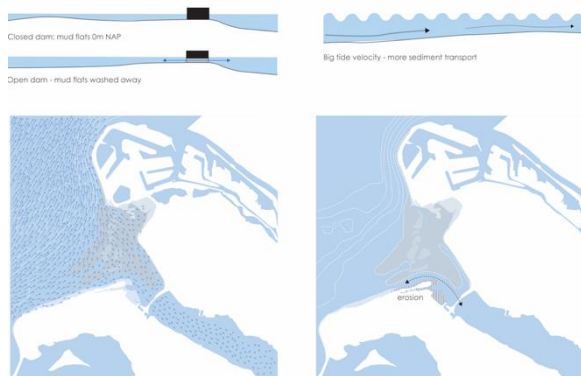


Fig. 3. Experiments on: What would happen if we would open the dam? © Maria Potamiali

The new islands also work as a buffer to reduce wave energy. Behind the dam the

intermediate space, between the existing new and old dikes, could be transformed into a new intertidal area by dike realignment.

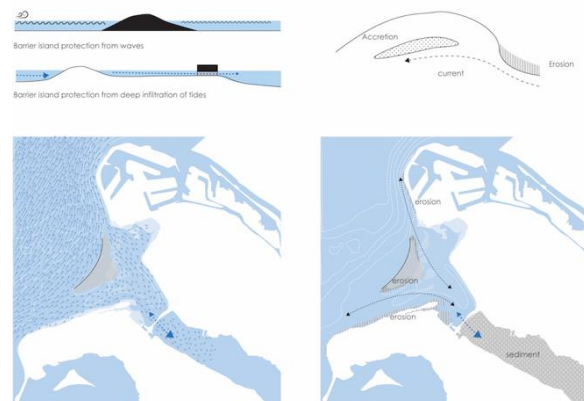


Fig. 4. Experiments on: What would happen if we create islands and open the dam? © Maria Potamiali

The tidal activity due to the opening of the dam, creates conditions for saltmarsh development and once saltmarsh vegetation is established sedimentation enhances the heightening of the zone, naturally. This mechanism can be identify as an adaptive strategy to sea level rise, that at the same time reduces wave energy, improves the stability of the dike and enhances biodiversity. With regard to ecosystem engineering, this mechanism can be applied both at the barrier islands as well as at the dam.



Fig. 5. Growth of an island using the concept of Building by Nature. © Maria Potamiali

In addition to the creation of new islands, which on the long term can become a building site for temporary housing, saltmarshes, mussel and oyster farms, windmills and tidal turbines positioned in the dike became part of the design. Whenever the

design principles were projected and transposed onto the site, the ideas were discussed with an civil engineer and altered as necessary. In this design-by-research-project, the intention was primarily to create an attractive, safe, site-specific liveable delta landscape. As Maria states in her report, “The design should be considered as an open end slow process towards an adaptive coastal self-sufficient region”. The constructed dam became part of an operational infrastructure playing a new role in a sustainable delta, a flowscapes.



Fig. 6. The Haringvliet landscape, where natural islands and technical structures work together. © Maria Potamiali

3. The Volta delta, a Living Estuary

The Volta delta is still (compared to the Haringvlietdam area) a dynamic environment, forming the interface between the Volta river and the Atlantic ocean and providing significant natural values for many species. Nevertheless, by constructing a dam in 1965 tens kilometers upstream, a reservoir was created (the largest lake made by humans), mainly to provide electricity for the aluminum industry. Downstream sediments since then have significant reduced by 90% which, together with sea level rise and the associated change to coastal currents, causes severe coastal erosion. Moreover, the mangroves that protect the banks of the river

from erosion are deforested and used for firewood. Due to the erosion, almost 50% of the inhabitants, that have settled both on the coastal shoreline and in the inland delta, experience flooding. Both, humans and natural values are threatened by these changes. Coastal protection in the form of dams and groynes have been recently installed without a long-term, comprehensive planning and don't provide the protection for the delta as a whole. Rapid informal urbanisation is moving into the delta.



Fig. 7. Eroding coastline Ghana. © Dano Roelvink / Currents / US Navy

The graduation project of Ayu Prestasia aims to develop landscape architectonic design principles for future adaptive strategies that integrate water, ecosystem and anthropic (human) dynamics in order to enhance the spatial quality and livability in the Volta Delta. System adaptability in this project refers to the definition of resilience by Holling [1973] as the ability of a system to absorb change and disturbance without changing its basic structure and function or shifting into a qualitative different state. It could also include the ability to self-organise change in the social ecological systems [e.g., Holling 1996, 2001; Levin et al. 1998; Carpenter *et al.* 2001; Folke 2006; Wu & Wu, 2013]. In a vulnerable natural area, such as the Volta Delta, and vulnerable civilisation development strategies and design interventions should gradually provide

opportunities over time for the environment and people. The project aims to optimise the potential of the ecosystems to cope with the challenges of the estuary, to work together with the water dynamics create safe condition for living and to improve its economic values. Therefore, a mutually supportive relationship between nature and people needs to be established. Interventions should involve active participation of local inhabitants and stakeholders to increase the resiliency towards changes in the systems. To do so three steps are taken, investigation, scenario building, and implementation. First, a deep investigation of the delta is conducted to identify the relation between natural and human processes through time is identified. Methods such as the layer approachⁱⁱⁱ and cross-reference mapping^{iv}, are used to look into the different relations between water dynamics, ecosystem dynamics and anthropic dynamics. Design experiments are conducted to find design principles that enhances the interrelations between the different dynamics in a way that they can enhance the delta as a living system. Secondly, scenario's^v, that elaborate on spatial changes in the region over 50 years are detailed and put on paper. They help to identify certain turning points in the development of the delta and point out significant elements which have a large impact on change.



Fig. 8. What will possibly happen in the next 50 years, if the population grows rapidly while the economic sector is not growing/stagnant and there is not much effort in nature conservation? © Ayu Prestasia

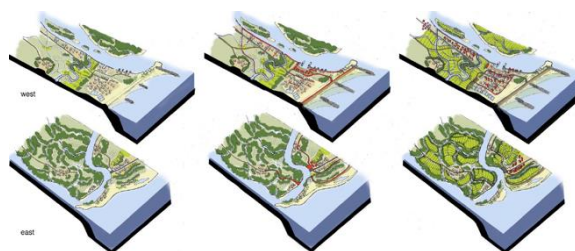


Fig. 9. What will possibly happen in the next 50 years, if the economy rapidly grown while the population grows in low rate and there is not much effort in nature conservation? © Ayu Prestasia

The comparison of the three extreme scenarios is used for further experimentation to formulate a feasible and desirable strategy on the regional scale of the delta. With the help of design experiments, the determined variables are combined and their influence on the spatial dimension is studied.



Fig. 10. What will possibly happen in the next 50 years, if the nature conservation become the priority in the estuary's development, while the population and economy grows in low rate? © Ayu Prestasia

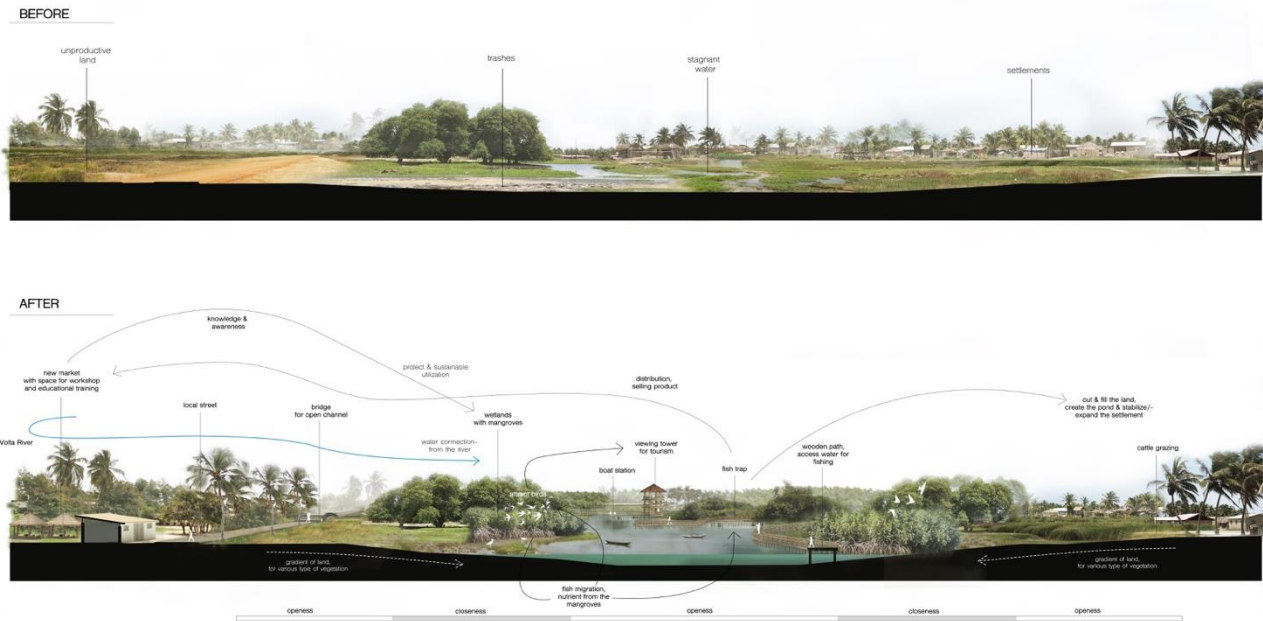


Fig. 11. Site 1 in Volta delta (before) and possible future (after).
 © Ayu Prestasia

Thirdly, design principles generated from the first step are implemented into the design strategy at the regional scale and are spatially and in its materiality elaborated at the scale of the neighborhood. The principles of ecosystem services are used as an assessment tool to guide and transform the implementations (design interventions) and to realise the sustainable development goals.

The three water, ecosystem and anthropic dynamics are integrated into a dynamic spatial design that only works if the balance between them is maintained. In addition, new programmes, such as tourism, new wetlands, and fish farming provide opportunities for income and increases the land values, they need to become part of the system. Zooming in to different areas in the region made clear that, by zoning through the implementation of new infrastructure or adjustments on existing infrastructure (water, greenery and

road structures) different kinds of circular systems can evolve on site. By encouraging and educating systems thinking, residents hopefully understand that they are, and need to be, part of the living delta, the flowscapes.

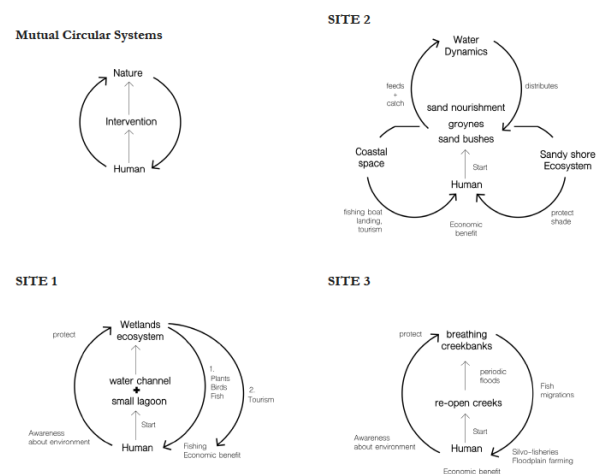


Fig. 13. Different circular systems due to site conditions.
 © Ayu Prestasia

4. Conclusion

Since landscape architecture is the discipline that works and thinks with processes, time, and through scales and can communicate with the help of drawn visions, landscape architects are key players (helped by many other experts) to steer delta's towards balanced livable environments for all species. The two delta's, differ substantially given their different geographical locations. The Dutch delta as of 2018, is a product of an overregulated and by the government-controlled system. Money and awareness is present and once a consensus is found which also satisfies the different interests of farmers, fishermen's, nature lovers and the water board the transformation can begin and can be monitored. The methods used by Maria generate an exciting possible future where anchor points, like the dams that create the barrier islands, are designed in such a way that they enhance and accelerate specific processes on site. By thinking in terms of a slow process, people living in the area can adapt to the new, much more dynamic conditions. The case of the Ghana delta is different since climate change is live-threatening due to the vast speed of the coastal erosion. Moreover, many other problems of livelihood are at stake. By visiting the site, we learned that nevertheless wildlife and forestry NGOs are nevertheless present in the area, they are working with the people and teaching them how to live with all that the delta has to offer in a more integrated way. Ayu expanded this strategy in her design in such a way that people not only invest in themselves but, at the same time,

become part of the living delta system. Again in a slow but constructive, adaptive (open to changes) process. In the project, the idea of people and nature benefiting from each other is strongly presented by proposing different circular systems in different zones. The interaction between people and the landscape is, in the case of this project, inseparable and could, if successful (let's allow us to dream), become a showcase for all future delta's. Both projects are striving towards the evolutionary phase 4 of a delta, creating a sustainable living environment, a true flowscape.

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ⁱ Flowscape 2017-2018 graduation study guide master track of Landscape Architecture, TU Delft, The Netherlands.

ⁱⁱ *Building with or by nature: The Building with Nature concept* aims at using ecological processes to shape deltas and coastal zones.

ⁱⁱⁱ Layer approach, in the perspective of landscape as processes and to address and understand the interrelation between the natural and human systems the water dynamics, ecosystem dynamics, and anthropo-dynamics are drawn separately.

^{iv} Cross-reference mapping, is bringing diverse information together in drawings, including diagrams. The information was gathered from literature study, various engineering

6. Acknowledgments

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fields, map readings, site visit and interviews and discussion with inhabitants, stakeholders and experts.

^v Scenarios pointing out extreme plausible conditions caused by certain variables in the future. Scenarios can be used to trigger the discussion between different stakeholders. In this project three independent variables (population growth, economic growth and nature conservation) and four dependent variables (water management, food production, erosion control and settlement and mobility) and one constant variable (sea level rise at a rate of 3 mm/year) are used.

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^{vii} <https://repository.tudelft.nl>, by name: Ayu Try Prestasia - available July 2018

Research on The Method of Resilience Urban Design Based on The Eco-oriented Development Model ——Taking Jiulongpo West City in Chongqing, China as an Example

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Abstract

In rapid development stage of urbanization, China's urban construction has made great achievements, but the extensive development lacks eco-friendly concept, has result in continuous deterioration of the human settlement environment, and the weaker ability of cities to withstand disasters. Under the global trend of advocating a resilience city concept, the eco-oriented development mode gradually raises concerns , how to achieve urban resilience by dealing with urban and external ecosystems has become a hot topic. This paper taking Jiulongpo new city in Chongqing China as an example, based on Geographic Information System, explore the framework of the urban design based on the concept of eco-oriented development. The details are as follows: Firstly, through the digital elevation model and horological model to build landscape protection pattern; secondly, green ecological network pattern is constructed based on remote sensing data and minimum resistance model; thirdly, the method of analytic hierarchy process is used to construct land sensitivity pattern by overlaying multiple factors; fourthly, construct historical and cultural heritage protection pattern through cultural value assessment; finally based on the four major patterns and various elements, conduct all kinds of city systems design and spatial pattern layout, to achieve the purpose of maintaining the health of ecosystems, protecting animal migration routes and large habitats, passing on cultural heritage, and improving the quality of human settlements.

Keyword: Eco-oriented development model, ecological safety pattern, resilience city, urban design;

1. Introduction

In recent years, China has paid more and more attention to the restoration and protection of the ecosystem. In December 2015, the Central City Working Conference put forward the framework of "energetically carrying out ecological restoration", Emphasizing the construction of ecological civilization, based on the principle of "respecting nature, complying with nature and protecting nature", and implement a strict ecological environment protection system which shaped the protection measures of green development mode and life style. The mountainous cities have special natural and geographical features which differ from the plain cities. Blind urban expansion causes fragmentation of ecological space in mountainous cities, severe destruction of mountain water resources, instability of ecosystems, and frequent natural disasters. Based on the concepts and design methods of the green infrastructure (here in after referred to as "GI"), this paper propose the ecological strategic framework, control various elements from the perspective of active defense and flexible control, and build a multi-scale, multi-functional, multi-target composite ecological network to guide the urban construction, aiming to maintain the health of the ecosystem, protect the migratory path of animals, and improve the quality of human settlement.

2. The core of Eco-oriented Development Model: GI

GI is a network of natural life support systems consisting of a hub and a link. Elements include natural open spaces such as water systems, wetlands, woodlands, greenways, parks, farms, and pastures. The core concept of GI is to emphasize the active involvement of natural ecology in land use, pay attention to the overall regulation of regional urban space from the evolution of macroeconomic structure, and create a sustainable human settlement environment by constructing a sound regional open space system^[1]. GI network is the ecological framework and strategic premise for human beings to carry out urban and rural development and construction activities. It can comprehensively manage natural life support systems at different scales (river basins, villages, cities, and communities) and has been considered to be able to guide efficient and sustainable urban spatial development^[2, 3].

The Boston necklace planned by Frederick Law Olmsted was considered as the origin practice of greenway. He integrated the broken and scattered open space into a continuous recreation line. Eliot Charles later inherited Olmsted's design philosophy and put forward the theory of "survey firstly before planning", providing scientific methods of greenways and open space planning^[4]. Warren Manning proposed an environmental planning model based on the superposition of survey results and basic data analysis. Then Ian Lennox McHarg developed a multi-factor overlay

analysis method^[5]. Phil Lewis created a landscape analysis method that can identify natural and cultural resources, and proposed the concept of “environmental corridor” with multiple elements and complex functions. Richard TT Forman elaborated on the relationship between spatial structure, pattern evolution and ecological processes of landscapes, and provided a method for assessing the health of ecological processes using landscape pattern indices, further improving the technical method green networks construction. With the development of GIS and RS technologies, the extraction and recognition of data, the construction of evaluation systems and the overlay analysis have become more sophisticated and complicated. The global environment deterioration caused by urbanization has attracted widespread attention. In urban design and regional planning, Europe and the United States have gradually paid attention to the ecological service function of the green infrastructure and the supplement of the gray infrastructure. The green belt construction in Berlin, Germany, is an important means of controlling urban sprawl and serving the daily recreational functions for urban residents. The East London Development Strategy proposes to construct the London Green Network, through the integrated use of land resources from the aspects of ecological security patterns, recreational preferences, regional cultural context, and open space. The Mawland's Green Print program developed^[6] a Green Infrastructure Assessment (GIA) method through evaluating regional resource value and ecological service value to plan and protect

multi-scale green space, and present an intuitive natural space value and protection map for government, land managers, planners, residents, and social groups. Subsequently, many cities in the United States started the green print program and managed urban internal-external natural environments through graphical language. At this point, the green infrastructure planning basically forms the methodological path and research paradigm: integrating basic data, analyzing key ecological elements, identifying and constructing ecological networks^[7,8,9].

3. Urban design based on the concept of eco-oriented development——case study of Jiulongpo new city

3.1. Characteristics of ecological environment in Mountainous Cities

The mountainous green space system formed by mountains, waterways and green areas has a high level of naturalization. It is the basis for safeguarding regional ecological security and supporting urban and rural areas for overall planning and sustainable development. Compared with the plains, the mountainous region has more complex natural environment features and ecological processes. The dramatic changes in slope and degree of undulation, the complex multi-element ecological network base (mountains, rivers, ravines, valleys, etc. can all be considered as large-scale habitat patches and corridors for material energy transfer), and larger spatial heterogeneity, make the ecological environment of

mountainous cities complex, changeable, in the state of low risk resistance. There is a staggered distribution of urban construction and green spaces. Ecological processes and patterns are extremely heterogeneous and complex in spatial distribution. Based on the characteristics of mountainous urban ecosystems and landscape patterns, this study used the principles and methods of GI to establish a GI network through the evaluation of mountain, waterway, green protection patterns and land use ecological sensitivity.

3.2. basic information of Jiulongpo west city

Jiulongpo west city with an area of 360 square kilometers is located in the valleys between Jinyun Mountain and Zhongliang Mountain, on the west side of the Jiulongpo District in Chongqing, and south to the Yangtze River. The topography gradually decreases from north to south. The site is dotted with rivers, lakes, reservoirs and wet spots, dense forests. The Current land use area of Jiulongpo west city is 37.6 square kilometers, and the land layout is more fragmented and scattered.

3.3. build landscape protection pattern

1) mountain protection pattern

Mountain is an important landscape feature of Mountainous City, and also a large habitat source and passage for indigenous animals and plants to live and migrate. Therefore attention should be paid to the maintenance of mountains and

continuity. According to the elevation and slope data, identify and divide the landform types in the study area. Strictly control the range and buffer scope of the mountain and avoid the ecological cycle chain break.

Importing 1:5000 contour topographic maps of Jiulongpo west city to GIS for surface analysis and reclassification. The mountain protection zone is defined as an area with a terrain slope of more than 20% and an absolute elevation of over 500 m where Strictly control development and construction activities and guarantee green cover and cliff line form. Slope protected areas are defined as areas where the terrain slope is greater than 8% and less than 20% and the elevation is greater than 300m where control the development strength and the height of buildings.(fig1,2)

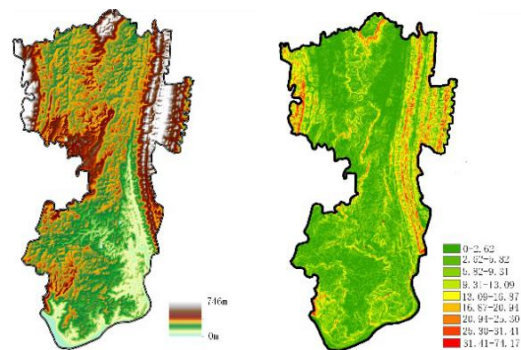


Fig.1. Elevation

Fig.2. slope

2) water way protection pattern

In mountainous watershed, topography and topography directly affect the pattern

and horological response process of water system. The supply of surface runoff in mountainous cities mostly comes from rainfall. A small amount comes from the supply of groundwater and high mountain snow melt. The water network is densely covered, the water system structure is complex, and the types of water bodies are diverse. Based on horological analysis, the water flow direction and confluence accumulation are analyzed to determine the surface water flow path and watershed units. Finally, the Strahler-Horton water classification method was used to classify and classify the internal water network of the site. The dominant water system is a well-established waterway with a fixed amount of water under long-term rainwater scouring, such as a river, stream. Semi-dominant water system refers to staged water storage, with the potential to form a fixed river channel, such as potholes, gullies, etc. Recessive water system refers to the lowest level of the water transfer network, which is not easy to form the waterway point. The higher-level catchment points are the most frequent areas for disasters and the most conducive to collecting and infiltrating rainwater for landscape design. According to the regional characteristics and planning requirements, the water system network for protection and restoration is delineated.(fig3)

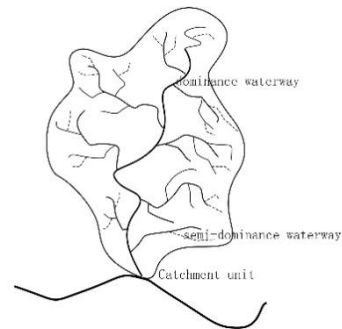


Fig.3. waterway types

In the GIS, the DEM elevation overlay road status and construction land information are integrated into terrain. In GIS, the road status and construction land information are integrated into terrain. The horological model was used to combing the runoff to calculate the network structure and grading of the river network within the site. The higher the level, the larger the catchment area, the greater the amount of water, and the more important the horological and ecological functions. Considering that the hidden water system contributes little to the restoration of the site's horological processes, and the entire water collection network is preserved, it will lead to the fragmentation of the construction land and facilities construction. Therefore, only the water level of more than 4 levels will be reserved.(fig4,5)

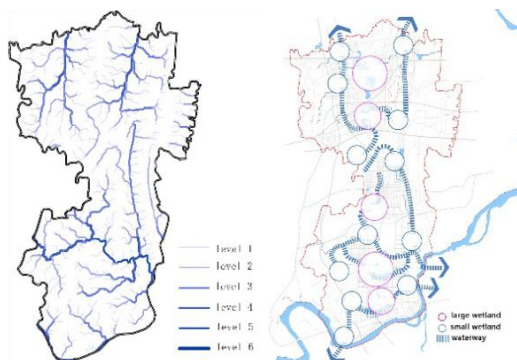


Fig.4. waterway grading

Fig.5. wetland location

3.4. build green ecological network pattern

Because of its poor connectivity and low carrying capacity, broken landscapes cannot provide effective ecological service functions, and thus have negative effects on the biological survival, ecological security, and sustainable human environment. The design path is as follows: 1) Identification of source patches based on relevant indicators (area, NDVI, nature reserves, biodiversity, ecosystem services) refers to areas where natural habitats that are less subject to external disturbances and which play a central role in ecological services. 2) Identifying corridors through the minimum accumulation resistance model, setting the calculated resistance surface for various types of ecological elements, and simulating potential corridors. 3) Establishing an evaluation system based on ecological importance assessment factors and building a multi-level ecological network.

We put Landsat TM Remote Sensing Image of Jiulongpo west city 2017 into Envi for Land Use Map and NDVI Index. Core patch is a collection area where the

landscape plays an ecological role. Only patches that reach a certain area and vegetation coverage can meet the selection requirements of core patch. Put land use maps into GIS and identify core patches based on vegetation indices and scale thresholds. Comprehending relevant research literature and expert advice, we set multi-factor integrated weights as costs, including land use type, vegetation coverage level (directly affects the degree of difficulty of corridor restoration) and terrain relief (direct impact on animal and plant migration routes). Then we identify ideal ecological corridors from the perspective of protecting species migration paths through the minimum resistance model. Finally, a green ecological network pattern of "Nine Cores - Twelve Corridors" was formed. (fig6,7,8table1)

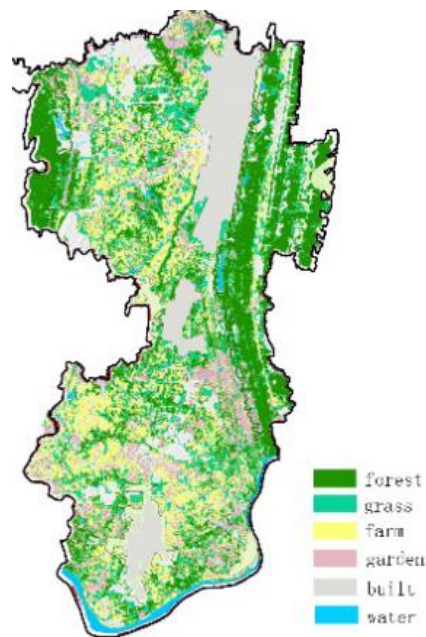


Fig.6. land use map

Table. 1.

type	weight	index	Subclass	Assignment					
Land use type	0.35	forest		1					
			garden	10					
			grass	20					
			farm	40					
		Construction land			distance=0	1000			
					distance< 50m	90			
					50m-200m	50			
					> 200m	10			
					road			distance< 100m	500
								100m-200m	350
> 200m	200								
water			width> 100m or area> 1km ²	600					
			other	500					
normalized difference vegetation index	0.35		> 0.55	1					
			0.4-0.55	20					
			0.25-0.4	40					
			0.1-0.25	70					
terrain undulating degree	0.33		< 0.1	100					
			0-9	20					
			9-20	100					
			20-40	300					
		> 40	500						

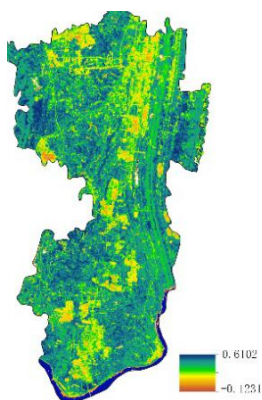


Fig.7. NDVI

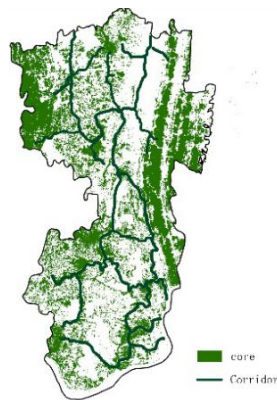


Fig.8. green network

3.5. Ecologically sensitive zoning

Eco-sensitivity reflects the ability of regional ecosystems to resist, adapt, and recover when they face natural or artificial disturbances, that is, under the same external forces, the possibility of ecosystem degradation in different regions. Eco-environment-based assessment of ecological sensitivity can effectively identify key ecological locations and provide a basis for rational land use layout, so as to avoid irreversible destruction of natural resources in the mountains and waters by blindly expanding and to ensure the sustainable development of human settlements in the mountains. The ecological sensitivity analysis steps are as follows: 1) Select ecological sensitivity factors by reviewing relevant data, expert consultations, field surveys, and grade the single factors. 2) The evaluation factor judgment matrix is established by the Delphi method. The weights represent the importance of the evaluation factors to suitability. 3) Using GIS to visualize single factors first, then multi-factor stacking according to weight values to finally get ecologically sensitive partitions.

According to the regional characteristics of Jiulongpo west city in Chongqing, five evaluation factors for elevation, slope, water body, vegetation and natural disasters were selected. The factors are divided into five levels according to the degree of importance. The AHP method will be used to weight the scores and superimposed in the GIS to obtain ecologically sensitive zoning, which guide develop management and control strategies for districts. (table2, fig9)

3.6. cultural heritage protection pattern

Based on the field survey data and historical and cultural data inside the site, the key districts such as historic districts and historical heritages are identified and buffer zones are established. The least resistance model is used to identify corridors and finally form a cultural network. cultural and ecological networks are superimposed and finally formed a strategic development framework.(fig10)

Table.2.

factor	Grading standards	Assignment	Sensitivity	Weight
elevation	< 100	1	lower	0.125
	100m-200m	3	low	
	200m-350m	5	medium	
	350m-500m	7	high	
	> 500m	9	higher	
water	0m	9	higher	0.195
	< 50m Buffer	7	high	
	50m-100m Buffer	5	medium	
	100m-200m Buffer	3	low	
	> 200m Buffer	1	lower	
vegetation	forest	9	higher	0.227
	grass	7	high	
	garden	5	medium	
	farm	3	low	
	other	1	lower	
slope	< 5%	1	lower	0.168
	5%-8%	3	low	
	8%-15%	5	medium	
	15%-25%	7	high	
	> 25%	9	higher	
disaster	extremely frequent	1	lower	0.285
	highly frequent	3	low	
	general frequent	5	medium	
	slightly frequent	7	high	
	Low frequent	9	higher	

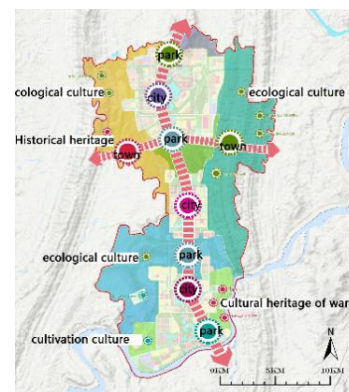


Fig.10. cultural heritage

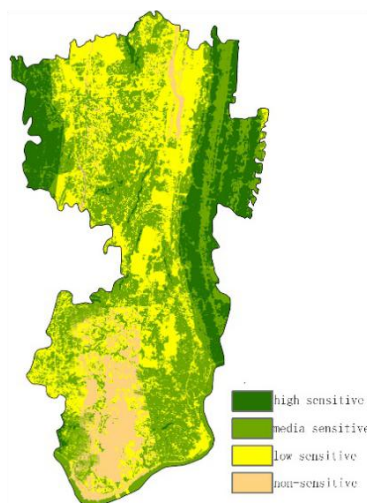


Fig.9. ecological sensitive zone

Conclusion

Mountainous cities have the features of complex terrain, dense water networks, broken landscape patches, and frequent disasters. Rapid urbanization construction neglects the destruction of landscape features, interferes with and disrupts ecological processes, leading to serious imbalances in urban ecosystem cycles and

deterioration of human settlements. Based on the planning methods of green infrastructure, this paper extends the connotation of ecological elements, proposes urban regional spatial development frameworks and strategies from the five aspects of mountains, waterways, green ecological network, ecological security patterns and culture analysis.(fig 11)

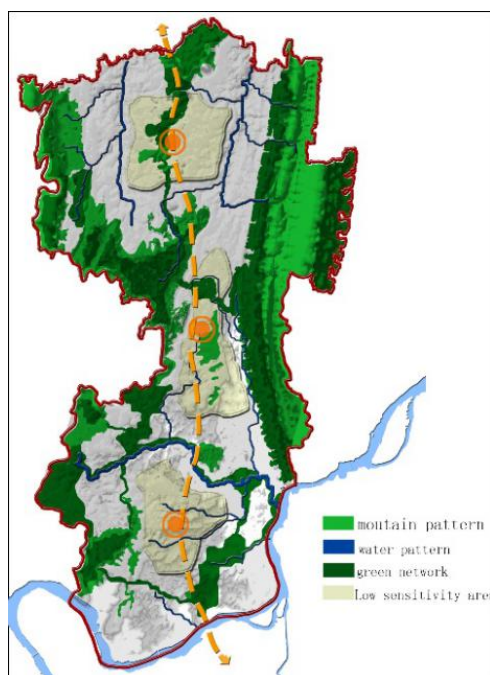


Fig.11. Development guidance for land use

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Recovery of the Geological Landscape as a Successful Geo-tourism Site in Gunung Keriang, Kedah by Implementing the Landscape Analytical Framework based on Ian McHarg Ecological Method.

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Abstract

Today, serious degradation of the geo-heritage has lead by technological development, economic and population growth and social changes in most parts of the world. These occurrences have encouraged many researchers and nature-lovers to a greater appreciation of this fragile natural environment and have resulted in numerous studies conducted in order to conserve it. The nature conservation is only related with the protection of biodiversity, but it is quite clear that conservation of other existing both abiotic and biotic nature also should get more much responsiveness. Geo-heritage may result in a wide range of impacts. This study is to identify the literature review of the recovery of the geological landscape in Gunung Keriang and to prepare the inventory-analysis for documenting the uniqueness of Gunung Keriang landscape geo-characters towards successful geo-tourism site. The methodology used in this project included (i) Ian McHarg's Ecological Inventory Method and (ii) Strategies and design guidelines for successful proposed design. This study showed that several key success factors for sustainable conservation which includes the level of the stakeholders' awareness, participation and appreciation towards heritage values and its economic potential and enforcement of legislation or policy would bring toward the success of the geo-tourism. Embracing this fact, and recognizing its implications for the nature, innovative public education programs and promotional activities will discourage the massive quarrying and the disoriented cultural-spatial design on site. Indirectly, the strong genius loci and successful ecosystem can be implemented. The last sections of the study show how the present practice of environmental designers preclude the generation of ideas towards successful geo-tourism in Gunung Keriang, Kedah. In conclusion, this knowledge on successful geo-tourism should be embedded in any geological landscape design as to prevent disoriented natural-spatial design on site.

Keywords: geological landscape; geo-tourism; and geo-heritage

1. Introduction

Making geodiversity significant to people, where they live and how they live, is crucial for successful geo-conservation. The need for its conservation and appreciation of the benefits can be delivered to society (Tilden, 1977 and Anderson & Brown, 2010). Unfortunately, numerous rare features in the geological landscape, have been destroyed and no longer can be treasured by visitors. The awareness of environmental change and its impact in geodiversity, will help us to make better and more informed decisions about the upcoming of our environment. It is very challenging to make policy and legislation work for geo-conservation.

The loss of identity and distinctiveness character of precious geo-sites contributed by the uncontrolled development plan. The new design will create a good visual quality of the geological landscape, but sometimes it may not consider in preserving the geo-heritage value. Our future generation will lose their appreciation towards geological landscape and the distinctive character of their value.

Disturbance of the rocky shore flora and fauna, including reducing their abundances, diversity, and reproductive output, shifting their size structure, and altering ecosystem functioning are harmed by the visitor activities, such as collecting, trampling, and rock turning. However, the active mineral site management and restoration can be synchronized on a landscape scale, the susceptibility of isolated habitats and species populations in geological landscape can be reduced and additional ecosystem services can be provided (English Nature, 1999).

The main objective of this study is to identify the literature review of the recovery of the geological landscape in Gunung

Keriang and to prepare the inventory-analysis for documenting the uniqueness of Gunung Keriang landscape geo-characters.

2. Literature Review

2.1. Geo-tourism & conservation

The concepts of geo-tourism have significantly well-known in the last ten years. According to David Newsome (2016), the geo-tourism terminology is the education-based tourism that using the geological heritage resources. However, the geological heritage resources must base on the vivid characters of the geological features that differ from other places. Scientific, aesthetic, recreational and cultural value are the examples of attribute that can identify the vividness between two or more the geological landscape. The Table 1 below are the definition of each attribute.

Attribute	Definition
Scientific value	Geological data or the history of geological feature development
Aesthetic value	The pleasant view and its landscape surrounding
Recreational value	Suitability of nature landscape to become the recreational area
Cultural value	Local or tourist behavioral toward the site

Table 1 Definition of vivid character of the geological landscape (Source: David Newsome, 2016)

The initial definition of geo-tourism define as a practice of tourism that its concentration are on geology and landscape. An appreciative of earth sciences through gratefulness and educational, will promote promotes tourism to geo-sites and the safeguarding of geodiversity (Hose (1995, 2000). Visiting the geological features, the

usage of geo-trails, identification of scenic view point, guided tours, activities surrounding of the geological landscape and the existence of information center are the examples of program that can be adapted to achieve Hose's believes (Dowling & Newsome, 2006; Newsome & Dowling, 2010).

2.2. Geo-tourism in Malaysia

In 2007, Malaysia declared the island of Langkawi, one of the wonderful geo-sites as its first geo-park. Mt Kinabalu in Sabah and Gunung Mulu in Sarawak are part of geo-site that listed in world heritage. The outstanding caves and karst formations in the middle of mountainous rainforest make Gunung Mulu National Park as one of the famous spot for the geological lover. The conventional geological resources that own by this landscape have significant and growing function the in industrial expansion of Malaysia and entire the world. Hydrocarbons, minerals, clays, rocks, soils, water, sands, gravels, and salt are examples of the geological resources that can be found (Dowling, 2009).

2.3. The development of geological features for geo-tourism

In 1997, state government gazette Maliau Basin Conservation Area as a Protection (Class 1) Forest Reserve due to the existence of a rounded sedimentary basin in central Sabah. Two approaches have entirely used by Malaysian Geological Heritage Group in this type of development. The first approach is using the support system that already practice and taking benefit from the geo-tourism area. A thorough study was delineated to map and characterize accessible geological sites at Kinabalu Park in Sabah (Badang, 1990). Planning the development at a specific site that has the vivid geological landscape character was

done as the second approach. Each site provided with the purpose of educating tourist through research and development activities focusing on mapping and categorization.

2.4. Principles of successful geo-tourism

There are many vital characteristics to form a geo-tourism. Dowling (2011) described the principles of geo-tourism as follow;

1. geologically based
2. sustainable
3. educative
4. locally beneficial
5. generates tourist satisfaction

The first three characteristics are measured to be crucial for a geological landscape to be reflected as geo-tourism while the other characteristics are observed as being required for any tourism.

3. The impacts of geo-tourism

Beneficial (good) and adverse (bad) are can be at any tourism as its impacts. New development and employment opportunities for community offered by the geo-tourism as a sustainable industry. Income growth, job opportunity, divergence and infrastructure expansion are also the range of the economic benefits that can be generated for them (Greiner, Stoeckl, and Schweigert, 2004).

4. Methodology

4.1. Ian McHarg ecological inventory method

This method extracted from "An Ecological Method for Landscape Architecture". This method provides three filters namely physical, biological and

cultural that must take into consideration during the site inventory and analysis stages.

PHYSICAL
Topography
Surface drainage
Geomorphological
Climatic factor
Skylight shadow
BIOLOGICAL
Plant communities
Wildlife
Ecological sensitive area
CULTURAL
Land use
Landownership
Circulation
Edge condition (visual study)

Table 2 Ian L. McHarg, "An Ecological Method for Landscape Architecture," Landscape Architecture (1967)

4.2. Observation evaluation

Identifying primary user group at site is essential to adopt the successful geo-tourism on site through the user participation. The author will interview the user about their activity-facility need for their satisfaction experiencing the site.

5. Results and discussions

5.1. Ecological inventory method

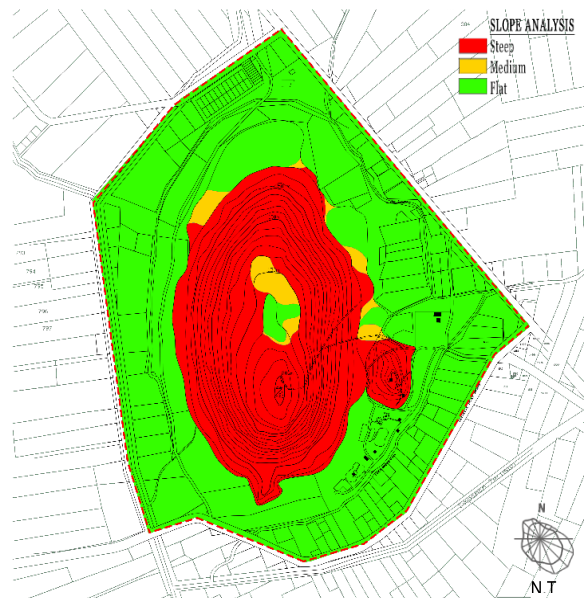
5.1.1. Site physical context

5.1.1.1. Topography

Two method used in order on identify and analyst the topography in Gunung Keriang which are slope analysis and elevation profile.

Slope Analysis

Observation has made on site. Based on the imaginary from google map, a slope analysis map delineated. From the map, shows that Gunung Keriang surrounded with flat terrain. The flat slope is suitable for any development while the steep slope is strictly prohibited for any development unless there were thorough research on development impact that will develop.



Map 1 Slope analysis map

Slopes	Colour	Slopes range (percentage)	Development order
flat	Green	0% < 15%	Suitable for any development
medium	Yellow	> 15% < 25%	Can be developed based on needs
steep	Red	> 25%	Strictly prohibited for any development

Table 3 Slope range



The existence flat area that has occupied with paddy plantation activity



Potential flat area that can provide functional activity such as recreation

Elevation Profile

The highest peak of Gunung Keriang from the ground was 217.92 meter. Landscape analysis was carried out using the landform classification by Tanot Unjah & Ibrahim Komoo (2005). The classification is an identification of landform according to rock type. From the elevation profile cutting section of Gunung Keriang, classification of landform based on types of rock. Two type of rock in the area are carbonate sedimentary rock and clastic sedimentary rock. The observation made by referring the view towards the cardinal direction which are north, east, south, and west. The landform representing different type of rock are shown below.

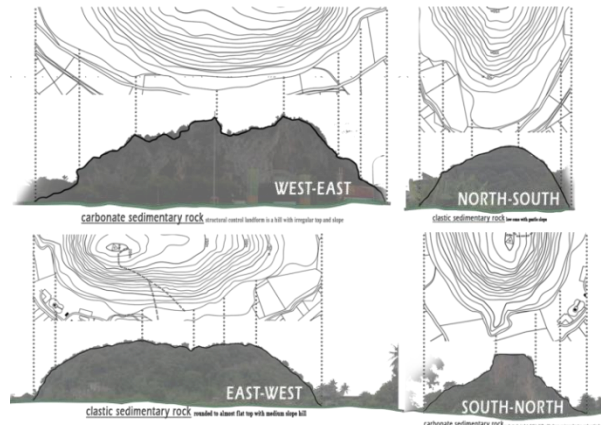


Figure 1 Elevation profile of Gunung Keriang

5.1.1.2. Geomorphological

Field Sketching

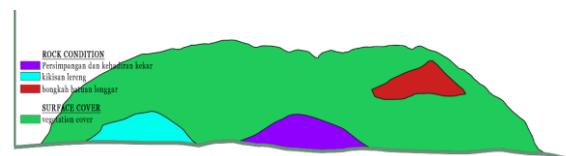
Topographic sketches of landforms for each 180o have been made referring the cardinal direction. From these sketches, the rock condition can be observed and classified in detail. The north-south, east-west, and south-north are obvious as much have been covering by vegetation compare to the west-east side.



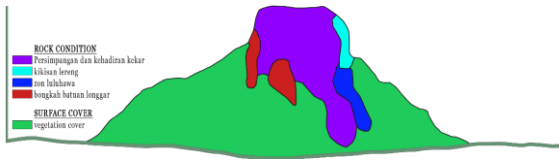
Sketch 1 Sketch view from West to East



Sketch 2 Sketch view from North to South



Sketch 3 Sketch view from East to West



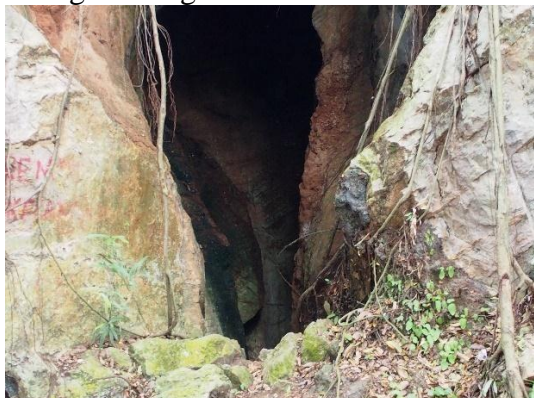
Sketch 4 Sketch view from South to North

Safe Zoning Map



Map 2 Safe zoning map

This data is gathered from Jabatan Geologi Malaysia. In their report that included in Rancangan Malaysia ke-9 has identified the level of safety of development for Gunung Keriang. The extremely dangerous zone clearly can be seen, mapped at the edge of Gunung Keriang.



Regular inspection of each cave entrance to prevent unwanted things happen

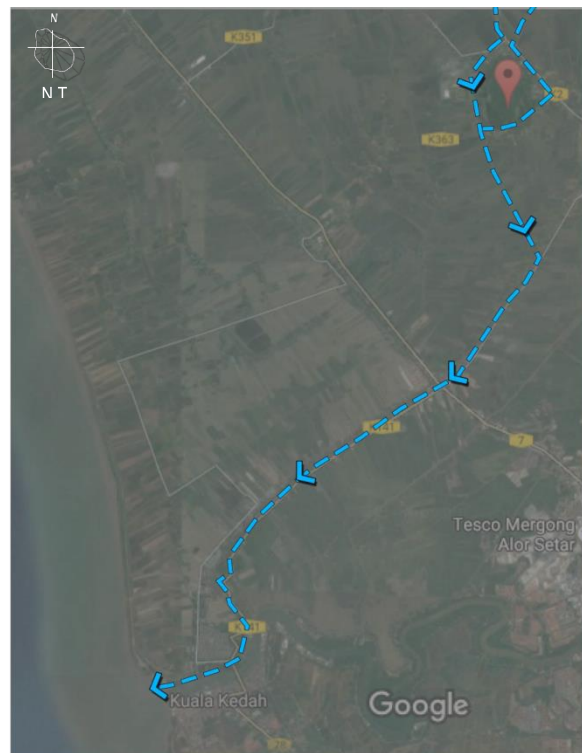


Keep far from any potential area of landslide

5.1.1.3. Hydrological

Macro Scale

The macro scale hydrological map shows the presence of stream channel flow from outside to the site channel and from site to the outside channel. The importance of this study is to restore the stream corridor and rejuvenate the boundary edges along the streamline.



Map 3 Macro scale hydrological map (Source: www.google.com)

Micro Scale

The presence of water bodies at site can see from the micro scale of hydrological map. The landform of the Gunung Keriang is one of the factors that influence the water flow from the catchment area that is the highest ridge to the lower levels. The rain water flow in all direction from the peak of Gunung Keriang and channeled to the nearby water body. It is an indicator of high biodiversity existed on site. It is a potential to provide exciting site visit here. However, this area only can be allowed for minimal human activity to flourish the flora and fauna in Gunung Keriang.



Map 4 Micro scale hydrological map



The application of recreational activity at the detention pond



The proximity between human activity and water edges should have the limitation.



The importance of this river to channel water to nearby paddy plantation area



The water element that can become one of the support element in design.



The existence of water flow at the ground of Gunung Keriang.



The water stagnant due to improper storm water management

5.1.1.4. Climatic factor

The average for the annually rainfall is 2805 mm occurring at the site which the local temperature is 26.5 Celsius.

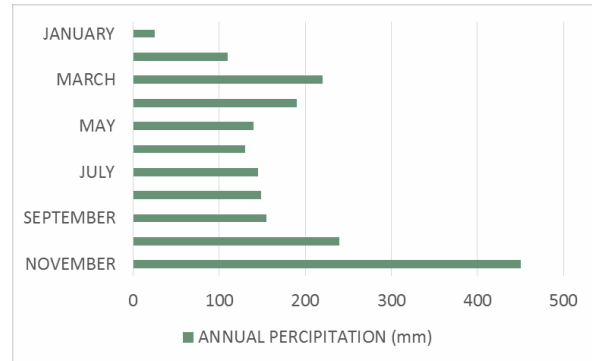


Figure 2 Annual precipitation (Source: Jabatan Matereologi Malaysia)

Accordingly to the graph above, the lower precipitation is at January month with the 45 mm of the average rainfall.

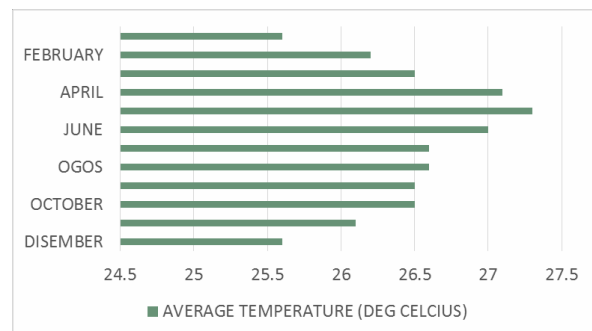


Figure 3 Average temperature (Source: Jabatan Matereologi Malaysia)

For the average temperature at Gunung Keriang is 26.5 Celsius, January is the hottest month in every years. The lower temperature in every year is in January which is 25.7 Celsius.

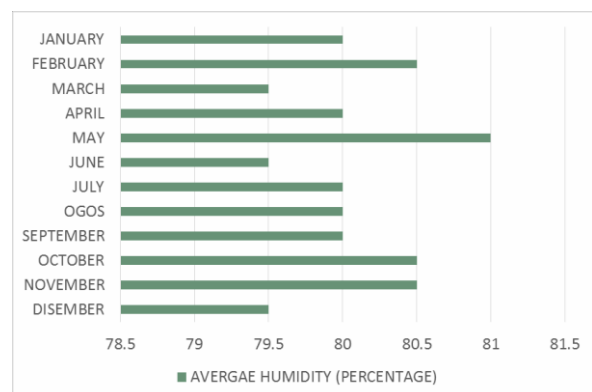


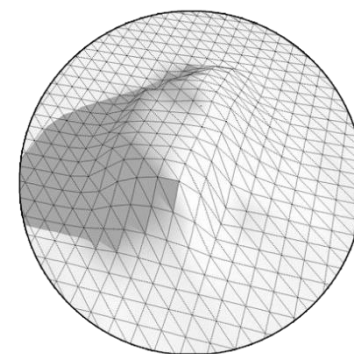
Figure 4 Average humidity (Source: Jabatan Matereologi Malaysia)

The 79.5% humidity or the lowest humidity can be identified in March, June and December. Humidity is affected both weather and climate as well as global climate change and also affects indoor environment, understanding it can help you determine the best place locate recreational area and suitable activities on site.

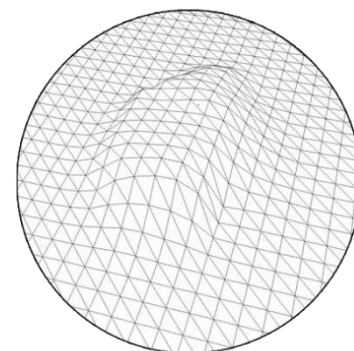
The sun path is significantly influencing the flow and the volume of the pedestrian. The activity attractiveness also is controlled by the shadow fall on ground. Based on the information collected, in the morning, most of the shadow is falling on the west side of Gunung Keriang. This causes less comfortable for the user who entered the Gunung Keriang from East side for recreational activity in the morning.

In the afternoon, the conditions of the area are uncomfortable. The shadows of the open space are getting reduced and people are started feeling uncomfortable. They only can rely on matured trees shades. To solve it, the open space must be planted with the large diameter trees that can provide shades during afternoon.

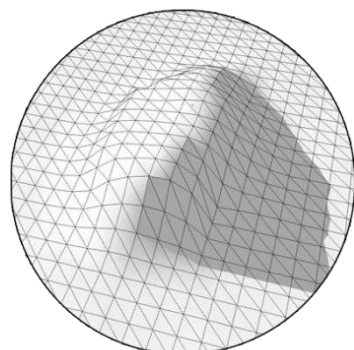
In the evening, the shadow conditions of the area are interchange with the morning sun path. The previous temperature rise is back down and people can use as an area of open space for them to relax and as a recreation area after a hard day's work at the east side of Gunung Keriang.



in Morning



at noon



in evening

Figure 5 Shadow fall direction

However, the different shadow that falls from the Gunung Keriang to the ground shows that this site always provided with sun shading based on the existence of matured trees.



Matured trees with wider branches provide shades at this park



Natural shade from the trees fall to the playground area



Road side trees also function for giving shades to pedestrian



Hawker that always attracted to the comfortable area for their business

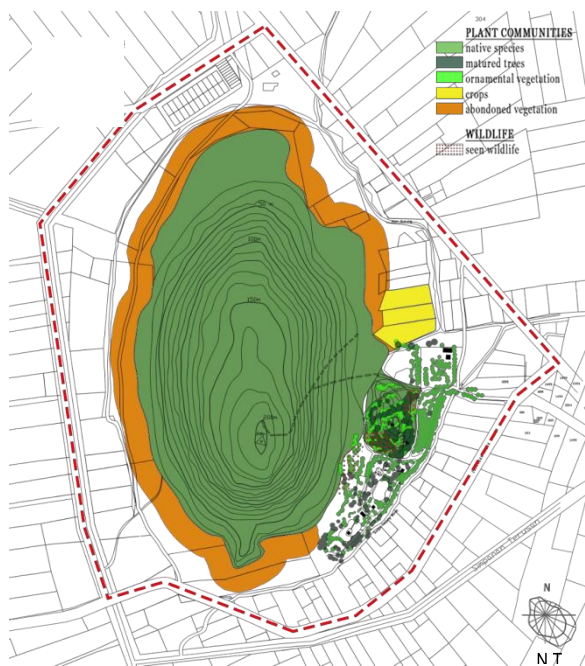
5.1.2. Site biological context

5.1.2.1. Plant communities and wildlife

Various flora and fauna can be found on site. The table below shows the detail of the significant wildlife and plant species that can be identified.

NATIVE & MATURED TRES	
Common Name	Scientific Name
Tekoma	<i>Tabebuia pentaphylla</i>
Tembusu	<i>Fragrea fragrans</i>
Brown salwood	<i>Acasia mangium</i>
The Flame of the Forest	<i>Delonix regia</i>
AGRICULTURAL CROPS	
Pokok Padi	<i>Oryza sativa</i>
Sawi	<i>Brassica juncea</i>
WILDLIFE	
Burung Gembala Kerbau	<i>Acridotheres tristis</i>
Helang Sewah Herdik	<i>Spizaetus cirrhatus</i>
Burung Pipit	<i>Anthus</i>
Monyet	<i>Macaca fascicularis</i>

Table 4 The detail of the significant wildlife and plant species that can be identified at Gunung Keriang



Map 5 The detail of the significant wildlife and plant species that can be identified at

5.1.2.2. Ecological sensitive area

An ecological sensitive area (ESA) is a designation for a natural area which needs special protection because of its landscape, wildlife or historical value. Three keys of aspect that take into consideration which are, plants distribution, wildlife distribution and the proximity of hydrology. The overlap of those three keys can be identified as the ecological sensitive area. The author buffered the areas as follow;

Attribute/parameter	Buffer zone distance(meter)
Native species	50
Matured trees	10
Seen wildlife	10
Hydrology	15

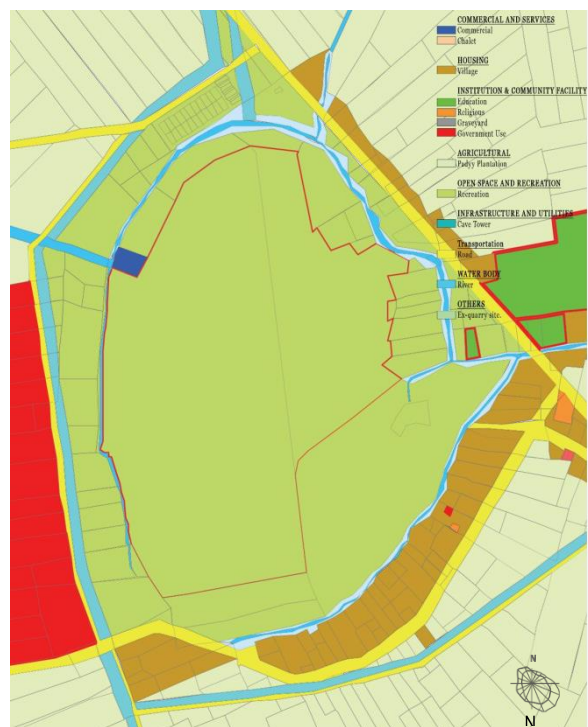
Table 5 The buffer zone distance for the ecological sensitive area

ESA in Gunung Keriang are land and water areas containing ecological functions of such significance as to warrant their protection in the best long-term interest of

the people. The delineation of this sensitive area can apply the zoning approach to control the visitor movement at the park and the proximity to nature closely monitored.

5.1.3. Site cultural context

5.1.3.1. Land use



Map 6 The land use map in Rancangan Tempatan Daerah Alor Setar

From the site land use, the site primarily encompasses with paddy fields plantation after the Gunung Keriang itself. Based on the proposed land use in Rancangan Tempatan Daerah Alor Setar (RTDAS), Gunung Keriang is intended to become an open space for the recreation area activity.

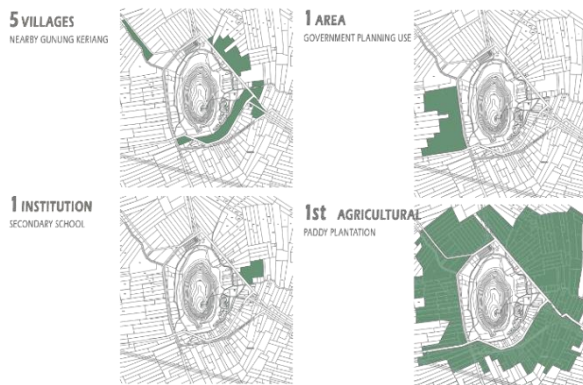


Figure 6 Significant adjacent land use

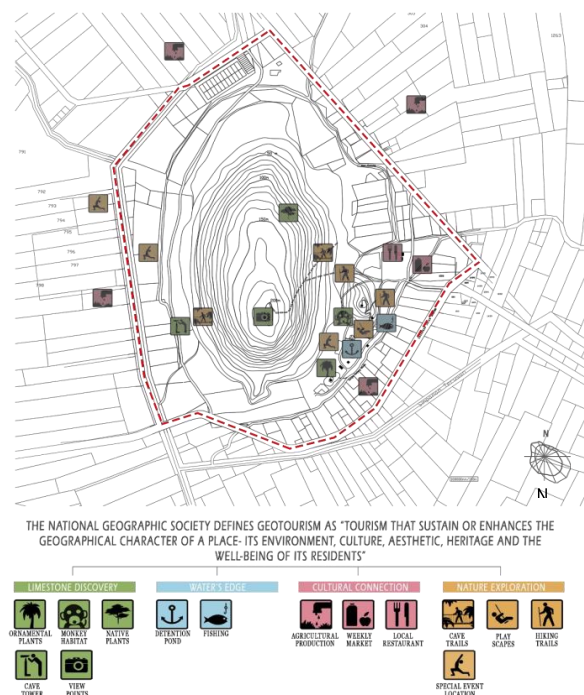
The beautiful geological landscape scenery in the middle of the paddy field and local settlement also have the significant adjacent land use. It will support the planning of recreation area at Gunung Keriang. The mountain area provided site activities that can divide into the limestone discovery, water edge activity, cultural connection and nature exploration.



Paddy Museum that become adjacent attraction to the user of Gunung Keriang



Weekly pasar of local people



Map 7 Detail site activities

5.1.3.2. Legal

Gunung Keriang itself and its surrounding is a state land which the only boundary that is separating this site. Road and river are the physical boundary that can be seen on site. Gunung Keriang surrounded with Jalan Kampung Gunung Hilir, Jalan Kampung Simpang Tiga, Jalan Kampung Bukit Raja and Kampung Gunung Hulu. This site also located about 10 km north-west of Alor Setar close to the Kedah Paddy Museum.

The nearby river is including Sungai Anak Bukit, Sungai Alor Gunung, Sungai Tanjung Morah, sungai Tanjung Pauh and Sungai Kampung Hutan. The private land in the study area boundary usually full of houses that nearby the crops plantation. The state land ownership can be categorized into developed state land and planned state land. This area gazette as geo-heritage site under state law.

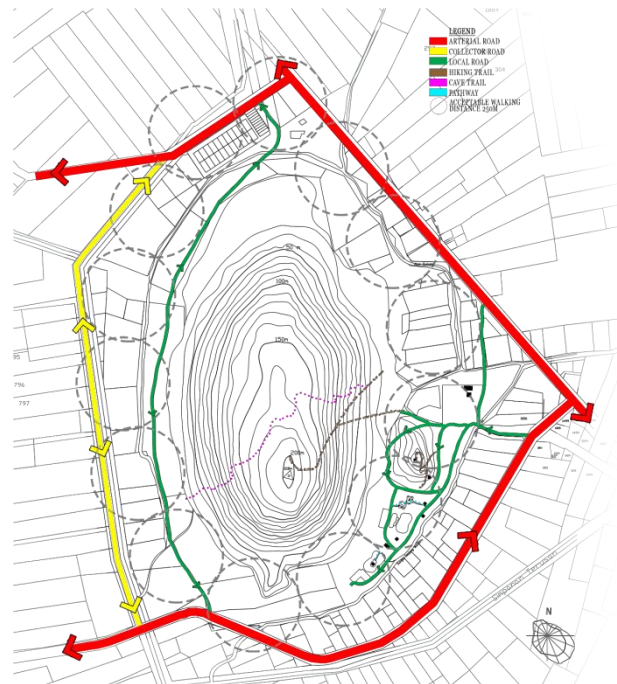


Map 8 State land ownership map (Source: Pejabat Tanah Daerah Kota Setar)

5.1.3.3. Circulation

Vehicular Circulation

The linkages are used only to connect user from adjacent area to the site. The majority of the users are move using their cars and motorcycles.



Map 9 Pedestrian and vehicular circulation

- *Existing Circulation*



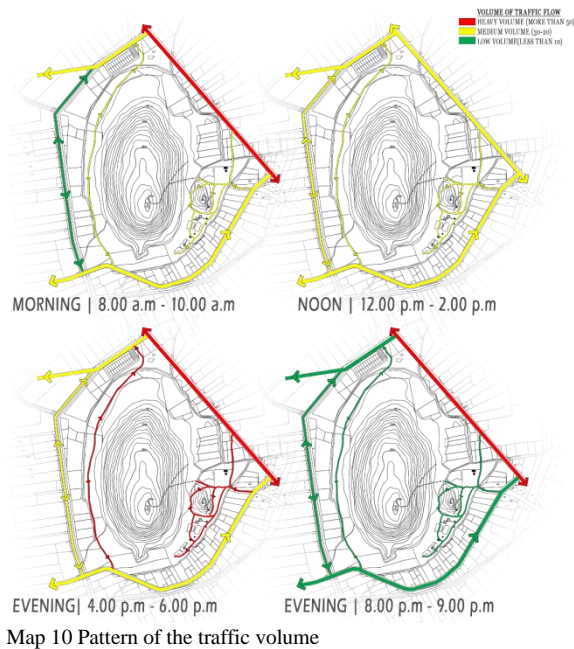
The busy route at the entrance of Gunung Keriang during the weekly pasar



The vehicular user are not park at the suitable place

- *Traffic Volume*

Due to the recreational area, the pattern of the traffic volume is quite different with other part urban context. This area mostly busy with traffic at the evening for the weekdays and for the weekend, the traffic will busy in the morning and evening. The map 11 below show the pattern of the traffic volume at the weekdays during morning, noon, and evening.



Pedestrianized Circulation

The natural area is mostly vibrant with people who walk, jogging and hike. The pedestrian map on Map 10 show the details of the several of existing pedestrianized system that provided.



The entrance of existing mid-extreme hiking trail



The pedestrian way linked to the playground



The hiking trails that combine the artificial rock structure with the natural rocky structure



Route to the inside of the cave at the east side of Gunung Keriang



Main entrance of Gunung Keriang that only priorities for the vehicular



The placement of gazebo as the pit stop for each end of pedestrian ways.

5.1.3.4. Edge condition

The assessment of edge condition at Gunung Keriang is based on Visual Management System(VMS) by Forest Practice Boars, Tasmania. The forest areas of Tasmania are of growing importance for their scenic,

cultural, biological and wood resource values. These are factors need a very careful evaluation. To address the public’s concern, the visual landscape must be considered a basic “resource”, to be assessed and managed along with other forest resource values.

Basic Visual Assessment Method

There are many steps to identify a visual quality of a specific area. For the Gunung Keriang, it is to follow t the Visual Resource Management (VRM), by using four criteria:

- a. Landform
- b. Vegetation
- c. Color
- d. Land cover

Next step is to categorize the suitable classes (grade) for each criteria into:

- (1) Low quality
- (2) Moderate quality, and
- (3) High quality (or more)

The rating criteria must be clear before the site inventory is conducted. These are the scenic quality valuation and criteria that has been used.

	SCENIC QUALITY FORM HIGH QUALITY	MODERATE QUALITY	LOW QUALITY
LANDFORM	steep, massive structure of landform	undulating	flat

COLOUR	more than 50% of the area is harmony and vivid in colour	30-50% of the colour in the area is harmony	harmonic colour in the area below 30%
VEGETATION	the variety of plants types and species more than 10	the variety of plants types and species from 4-9	variety of plants types and species below 3
LANDCOVER	the amount of green space/natural area is more than 50%	amount of green space is within 20%- 49%	amount of green space is less than 20% (significantly more developed area)

Table 6 The scenic quality valuation and criteria that has been used by author

Visual Impact Assessment Evaluation

Determination of public sensitivity levels are as follow;

LEVEL 1- HIGH SENSITIVITY

Primary transportation systems of state importance. These includes classified tourist roads and routes, and tourist trails. The roads with cultural and scenic significance. Primary and high-use recreational routes. High level of concern for scenic quality and landscape change.

LEVEL 2- MODERATE SENSITIVITY

Recreational, cultural or scenic sites and viewpoints of state significance. Low-use recreational areas. Villages or residential areas with moderate concern for scenery and landscape change.

LEVEL 3- LOW SENSITIVITY

Forest and only busy on weekends in peak season. Walking track of local significance. Recreational areas with only very occasional use and of local significance.

LEVEL 4- VERY LOW SENSITIVITY

Roads with fewer recreational vehicles per day. Seldom-used forest tracks.

Three distance zones, as measured from the viewpoints, are used to stratify the viewing importance of the plotted seen-area

Table 7 The table of valuation and criteria for Gunung Keriang.

VOP	SENSITIVITY LEVEL 1 (High) – 4 (very low)	SCENIC QUALITY CLASSES 1 (Low) – 3 (High)				TOTAL	VISUAL QUALITY 4 – 6 L 7 – 9 M 10 – 12 H
		LANDFORM	VEGETATION	COLOR	LAND COVER		
WEST-EAST	1	3	3	3	3	12	HIGH
NORTH-SOUTH	4	1	2	2	1	6	LOW
EAST-WEST	3	3	3	2	1	9	MEDIUM
SOUTH-NORTH	4	2	3	3	1	9	MEDIUM

Table 8 The table of valuation and criteria for Gunung Keriang.

		DISTANCE ZONE/ SENSITIVITY LEVEL								
		fg1	mg1	bg1	fg2	mg2	bg2	fg3	u	
SCENIC QUALITY CLASSES	H	A	A	A	A	B	B	B	B	B
	M	A	B	B	B	B	C	C	C	C
	L	B	B	B	B	C	C	C	C	C

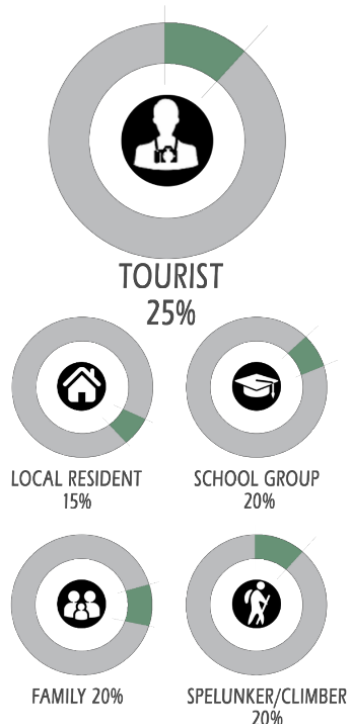
LANDSCAPE PRIORITY ZONE

Table 9 The matrix formula for the evaluation.

LANDSCAPE PRIORITY ZONE BASED ON EACH VOP		
VOP	ZONE	CONSIDERATION
WEST-EAST	A = IA	High concerns for visual resource values = Inevitable Alteration objective; the landscape character must be fully retained
NORTH-SOUTH	C = DA	Low concerns for visual resource values = Dominant Alteration objective; the landscape character may be modified
EAST-WEST	C = DA	Low concerns for visual resource values = Dominant Alteration objective; the landscape character may be modified
SOUTH-NORTH	B = AA	Moderate concerns for visual resource values = Apparent Alteration objective; the landscape character must be partially retained

Table 10 The Landscape Priority Zones- result of the evaluation.

5.2. Identification of primary user



USER GROUP	ACTIVITY-FACILITY NEEDS
TOURIST	<ul style="list-style-type: none"> • Geology information • Toilet • Information center • Water activity • Viewing spot • Decking • Flora and fauna information • Food court
LOCAL RESIDENT	<ul style="list-style-type: none"> • generate income • Food court • Stall • Gathering space • Local community spot
SCHOOL GROUP	<ul style="list-style-type: none"> • open space for outdoor education • Light recreation area • hiking • Geology information • Toilet • Food court • Souvenir shop
FAMILY	<ul style="list-style-type: none"> • Recreation space • Camping site • Information center • chalet • Food court • Picturesque view deck
SPELUNKER/CLIMBER	<ul style="list-style-type: none"> • Highlighted entrance/exit • Information center • Extreme activity • Connectivity of extreme activity • Wall climbing

Figure 7 The percentage of user group the the activity-facility need

Target users obtained from observation evaluation revealed that 25% of user are from the domestic tourist. This make them are the primer user of this site followed by school group, family, spelunker/climber and local resident. After being interviewed on what they need on site, the activity- facility needed are gathered in the table above.

6. Conclusion

Based on the inventory and analysis has been made, it can conclude that the Gunung Keriang must be protected as its valuable element that are unique. If they disappear, our future generations will not able to appreciate them and to understand the past. Thus, efforts are need to be taken to maintain the geological landscape at their original condition. Gunung Keriang area has potential to become a successful geotourism site by flourish the flora and fauna that are needed by community here. Knowledge about geological landscape are lacking among the professionals and they have to undertake in-house training for the enrichment of their knowledge.

Acknowledgement

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Constructed reproduction channels for fish

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Abstract

The ecological state of rivers is declining worldwide because of regulation and construction of hydro power. On the other hand, there is an interest for removing dams and reviving migratory fish stocks also in constructed rivers. When removal of dams is not possible, nature-like fish passes and reproduction channels enable migration of all species but also reproduction of fish. They provide an option to compensate the loss of river habitats. They can also bring new aesthetic values with flowing water.

The Imatra City Brook in Finland was constructed in 2014 to be a new spawning and reproduction site for a local stock of Brown trout (*Salmo trutta*). Also the importance of the site for tourism was considered. With height difference 25 m and length 1 km, stone material as rapids was used in the entire length of the channel. Logs and stumps were added for protection of fish. The steep sections fish migration was a concern. The water into the brook is lead into two ponds at and the upper reach flows at the site of an old log floating chute. The brook flows in a tunnel under a street with a peer for pedestrians along the brook. An aqueduct over a valley is constructed as a resemblance of log floating. The downstream section is curving to reduce gradient and to increase length and width for optimal fish habitats.

Flow and habitat modeling was used during the design to evaluate flow velocities, depths and suitability for juveniles of different age. The finalization of the construction was done according to the best practices of river restoration. After construction, measurements showed that the gradients and hydraulic features were near to the planned.

Monitoring of benthic macroinvertebrates show that the brook is getting high diversity and that the macroinvertebrates serve well as nourishment for fish. The brook has been adopted by several natural fish species. Brown trout has migrated and spawned in the brook from the first autumn onwards and in two years the densities of trout juveniles became even higher than normally in natural brooks. The brook has fulfilled or exceeded the expectations of the

performance as reproduction channel. Ongoing monitoring will show the development and limits of the juvenile production.

In landscape design of channels with special requirements for fish, knowledge of hydraulics and fisheries needs to be combined with aesthetics. Monitoring of succeeded cases is essential to convince decision makers of the benefits of compensative habitats as an effective way to implement environmental flows. The good results of Imatra City Brook are equal to international similar cases and gives confidence that the experience can be applied at other hydropower sites all over.

Keywords: nature-like fish pass; rearing channel; compensation; fish; benthic macroinvertebrates

1. Need for research

Rivers with rapids and waterfalls are prominent features in landscape. Their natural values with migratory fish have in many cases been lost or deteriorated by other interests like power generation. In many countries movements for removal of dams are increasing. Political decisions have been made to revive fish stocks despite also use of power generation. Defining environmental flows for the benefit of river ecology in power plant permits is ongoing. In Finland the National fish pass strategy is made to promote decisions for reviving migratory fish.

In constructed rivers where natural reproduction areas have vanished under damming, fish passes are not a sufficient solution reviving fish stocks. Compensation measures and are needed to replace the lost reproduction areas by constructing new ones.

In some countries like Canada there is a long history of reproduction channels for

Pacific salmon species [1] and there are applications also for Atlantic salmon [2]. In Germany, Switzerland and Austria new reproduction channels have been constructed according to environmental legislation requiring compensation of lost habitats [3]. The channels serve also as migration routes or they can be connected with separate fish passes. In Finland there is some experience and guidelines of constructed habitats.[4] Their values need still to be proved by research.

2. Case: Imatra City Brook

Imatra City was founded at the famous rapid of Imatrankoski, once the biggest rapid in Finland. The place is still important for tourism. After construction of a hydro power plant in 1929 the rapid can only be seen during limited water release events in summertime. Imatra City Brook, constructed in 2014, is the first artificial channel in Finland which was planned mainly as a new habitat for fish, Brown trout (*Salmo trutta*) in connection to a hydro power plant (Fig. 1).

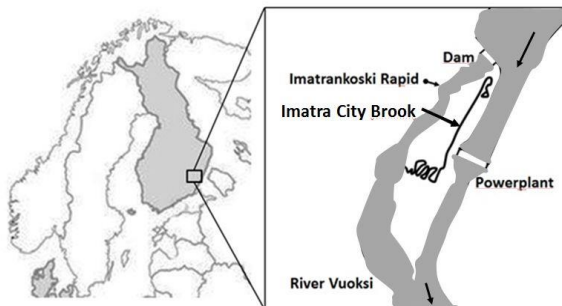


Fig.1 Imatra City Brook at river Vuoksi

The length of the brook is one kilometer and height difference 25 meters. Rapids are prominent in the course of the brook. The upper, rather straight section is constructed on the site of an log floating chute.(Fig 2).

The city wanted to promote natural trout reproduction for touristic fishing at the river Vuoksi and also to design a new water feature in which flowing water can be seen all year round. The power company Fortum was willing to give water into a compensative habitat for the local Brown trout stock, which was in danger in the seepage brooks because of dam reparations. The discharge, 300 litres/sec in summer and 180 litres/sec in winter, is lead into the brook by pipes into two ponds (Fig. 3.)

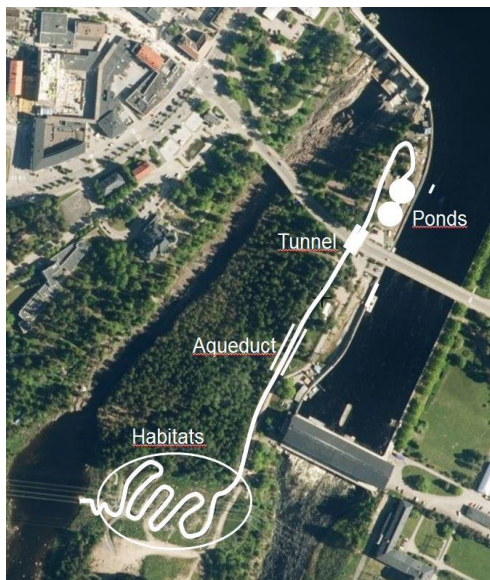


Fig.2 Imatra City Brook with its characteristic features



Fig. 3 The second pond

The brook goes in a tunnel under the street with a peer for pedestrians (Fig. 4) and flows as aqueduct over a valley, resembling the old floating chute (Fig. 5) The downstream part is designed curving as a more gentle sloped habitat section. Because of the need of protection for fish, a lot of wood material is placed in the brook.



Fig. 4 The tunnel with a pier for pedestrians



Fig.5 The aqueduct in winter

2.1 Planning

The leading planner of the project was landscape architecture bureau MA-Arkitehdit, together with Finnish Environment Institute SYKE and Ecoriver Ltd. Special consideration was set in the planning of the habitat section, which was planned meandering to increase length and

to maximize good quality of juvenile habitats (Appendix).

Gradients in the plan of the habitat section were from 0.25% to 5 % with deeper pools between. Cross sections were defined considering low water depth for juveniles but also possibility for bigger fish to migrate up and down. (Fig. 6.)

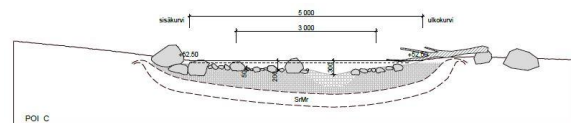


Fig. 6 Example of a cross section

2D flow modeling was used to evaluate the velocities and depths by different discharges (Fig 7.)



Fig.7 The flow model shows velocities up to 1 meter/sec

Habitat model was created by adding bottom substrates and preference conditions of Brown trout in the plan. The habitat model showed good condition especially for small juveniles (Fig.8.)

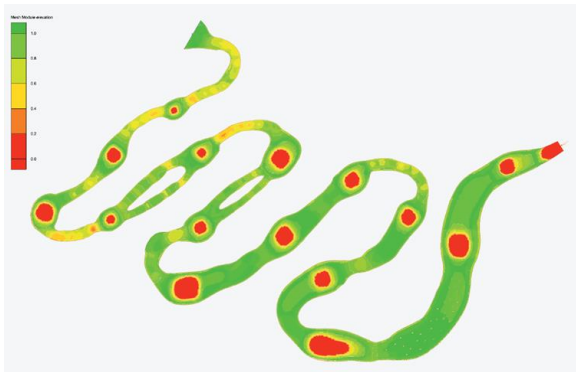


Fig.8. The habitat model shows good conditions for small trout juveniles (green).

2.2. Evaluation of the channel after construction

The channel was first constructed roughly according to the plan and then finalized, having water in the channel, by experts of river restoration. After construction the channel was scanned and gradients between pools and steep rapids were counted. The gradients were mostly between 0.5 and 1 %, which are similar to the plan. (Fig.9)



Fig. 9 Scanning of the constructed channel, showing individual stones, tree trunks and stumps



Fig. 10. A site with gradient 0.5 %, indicated also as excerpt in the scanning in Fig.9

The scanning showed that even if the construction was not done exactly, by good finalizing cross sections and gradients could be accomplished according to the aims of the plan.

2.3 Measurements of hydraulics

The hydraulic parameters, flow velocities and water depths were measured in three channel types: juvenile habitats with gradient 0.5 %, spawning gravel areas, and steep sections, which could be difficult for fish to swim up [5]. The juvenile habitats (Fig.10) showed velocities 0.05-0.85 cm/sec and depths 0.3-0.4 m. The spawning gravel areas which are mostly situated at places where the velocity begins to accelerate after pools (Fig.11), velocities were 0.5-0.75 cm/sec and depths were 0.1-0.25 m.



Fig. 11. Spawning gravel site

The steepest section downstream had gradient 16 % and maximum velocities 2 m/sec (Fig12.)



Fig 12. The steep section downstream

The measurements verified that the velocities and depths were nearly same as in the flow model and also within the limits of the preference conditions of trout in natural streams. The fastest velocities were higher than normally in fish passes but still under the burst velocities of most fish species. Fish are also able to find smaller velocities in vortices.

3. Monitoring of vegetation and fauna

First monitoring of fish was possible in May and June 2015, as big amounts of Roach (*Rutilus rutilus*) and Bleak (*Alburnus alburnus*) were seen in the up most pond, showing that the steep section is passable for also weak swimming species. Comprehensive monitoring of fish and benthic macroinvertebrates was conducted in 2016 and 2017, taking samples of different sections of the channel (Fig. 13).

3.1 Vegetation

Especially the downstream section is still without shading and protecting trees. Trees like alder (*Alnus glutinosa* and *A. incana*) were noticed to have natural sprouts on the banks. Aquatic vegetation begun to spread from upstream, entering probably with the water through the pipes. Monitoring in 2017 showed 10 submerged aquatic plant species in the ponds upstream. Most of them were typical for lakes, showing an influence of the great lake system of the Vuoksi river basin.

3.2 Benthic macroinvertebrates

Benthic macroinvertebrates consist mostly of larval stages of insects. A significant increase of individual amount in the samples, from 1500 to more than 8000 could be noticed between the two years. Also the amount of species increased from 26 to 40.

The composition of the invertebrates was analyzed by dividing them into functional feeding groups. In 2016 there was a

dominance of predators, which shows availability of other groups and high diversity in the new channel (Fig.14). 2017 the amount of scrapers, which feed on algae, increased significantly. The algae are a result of openness of the new channel.(Fig 15). Gatherers and shredders were still rather few because of the lack of litter from leaves.

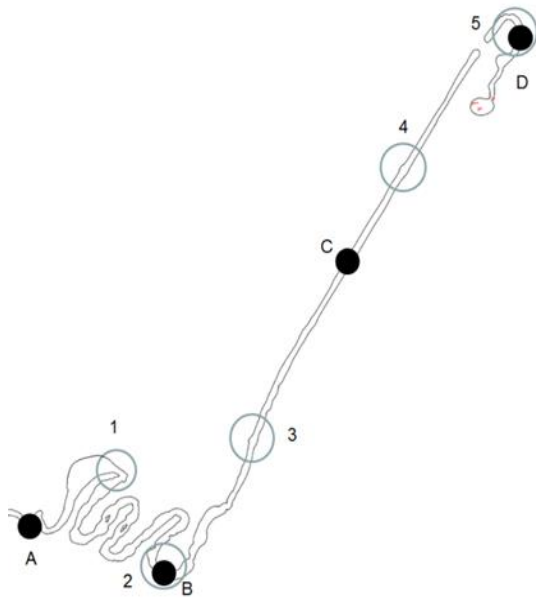


Fig.13. Monitoring sites of macroinvertebrates A-D and electrofishing 1-5

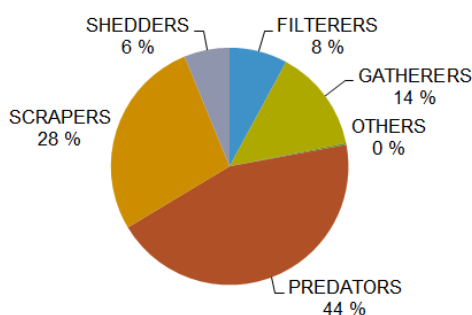


Fig.14. Functional feeding groups according to the abundance of macroinvertebrate individuals in 2016

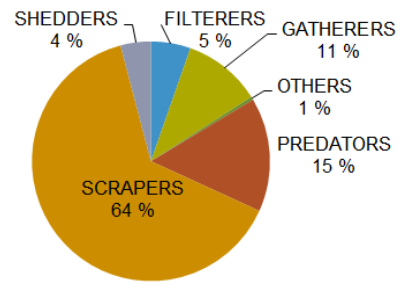


Fig.15. The functional feeding groups 2017 show dominance of scrapers

3.3. Electrofishing

Electrofishing in 2016 showed that Brown trout had found the brook in autumn 2015, already. There was a high density of first summer (0+) trout juveniles in the channel, average 40 juveniles /100 m². In 2017 there was again about same density of first summer juveniles (Table 1).

Site	2016 0+	2017 1+	2017 0+
1	63	13	64
2	76	42	3
3	17	62	0
4	41	19	131
5	3	17	17
	40	30.6	43

Table 1. Results of electrofishing for Brown trout

In 2017 there was an exceptionally high density, altogether 150 juveniles/100 m² on site 4 downstream from the tunnel (Fig 4). In average there were 30 second summer (1+) juveniles /100 m². The survival rate, 75 % is much higher than normally in natural streams. This gives the estimation of 2000

smolts (juveniles beginning migration to the river) per hectare, which is much more than in natural rivers. Estimation is normally only 400 smolts per hectare. Additionally, several bigger trout were caught in the electrofishing (Fig 16)



Fig.16. A trout of half kilograms was caught

3.4. Dietary samples of fish

Dietary samples were taken by flushing from some fish (not harming them). The most common nourishment were larvae of Mayfly (*Baetis*), which were also the most common species of the macroinvertebrates. The fish were in a very good condition, showing that there is enough nourishment for them in the brook.

4. Conclusions and applications

The Imatra City Brook is an example of landscape architecture project where special ecological and hydraulic knowledge were combined in the planning. An interesting new feature in the landscape could be created in an area with touristic importance.

The monitoring of the hydraulics verified the information of flow and habitat

modeling, which thus was proved to be useful in evaluating the expected effects of the planning of aquatic habitats in the planning phase.

The monitoring of benthic macroinvertebrates showed a rapid colonization and development of the channel to a diversified new ecosystem and that there is plenty of nourishment for fish.

The immediate migration and reproduction of Brown trout and high densities, good condition and survival of juveniles give confidence that constructed reproduction habitats can have great possibilities in reviving migratory fish stocks. Steady and protected circumstances give basis to a high production rate per channel area with a rather limited amount of discharge.

The case shows that in relation to the discharge which is needed for the channel width and habitat area, reproduction channels are an effective way to utilize environmental flows for creating new reproduction habitats. The reproduction is in three years bigger than natural streams. This corresponds to some international similar sites. The good experience can be applied in hydropower plants in different circumstances.

Acknowledgments

The modeling during the planning was conducted by Simo Tammela. Construction of the brook was done by VRJ South Finland and finalizing and later electrofishing by Markus Tapaninen and Pekka Vähänäkki from Southeast Finland ELY -centre. Macroinvertebrate samples in 2016 were taken by Pinja Kasvio from

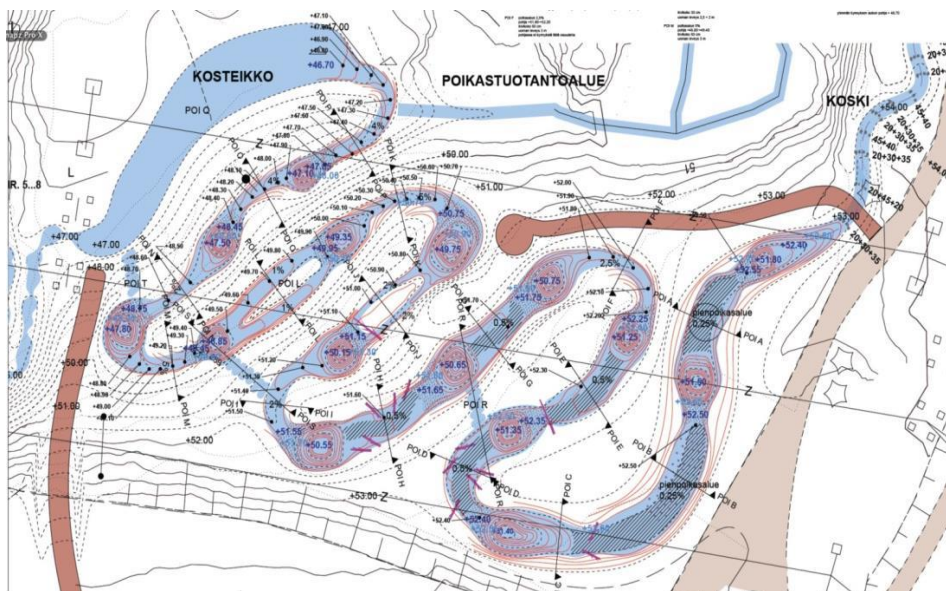
SYKE. The samples in 2017 were taken and all samples were analyzed by Kirsti Leinonen from SYKE. Dietary samples of the fish were taken by Saija Koljonen from SYKE.

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Appendix. Plan of the habitat section



Sustainable recovery of the mangrove forest based on productive landscape

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Abstract

Due to the pressures of urbanization, land exploitation and economic development, we are losing urban habitats at an alarming rate, such as the mangrove forest in the south of Shenzhen City. This paper aims to discuss the problems of disappearing mangroves caused by the aquaculture, and also attempts to propose some feasible methods to balance the habitats preservation with land exploitation. According to mangrove's characteristics and water environment of the experimental site, it is suggested to transform the aquaculture ponds into productive landscape. In this case, a symbiotic relationship between mangroves and aquatics would be built, and the gradually sustainable recovery of the mangrove forest would be great potential.

Keywords: mangroves; habitat; productive landscape; recovery; water environment

1. Background

Nowadays, most of the mangroves have been relegated to the edge of the city because of the serious urbanization. As one of the most diverse ecosystems in the world, mangroves have a positive effect on the development of the city, such as wind protection and wave protection, the promotion of silting and the beach protection and the bank protection. It is a special ecological system for the transition from land to the sea. However, this ecosystem is being seriously threatened by human beings.^[1]

Shenzhen, located on the East Bank of the Pearl River Delta in southern China, is a new and modern city with a certain international

influence. The coastal border of Shenzhen has a large number of natural mangroves, but as the population of Shenzhen continues to increase, the urban area is expanding. In order to meet the demand for production, in order to obtain more economic value, the mangroves are cut down, the border of the city and the sea is encroached, and the cultivated fish in the sea are encroached by the sea. Shrimp. Over time, a large number of mangroves at the junction of land and sea gradually evolved into shrimp ponds for production. At the same time, because of the gradual disappearance of the mangroves on the east coast of the Pearl River Delta in recent years, Shenzhen has been repeatedly attacked by typhoons, and the shrimp ponds have also been damaged by the waves, which

have brought bad influence to the local urban construction and economic development.

2. Objectives

Based on this situation, we seek to create a sustainable development mode combining production and ecology based on the concept of protection and economic development.

Through the analysis of the current land use, we found that the area of mangroves and the area of urban land are disproportions, and the area of mangroves and the proportion of the area of the shrimp ponds are disproportions. The development of the urban border is incongruous. If we can make mangrove, shrimp ponds and urban land balanced development and achieve "dynamic balance", we can achieve a sustainable development mode.

3. Medium: mangroves

Mangrove forest is a woody biome of tidal flat wetland, which is composed of evergreen shrubs or trees with mangrove plants as the main body of the tropical and subtropical low energy coastal intertidal zone, which is flooded with periodic tidal water. It is a special ecosystem of land to ocean transition, growing on tidal flat shoal of land and sea. [2] The mangrove is the main component of the mangrove family, and the mangrove family has 16 genera and 120 species. Some of the mangroves are grown in the inland, a part of the mangrove, and some of the associated elements of the so-called semi mangrove trees near the mangrove community.

Mangrove is the last "ecological barrier" in the transition from land ecosystem to marine ecosystem. It plays an important role in purifying sea water, resisting wind and wave, protecting the coast, improving ecological conditions, maintaining biodiversity and ecological security in coastal areas. As mangroves grow on the sea tide and soaked saline soil for a long time, a unique and unique ecological characteristic is formed. It promotes the formation of the soil through the net debris, resists the impact of the tides, and has a good effect on retaining the bank and resisting the wind and waves. The strong roots of the mangroves, which grow in the seashore, have a strong ability to fix the banks of the beach, and have a strong "energy dissipation" effect on the wind and waves, which are the natural barriers to the tsunami.

3.1. Biological characteristics of mangroves

Because of the special conditions of marine environment, mangrove plants have a series of special ecological and physiological characteristics. In order to prevent the shock of the waves, the trunk of the mangrove plants generally does not grow infinitely, but most of the support roots from the branches and into the mudflats to keep the plant stable. At the same time, a lot of finger shaped aerial roots grow from the roots and come out on the beach floor. They are used to ventilate at low tide or even when the tide is submerged, so they are called breathing roots. [3]

The most wonderful feature of the mangrove is the so-called "viviparous phenomenon". Many of the plants in the mangrove, which have not yet left the mother, have begun to germinate in the fruit and grow into a bar shaped hypocotyl. When

the hypocotyl develops to a certain extent, it breaks away from the mother tree and falls into the silt of the beach. After a few hours, it can grow in the mud and grow into a new plant. The hypocotyl that fails to root in the silt in time can grow on the coast of thousands of miles along the sea for several months.

3.2. Growth environment of mangroves

The distribution of mangrove plants on tidal flats is strictly controlled by the degree of tidal immersion. Mangroves can only be distributed on the beach surface between the average sea level and the average high tide level of the regression tide.^[4] The high or low tide immersion will affect the normal growth of the mangrove plants. This is the most suitable area for mangrove growth. We call it intertidal zone. With the development of coastal landform and mangrove itself, mangroves often extend to the outer edge of the coast.

The adaptability of mangrove plants to salt soil is stronger than any terrestrial plant. It is determined that the salt content of the sea water in the outer edge of the mangrove belt is 3.2 - 3.4%, and the salt content of the inner rim is 1.98 - 2.2%. At the outlet of the river, the salt content of the sea water is lower. Mangrove plants are salt loving plants. They are usually not found in riparian banks.

Temperature plays a decisive role in mangrove distribution and community structure and appearance. The mangroves of the equatorial region are up to 30 meters high, and the species are also the most complex, showing the appearance and structure of some terrestrial tropical forest communities

and the presence of vines and epiphytes in the forest. With the increase of latitude and temperature, mangrove forest is less than 1 meters. The most suitable for the growth of mangrove sea surface temperature is 21°C—25°C.

4. Strategies

4.1. Base peri aquaculture system

The base peri aquaculture system is a low investment and low production of self-sufficient and self-sufficient farming system, which can be contracted by farmers. It uses natural seeds and natural bait, which could continue to operate for a long time without damaging the environment. Its specific practice is that surrounded by a slightly higher earth dyke, a pond is constructed, while there would be several artificial dredging connected channels between them. In this simple system, the beach land can be grown for mangroves, and mangrove plants provide a better breeding environment for fish and shrimp. At the same time, waterways can be used to breed fish and shrimp, and the excreta of fish and shrimp can also promote the growth of mangrove plants.

4.2. Suitable environment for growth

Considering that the normal growth of mangroves requires suitable intertidal zone, suitable salinity and temperature, we try to put the pile array out a suitable area for the growth of mangroves. Then, some baskets filled with soil could be used to fasten the pile. During the tide, the silt brought by the sea was deposited in the region. Over time, the silt raised the elevation of the beach surface,

increased the area of the intertidal zone, and also changed the salinity and temperature of the sea water to a certain extent, and provided a more suitable environment for the breeding and growth of the mangrove.

5. Results

In terms of the overall planning strategy, we aim to minimize human intervention. First of all, we should protect the existing areas where mangroves grow well and create suitable conditions for their growth and reproduction in their marginal areas. Then, combined with fishery production, the shrimp pond area with the largest area will be rebuilt based on the base aquaculture system.^[5] Finally, landscape elements, transportation system and auxiliary facilities are introduced into the small area to meet the functions of modern fishery production and recreation.

5.1. Layout

According to the urban land use type and the growth cycle of mangrove, we take the shallow coast suitable for the development and growth of the mangrove area as the protection area, the original farmland and the reformed shrimp pond as the production area, the green space and the park near the city are transformed into a recreation area with the mangrove landscape and culture.

The mangrove protection area has minimal manual intervention, minimal facilities design and strict human volume control to guarantee the natural growth of mangrove plants. The main activities here are scientific researchers and professional maintenance workers and help to reproduce mangrove

plants with professional technology. Tourists can enjoy the mangrove landscape at a distance, and there are also a few walkways for crossing mangroves and close contact with plants and animals.

In terms of economic benefits, we optimize its environment in the production area and refer to the new mode of fishery production and operation to promote the growth of mangrove and fishery production. The production area as a transition area of the city to mangrove community, coordinate the contradiction between human and nature, and achieve a symbiotic ecological balance.^[6]

Recreational areas are mainly distributed on the outer edge of the city, connecting to the urban area, providing an open space for citizens and tourists. In these public spaces, people can not only carry out leisure activities, sports activities and parents and children's activities, but also know some of the science knowledge about mangroves, so that tourists can understand the important role of mangroves and improve the awareness of mangrove protection at the same time. In addition, the recreation area as the city green corridor, to enrich and enhance the city border color and energy.

5.2. Transportation

The external transport links attached to the Shenzhen City traffic system, the traffic is divided into urban ring road, urban expressway and urban primary and secondary roads after the planning and adjusting which provides a convenient transport links between the city boundary and the city.

The internal transportation system within the growing mangroves' border mainly have the primary and secondary roads in the boundaries to connect the urban transport system, the water marine traffic routes to meet the needs of transportation at sea, the roads in the shrimp ponds for the product requirement and the garden path to service open space areas. The planning takes the sustainable development goals of the municipal boundaries into consideration, trying hard to provide a balanced developed environment for the mangrove forest, shrimp ponds and the urban land.

5.3. Facilities

To meet the development and life needs of the city boundary's growth, we organize the auxiliary facilities into a system. Based on its function and local conditions, those facilities are arranged properly. In the place of highly used, ancillary services, medical care, inquiry, restrooms, and parking lots are planned to satisfy the tourists' need as well as the requirement of production. Meanwhile, in those areas, several medical care and services that supply insurance for the travelers are taken into account. Besides, to fully protect the protected area, little facilities are set to control the tourist's number.

6. Conclusion

The sustainable recovery of mangroves is crucial to the future development of the city and the protection of the global environment, which is widely used in other cities with similar status in the world by using the system of basic peri aquaculture, the insertion of recreation, production and protection of

different functions. We hope to realize the dynamic and balanced development of mangroves, shrimp ponds and cities through this sustainable development model, take the growing border of mangroves as the protection Gallery of urban development, use green barrier to protect the city and provide fresh vitality for the city, attract different people and strengthen the economic development of the city.

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Impact of Summer Campus Square Marginal Space on Microclimate Environment

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Abstract

Abstract: Taking the edge space of three plazas in a campus in Fuzhou, Southeast China as the survey object, selected the typical summer weather (after rain, cloudy and sunny days), monitored the data of wind speed, humidity, temperature, and so on, discussed climate monitoring data and human comfort degrees of time and spatial change characteristics and regularity of degree index in different constituent type edge spaces. The results show that: (1) The temperature and humidity changes at different sites are basically the same in different weather conditions. The comfort index of the human body is uncomfortable on sunny and cloudy days, and the comfort index of the human body after the rain is comfortable; (2) The plant constitutes the main In addition, the edge of the tree shading has the strongest ability to adjust the edge space, and the monitoring ability of the monitoring site with the hard paving and no shading on the underlying surface is the weakest; (3) Different types of edge space have different functions, and the adjacent space has different functions. There is a clear difference in the microclimate environment.

Keywords: campus square; edge space; typical weather; microclimate; human comfort

1. Introduction

Christopher Alexander stated in the book "Architecture Mode Language": "If the boundary no longer exists, then space will never be full of anger"[1]; American design master William White defined the edge as "a positive margin is a means to enhance the sense of place in a square, and a sense of security is at the edge of the Plaza"[2]. In summary, the edge can not only cut off the space, but

also the limitation of the field, which is equivalent to the connection and transition of the two adjacent main bodies.

With the development of urban leisure life in China, people's demand for outdoor activities is increasing day by day. Squares are the spatial forms of people's leisure activities in cities, and they also affect people's physical and mental health [3-7]. College squares are part of the city square and their clients are more clearly focused [5]. At present,

the researches on microclimate mainly focus on green space systems, urban waterfront belts, urban plazas, and urban residential areas [8-15]. There is little research on campus plazas, and about the campus plazas mainly focusing on the interior of the site, while little research about the microclimate environment of the edge space.

The square edge space described in this article refers to the space within the red line of the square land and directly adjacent to the land surrounding the square, that is, the outermost space around the square [16-18]. The research chose different types of edge space of Fujian Agriculture and Forestry University campus square as the research object, seted up its adjacent space as the reference object, and explored the relationship between different typical weather, different time periods, different space and temperature, humidity and wind speed. This study provides data support for the planning and design of urban square marginal spaces and new construction ideas to ensure a comfortable microclimate environment. Research can also expand the relevant aspects of microclimate environmental research, provide guidance for the planning and design of the square and the travel of people in Fuzhou and even the whole country.

2. Test plots and research methods

2.1. Sample selection

The test sample was selected on the campus of the Fujian Agriculture and Forestry University in Fuzhou, Fujian Province (119°23' east longitude and 26°08' north latitude). The campus is located in the west of Fuzhou City and belongs to the maritime subtropical monsoon climate, the winter is short and summer is long. Therefore, the season of this study chose long summer. Three spaces in the campus of Fujian Agriculture and Forestry University were used, which are relatively frequent and representative: the front square of Boxue Building, the front square of Yifu Library, and the Tuohuang Square. Finding the test points of the edge space in accordance with this study, and the control test points were seted outside the center of the square and inside the square. A total of 17 test points were used for the actual measurement of the microclimate data.

The components of the test points mainly include: plants, pavement, cement and so on. The 17 measured sites can be divided into 6 types: lawn-based edge space (S7), arbor and lawn-based marginal space (S2, S4), arbor, shrub and lawn-based edge space (S9, S16), arbor, lawn and pavement-based edge space (S12, S14), pavement-based adjacent spaces (S1, S6, S11, S13, S15), and the cement-based adjacent spaces (S3, S5, S8, S10, S17) [19].

Table. 1. Basic information on observation points

Sample name	Observation point number	Observing point type	Measure d position	Underlay surface material	Shading	Widt h(m)
Boxue Square center	S1	Pavement	Inside	Square	No	/

			the square	pavement	shading	
West side of Boxue Square	S2	Arbor	Marginal space	Lawn	Shading	27
West side of Boxue Square	S3	Cement	Outside the square	Cement	No shading	4
East side of Bo-Xue Square	S4	Arbor	Marginal space	Lawn	Shading	27
East side of Bo-Xue Square	S5	Cement	Outside the square	Cement	No shading	4
Yifu Library plaza center	S6	Paving	Inside the square	Square pavement	No shading	/
South side of Yifu Library plaza	S7	Lawn	Marginal space	Lawn	Shading	14
South side of Yifu Library plaza	S8	Cement	Outside the square	Cement	No shading	7
North side of Yifu Library plaza	S9	Arbor, shrub and lawn	Marginal space	Lawn	No shading	27
North side of Yifu Library plaza	S10	Cement	Outside the square	Cement	No shading	6
Tuohuang Square center	S11	Pavement	Inside the square	Square pavement	No shading	/
North side of Tuohuang Square	S12	Arbor, lawn and pavement	Marginal space	Wooden walkway	No shading	8
North side of Tuohuang Square	S13	Pavement	Outside the square	Road pavement	Shading	5
South side of Tuohuang Square	S14	Arbor, lawn and pavement	South Border	Built-in straw brick	No shading	3
South side of Tuohuang Square	S15	Pavement	Outside the square	Road pavement	Shading	4
West side of Tuohuang Square	S16	Arbor, shrub and lawn	Marginal space	Lawn	Shading	20
West side of Tuohuang Square	S17	Cement	Outside the square	Cement	No shading	7

Fig. 1. Edge space distribution location

2.2 Test instrument

The test equipment adopted the United States NK5920 Kestrel 4500 portable climate measuring instrument, measuring range was $-29.0 \sim 70.0$ °C, resolution was 0.1 °C; Humidity measurement range was 0 % ~ 100.0% RH, resolution was 0.1 %RH; Wind speed measurement range was 0.4 to 4 m/s, resolution was 0.1 m/s.

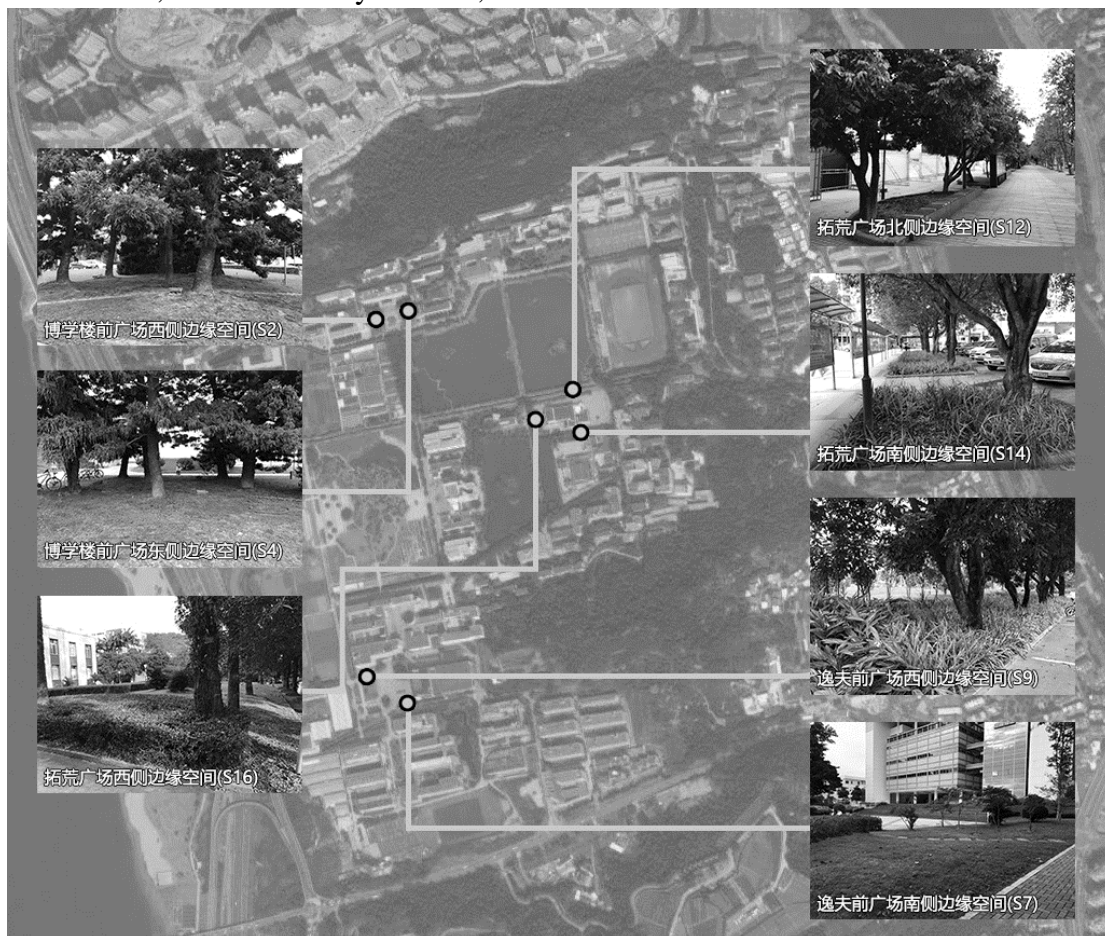
2.3 Test content and methods

The monitoring date was June 22, June 17 and June 27 (cloud after rain 2d); June 24, June 25 and July 10 (sunny day 3d); July 3, July 4 and July 11 (cloudy 3d) [20-21]. The observation period was 6:00-22:00, observed every 2 hours, and

Kestrel 4500 portable climate measuring instrument was used to measure the points in three sample plots in advance, for a total of 17 points. The actual measured data were temperature, humidity, and wind speed data. Each observation point was seted to repeat three times for each measurement. The test height was 1.5 m, which is the height that the human body is most sensitive to temperature and humidity. The final data statistics, processing, and chart production were performed using SPSS19.0 and Excel2013 software.

2.4 Human comfort

Human comfort is based on the



monitored 8 times daily. The NK5920

principle of mutual exchange of energy

exchange between the human body and the surrounding environment, and it is a meteorological point of view to evaluate a biometeorological index of humans in different climates [22-23]. In this experiment, the “comprehensive comfort index” proposed by Lu Dinghuang [24] was used to evaluate the microclimate comfort of the campus square in Fujian Agriculture and Forestry University. The formula is as follows:

$$S = 0.6(|T-24|) + 0.07(|RH-70|) + 0.5(|V-2|)$$

In the above formula: S is the comprehensive climate comfort index, T is the temperature (°C), RH is the relative humidity (%), and V is the wind speed (m/s). The classification criteria for S and human comfort [25] are shown in the table.

Table. 2. Human body climate comfort index evaluation criteria

Rating	Comprehensive comfort index (S) range	Somatosensory comfort level
I	$S \leq 4.55$	Very comfortable
II	$4.55 < S \leq 6.95$	Comfortable
III	$6.95 < S \leq 9.00$	Uncomfortable
IV	$S > 9.00$	Very uncomfortable

3. Results and analysis

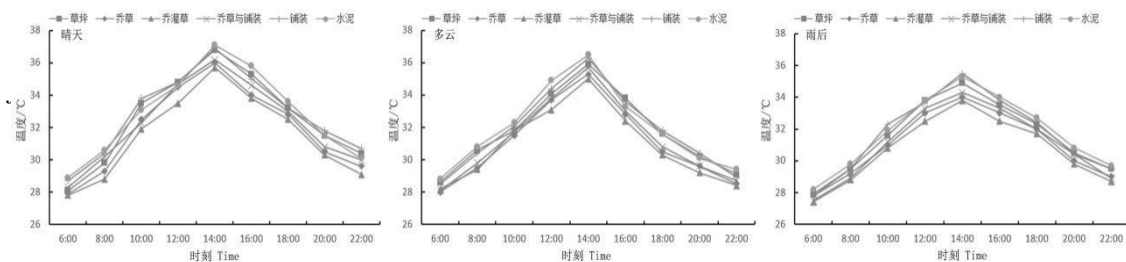


Fig. 2. Diurnal variation of temperature

According to Fig. 2, the microclimatic elements had obvious changes under different typical weather conditions, and the characteristics of the test points under the three typical weather conditions were basically the same. The overall trend was that they first increased and then decreased. The

with shade; After the rain, the overall temperature difference between the observation sites was relatively cloudy and the weather was relatively small. Because the rain and rain water evaporate, the temperature dropped rapidly, and the humidity in the air was higher than the sunny days and cloudy

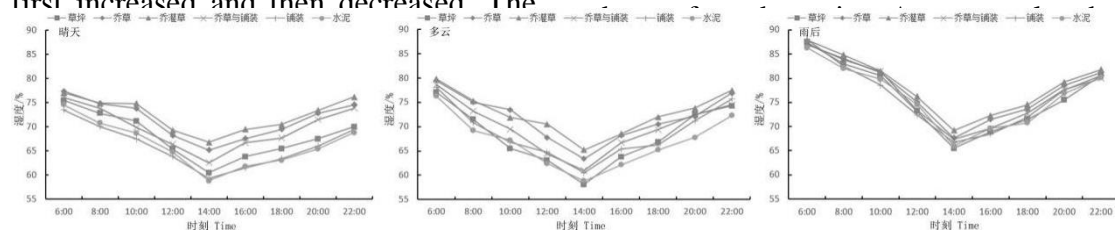


Fig. 3. Diurnal variation of humidity

According to Figure 3, the humidity changes at the three test points were basically the same, the trend of change was opposite to the temperature, showing a “V” change trend of

decreasing first and then rising, and the lowest humidity appears around 14:00. In sunny days and cloudy days, the humidity at the test points decreased with the increase of temperature, the

humidity reached the lowest value at the highest temperature, and then gradually

weaken, therefore, the overall difference in humidity within the air was small, but

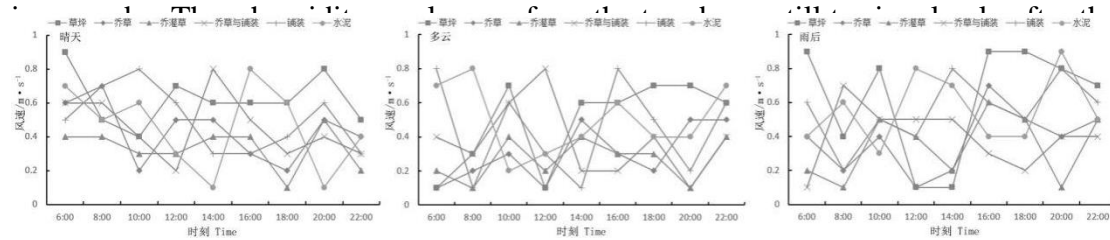


Fig. 4. Diurnal variation of wind speed

According to Fig.4, in the three types of weather, the wind speed changed most when the site was relatively open or there were no shelters around the test points, while the change of wind speed was relatively gradual at test points where the vegetation is rich

space is frequent, the change trend of wind speed was more obvious. The maximum value of wind speed in all three kinds of weather appeared in the empty and unobstructed observation point, while the wind speed in the marginal space formed by plants was lower, indicating that the higher the

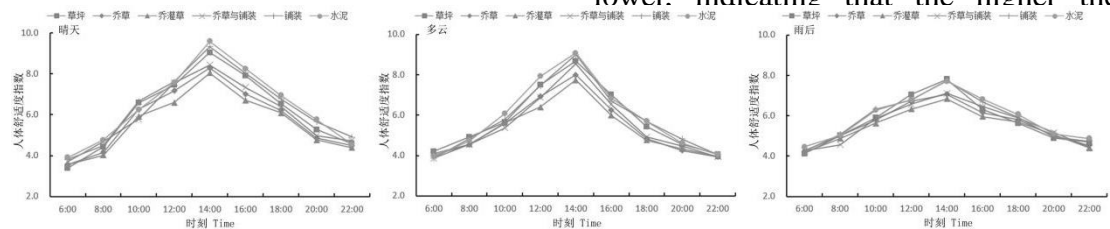


Fig. 5. Diurnal variation of comfort index

The comprehensive human comfort index can directly reflect whether the crowd is comfortable or not, and it is also an evaluation index of the site's microclimate environment. As can be seen in Figure 5, the overall human comfort index at various test points in sunny and cloudy weather showed an inverted “V” pattern, which basically appeared at around 14:00, this time period basically coincides with the time period when the highest temperature and lowest humidity occur; The overall change trend of the weather after the rain also showed a first rise and then a decrease, but the change was more gradual than the sunny and cloudy days. On sunny days, the marginal space

formed by arbor and shrubs and grasses reached grade 3 after 12:00, and the uncomfortable feeling appeared, the rest of the test points were reached after 10:00; On cloudy days, the basic trend was consistent with that of sunny days, but except for the marginal space formed by arbor and lawn, the time to reach the level 3 of the edge space composed of arbor, lawn and pavement is also delayed by 2 hours; After the rain, the comfort level of all test points reached the third grade, which was mainly due to the increase of humidity and the decrease of temperature after the rain.

3.2 Comparison of Microclimate Data of Different Types of Monitoring Sites

Table. 2. Microclimate situation of observation points at sunny day

Observing point Type	Temperature				
	Daily average(°C)	Maximum(°C)	Min(°C)	Daily fluctuation(°C)	Cooling rate(%)

Type	Daily average(°C)	Maximum(°C)	Min(°C)	Daily fluctuation(°C)	Humidification rate(%)
Pavement	32.8	36.9	28.7	8.2	—
Lawn	32.6	36.8	28.1	8.7	0.6
Arbor and lawn	31.9	36.0	27.9	8.1	2.8
Arbor, shrub and lawn	31.5	35.7	27.8	7.9	4.0
Arbor, lawn and pavement	32.2	36.2	28.3	7.9	1.8
Cement	32.8	37.1	28.9	8.2	0.0

Type	Humidity				
	Daily average(°C)	Maximum(°C)	Min(°C)	Daily fluctuation(°C)	Humidification rate(%)
Pavement	66.1	73.5	59.3	14.2	—
Lawn	68.0	75.5	60.5	15.0	2.9
Arbor and lawn	71.5	77.4	65.2	12.2	8.3
Arbor, shrub and lawn	72.5	77.0	66.8	10.2	9.7
Arbor, lawn and pavement	69.8	76.1	62.6	13.5	5.7
Cement	66.3	74.6	58.8	15.8	0.4

Type	Wind speed				
	Daily average(°C)	Maximum(°C)	Min(°C)	Daily fluctuation(°C)	Wind reduction rate (%)
Pavement	0.5	0.8	0.3	0.5	—
Lawn	0.6	0.9	0.4	0.5	-20.0
Arbor and lawn	0.4	0.7	0.2	0.5	20.0
Arbor, shrub and lawn	0.3	0.5	0.1	0.4	40.0
Arbor, lawn and pavement	0.5	0.8	0.2	0.6	0.0
Cement	0.5	0.8	0.1	0.7	0.0

Table. 3. Microclimate situation of observation points at cloudy day

Type	Temperature				
	Daily average(°C)	Maximum(°C)	Min(°C)	Daily fluctuation(°C)	Cooling rate(%)
Pavement	31.8	36.3	28.5	7.8	—
Lawn	31.7	35.9	28.6	7.3	0.2
Arbor and lawn	31.0	35.3	28.0	7.3	2.4
Arbor, shrub and lawn	30.9	35.0	28.2	6.8	3.0
Arbor, lawn and pavement	31.2	35.7	28.1	7.6	1.8
Cement	32.0	36.5	28.8	7.7	-0.5

Type	Humidity				
	Daily average(°C)	Maximum(°C)	Min(°C)	Daily fluctuation(°C)	Humidification rate(%)

Pavement	68.8	78.1	60.5	17.6	—
Lawn	68.1	77.1	58.1	19.0	-1.1
Arbor and lawn	71.9	79.5	63.4	16.1	4.4
Arbor, shrub and lawn	72.7	79.8	65.2	14.6	5.7
Arbor, lawn and pavement	70.0	78.6	61.0	17.6	1.7
Cement	66.8	76.3	58.8	17.5	-2.9

Type	Wind speed				
	Daily average(°C)	Maximum(°C)	Min(°C)	Daily fluctuation(°C)	Wind reduction rate (%)
Pavement	0.4	0.8	0.1	0.7	—
Lawn	0.5	0.7	0.1	0.6	-25.0
Arbor and lawn	0.3	0.5	0.1	0.4	25.0
Arbor, shrub and lawn	0.3	0.4	0.1	0.3	25.0
Arbor, lawn and pavement	0.4	0.8	0.1	0.7	0.0
Cement	0.5	0.8	0.2	0.6	25.0

Table 4. Microclimate situation of observation points at the day after rain

Type	Temperature				
	Daily average(°C)	Maximum(°C)	Min(°C)	Daily fluctuation(°C)	Cooling rate(%)
Pavement	31.7	35.5	27.8	7.7	—
Lawn	31.5	34.9	27.9	7.0	0.5
Arbor and lawn	31.0	34.0	27.8	6.2	2.1
Arbor, shrub and lawn	30.7	33.8	27.4	6.4	3.1
Arbor, lawn and pavement	31.1	34.3	27.5	6.8	1.8
Cement	31.8	35.3	28.2	7.1	-0.5

Type	Humidity				
	Daily average(°C)	Maximum(°C)	Min(°C)	Daily fluctuation(°C)	Humidification rate(%)
Pavement	76.3	88.0	66.7	21.3	—
Lawn	76.2	87.5	65.5	22.0	-0.1
Arbor and lawn	77.7	86.9	67.6	19.3	1.9
Arbor, shrub and lawn	78.6	87.9	69.2	18.7	3.0
Arbor, lawn and pavement	77.0	87.2	67.4	19.8	1.0
Cement	76.2	86.3	66.0	20.3	-0.1

Type	Wind speed				
	Daily average(°C)	Maximum(°C)	Min(°C)	Daily fluctuation(°C)	Wind reduction

					rate (%)
Pavement	0.6	0.8	0.2	0.6	—
Lawn	0.6	0.9	0.1	0.8	0.0
Arbor and lawn	0.4	0.7	0.1	0.6	33.3
Arbor, shrub and lawn	0.3	0.6	0.1	0.5	50.0
Arbor, lawn and pavement	0.4	0.7	0.1	0.6	33.3
Cement	0.6	0.9	0.3	0.6	0.0

3.2.1 Comparison of microclimate regulation effects in different types of marginal spaces

The marginal space observed in this experiment can be mainly divided into four types: lawn, arbor and lawn, Arbor and shrub and lawn, Arbor and lawn and pavement. According to Tables 2, 3, and 4, it can be seen that the average daily temperature was the lowest in three typical weathers in the marginal space dominated by arbor and lawn, the daily average temperature of marginal space dominated by lawn was the highest among the four types and the largest daily diurnal variation. This was mainly due to the fact that it without shade of trees, low canopy density, and accepts increased solar radiation, resulting in rapid heat dissipation, The ability to regulate temperature is weak; Also in the three weathers, the average daily humidity in the marginal space dominated by arbor and shrub is the highest and the daily amplitude is the smallest. This is due to the higher canopy closure, the plant leaves can adhere to water vapor, and the internal air convection is slow, and the evaporation effect is slow; The maximum daily average wind speed basically appeared in the marginal space that was mainly composed of lawns, and the marginal space of the other three types was relatively low, indicating that the marginal space with large canopy

closure can reduce the average wind speed to some extent.

In the marginal space consisting mainly of lawn, arbor and lawn, arbor and lawn and pavement, the middle layer of the plant is more open and transparent, which has a positive effect on the integration of landscapes inside and outside the square; While the marginal space formed by arbor, shrub and lawn is rich in vegetation, and the sights inside and outside the square are not transparent, so the opening is poor and closed, and its ability to regulate the microclimate environment is strong [26]. Lawn, arbor and lawn and pavement are the main elements of the edge space where people can walk through and belong to a relatively open edge space.

3.2.2. Comparison of microclimate regulation effects between marginal and adjacent spaces

As can be seen from Tables 2, 3, and 4, the average daily temperature of the interior space consisting mainly of pavement and the external space composed of cement is the highest among all types of test points. Among them, the marginal space difference between the arbor, shrub and lawn type is the largest, and the difference between the marginal space and the lawn type is the smallest. Because there is no shelter on the site, the solar radiation directly

acts on the underlying surface, and the ability to adjust the temperature is weak. There is a large temperature difference between the edge space where the trees are shaded and the observation point in the square. This is mainly due to the fact that the plant has a certain transpiration, and the arbor crown itself also has the effect of absorbing heat and reflecting. Therefore, the cooling rate is larger, but the temperature variation is smallest throughout the day. The order of cooling rates of various types of observation sites under the three kinds of weather is: Arbor, shrub and lawn > arbor and lawn > arbor, lawn and pavement > lawn > cement; In the three kinds of weather, the humidification rate of the marginal space dominated by arbor and shrubs is the largest, and the external space with the cement composition mainly has the lowest humidification rate. Because the underlying surface belongs to the hard paving, the air convection and exchange capacity are increased. Among them, the difference in humidification rate was greatest at each observation point on the sunny day, and the difference was smallest after the rain, because the increase of water vapor in the air caused the humidification rate of the observation points to decrease. However, the daily changes in humidity at the observation sites have increased relative to sunny and cloudy days. The humidification rate of each observation point was ranked as follows: Arbor, shrub and lawn > arbor and lawn > arbor, lawn and pavement > lawn > cement [27-28]; The smallest change in wind speed is the marginal space formed by arbor and shrub grass. The wind reduction rate is higher than that of other observation points, because the wind

speed changes are relatively flat and the wind speed can also be reduced.

The marginal space microclimate environment has certain differences with the interior of the site. Through the comparative analysis of the marginal space of the site and the microclimate elements of the interior and exterior spaces of the site, different types of edge spaces have a certain regulatory effect on the site's microclimate environment, demonstrate that marginal space has a greater impact on the site's microclimate environment.

4. Conclusion and discussion

(1) Marginal space has a moderating effect on the microclimate environment. Through this study, relatively shady monitoring sites with shaded plant monitoring sites have a stronger ability to regulate the microclimate, and the research results are consistent with the previous ones; However, in this study, the main selection of the site marginal space and the adjacent space microclimate and human comfort compared, while the predecessors focused mainly on the site of the microclimate environment research.

(2) Giving people a certain reference value for travel. The different types of edge space in different weather have a significant effect on the microclimate and human comfort. The comprehensive index of human comfort on the edge of the campus square was the lowest after the rain and the highest on the sunny day. The marginal space composed of abundant plant elements plays a relatively obvious role in reducing temperature and increasing humidity, and the human comfort index

is relatively low, The underlying surface is mainly composed of paving or cement and the adjacent space has weak adjustment capacity [29]. The human comfort index is high. The conclusions of this study can provide more comfortable weather, space, and time for the campus and student and recreational activities of foreign tourists.

(3) Guiding Square Planning and Design. The fringe space can also regulate the microclimate environment of the square to some extent, so the planning and design of the fringe space is an important issue to be solved in the site planning and design [30]. This study mainly compares the measured microclimate data, and uses statistical methods to organize and analyze the relevant data. It is found that different types of edge space have great differences in the adjustment of microclimate and human comfort. The results obtained from the research have certain reference value for the construction and transformation of the future city square.

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The research of spongy or eco- campus practice— Case study proposal of Fujian Agriculture and Forestry University at Fuzhou, China

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Abstract

This study examines Fujian Agriculture and Forestry University as a possible site of “spongy-” or “eco-” (ecological) campus practice. Located within an urban catchment for a bigger urban “spongy city” green and gray infrastructure area, the site analysis follows the China Spongy City Construction Technological Guideline policy and determines that the query of direct volume of 15% to 20% of annual precipitation in total volume of storm and runoff water allowable to drain out of city boundaries and rivers is possible. An estimated total of 80% to 85% of a 2.5 recurrence storm and runoff water volume is detained at the site of the campus. Consequently, the study proposes a schematic plan to adapt potential hazards due to a series of predictable extreme weather events. It proposes progressive design rainfall intensity with unexpected precipitation as well. The study preliminarily concludes that the site has no impact on the extraordinarily improbable flooding or combined sewer or overland drainage detain function. Yet it is very likely a lack of communication and an attitude on campus to bring in in-field and off-site water of deteriorating quality. The study boldly innovates a collecting and recycling garbage plan. All students, teachers, and university staff along with surrounding business district owners, shall collect and recycle all kind of paper, plastic, and metal products associated with disposable boxed brunch, lunch, and dinner and wastes in the near future. The study hypothesizes that the programming will lower solid suspensoid pollutants in retention facilities and stop possible in-field and off-site water quantity and

quality deterioration together. The study organizes these independent variables and tests the hypothesis in respect to two major strategies: first, to launch watershed-based water contamination which includes, but will not be not limited to how to apply site planning and life-quality improvement by this unconstructed collecting and recycling measure; second, to reduce possible imperviousness of the campus site if campus land use is changed. In the end, this study is to place a voluntary participation of recollecting, recycling, and reprocessing campus garbage and particularly taking individual take-out food wastes out of campus site and further making composts and manures for campus and or community's vegetation use. The study will simultaneously measure the contamination ascending and descending indicators on the in-field site. This bottom to top programming is to observe the said spongy city concept with different or seemingly improving urban and or rural community- residences. The study must count and solve the ecological and nature element which improves polluted and tainted environments associated with worsening runoff and storm water problems.

Keywords Spongy City Concept; Eco-Campus; Precipitation, Overland flow; Surface Water Discharge to Retention Facility Wet Pond;

1. Background: Defining the Problem

Hand in hand with the swift momentum of industrialization and urbanization these years, China de facto has developed a polluted and tainted environment associated with worsening runoff and storm water problems. [1,2]. A great deal of unexpected precipitation poured into overland drainage system elevates in-field and off-site urban storm and runoff water drainage quantity and quality corrosion. (3).In several regions and cities such as Beijing on July 21, 2012, within 16 consecutive hours, 170 mm of precipitation in total caused a fearsome catastrophic consequence: 79 fatalities, 1.6 million evacuations and 11.6 billion yen in property damage. See the Figure 1 the precipitation of Beijing and its surrounding areas on July 21, 2012. The Figure presents a sample of clear picture between higher dBZ value of representative of basic albedo

rate and the much higher rainfall of precipitation around Beijing Metropolitan.

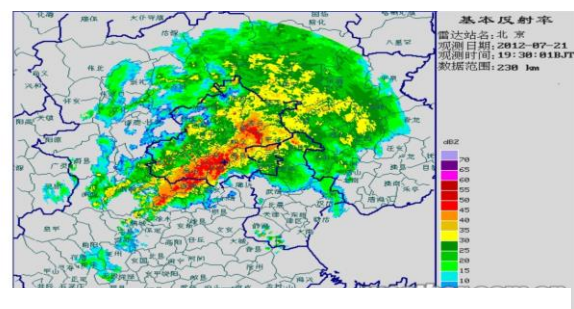


Fig. 1 The precipitation record of Beijing metropolitans and its surrounding areas on July 21, 2012.

From the year 2012, China officially has set into motion an energetic program which applies the “spongy-city” policy to mitigate the situation of storm and runoff flooding. Governments in 2015 specify 17 cities to comply with Spongy City, cities that had a kind of adaptation, reduction, detention, retention, and or absorbance of urban storm and runoff, and infiltrate, treat and improve pollution issue. These cities must meet,

among others measures, low impact development standards.

At the same time, various governments and agencies also fiercely initiate a hypothermic “beautiful village”, or, “beautiful rural community” enhancement or movement. The movement defines a “beautiful countryside” with an appropriate or a beautiful “human settlement living environment” for all of people; this is a from-top-to-bottom approach, a policy generated series of aggregative agenda for so-called “beautifying” metropolitan surroundings and or rural communities. Yet, they are ironically evaluated as an uncompleted solution at best if not total failure at worst.

Many agencies have recognized that expensive cost and low effectiveness of investment is inevitable. Even worse, it is the case that the programs spoil or worsen rural county’s eco- or nature factors. The land use of a campus, of course, whether it is established for a higher education level such as universities or colleges or for a junior or senior elementary one level at urban or rural areas, is eventually an excellent spongy city experimental component of the city and rural area.

2. Programming and Analysis of Eco- and Nature Campus

In view of a straight question and answer or rational approach, the flooding overland drainage associated with in-field and off-site storm and runoff water quantity and quality deterioration problem appears to be too complicated to understand. It is unlikely that a thorough or “right” solution has ever existed since there are so many

existing questions and unknowns. Nevertheless, this study looks at issues of contamination and inundated land-use coverage concerns, and exposes the reality of their possible failure at the study site.

Preliminary test results make the said water quality and quantity questions sound coherent and linear when in fact the recital of results is only conventional. See figure 2, 3, and 4. for the site, Fujian Agriculture and Forestry University at Fuzhou.

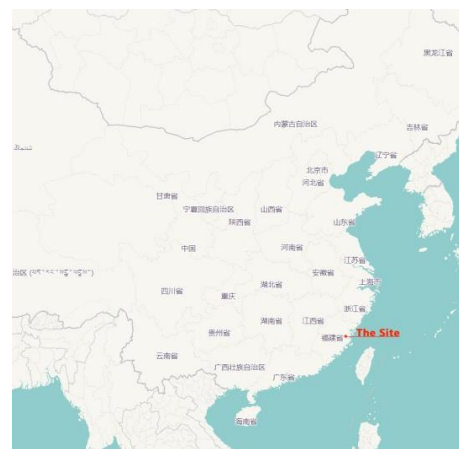


Fig. 2 The Site by region.

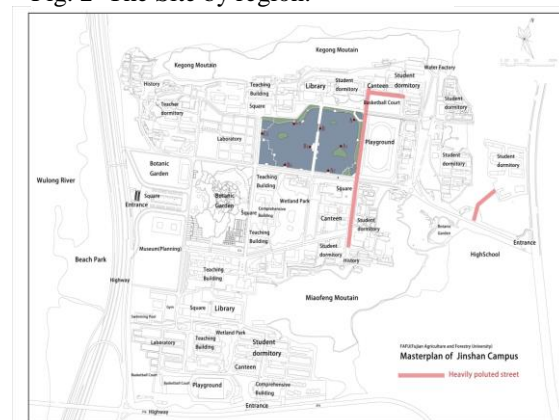


Fig. 3 The campus site and its possible fund pollutant s' locations

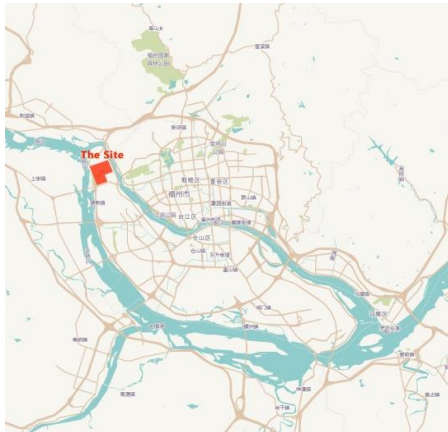


Figure 4 The site at campus and its surroundings.

The Figures of 2 and 3 present the study site, Fujian Agriculture and Forestry University, at Fuzhou, China; The campus is located between Oolong River and Min Jiang River as shown. Figure 4, presents the Campus Guanyin Lake waterfront which is heavily polluted by small business strip area. There are garbage dump sites located along the water-front nearby retention facility of wet pond, that is, the Campus Guanyin Lake. The darkened hatch areas represent a varied garbage tanks. Inside of the lake at Figure number 4, present s the test checkpoints for the pond’s temperature, pollutants and fluctuation levels; The preliminary test results, see the Figure 5,6,7. Figure 5, 6, 7, and 8 present the existing garbage collection and or pollution situation.

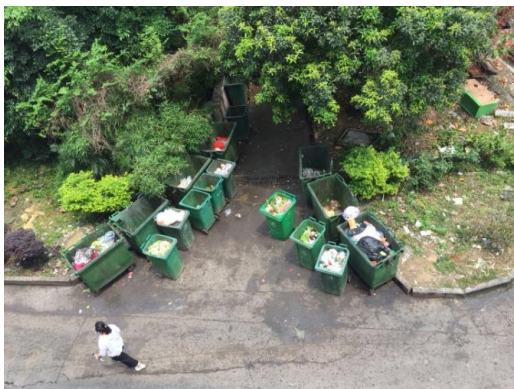


Fig. 5 The garbage tanks at campus.



Fig. 6 Garbage Creating: night market stalls and pedlar booths surrounded campus.



Fig. 7 Garbage creating : Night market and street peddlers.



Fig. 8 Garbage picking and collections.

The study in the beginning is anticipated working with communities and

other universities nationwide to compare the possible outcomes of launching recycling of plastic and food-waste for eliminating condemnation, particularly for solid waste in the retention facility on seasonal basis. Later, during and after the last summer, this study preliminarily concluded that the site of FAFU campus and the impact of extraordinarily improbable flooding of overland flow and drainage are not effected or were not to bring about in-field and off-site water quantity and quality deterioration.

The study then moved to emphasize that garbage concern such as paper, plastic, and metal products associated with brunch, lunch, and dinner wastes directly bring about solid suspensoid pollutants.

Furthermore, a tentative explanation in the form of an observation is that a number of places across campus are developing into polluted and tainted environments. See the Figure 5, 6, 7, and 8 of photos taken at the corner and at Campus restaurants, transportation hubs, and pedestrian gateways. The hypothesis is that if promotion of re-progressing of “county beautification and amenity enhancement” can lead to a neater, cleaner and more beautified setting than before. The study site would then have greatly reduced pollutants flowing into the retention facilities.

The study assumes that any current successes, if there are any, are not final, and any failure is not fatal either. It is the courage to continue that counts. The study is to try a new approach that a neighborhood community resolution, by, from, and of Olmsted’s “communitiveness” shall apply successfully. The application of a sense of shared community and dedicated service, shall count. [4]This urban or rural urbanism

of China shall particularly fit into the community and students, teachers and staff. So do the University and educational administration staff.

3. Preliminary Research and Details

This study is thus to place a voluntary program of recollecting, recycling, and reprocessing campus garbage and particularly for individual take-out food wastes of brunch, lunch, and dinner for making composts and manures for campus and community vegetation use. The study will measure in parallel campus contamination ascending and descending indicators. This will be a bottom to the top programming and observation. And the administration is to elevate a spongy city concept of improving urban and rural community-residence beautifulness to solve the eco- or nature elements. A polluted and tainted environment associated with worsening runoff and storm water is to be solved by an un-constructed approach.

In the end, that is not an approach through a so-called “constructed”, “engineering structures”, or “mechanism” approach but through a non-constructed measure, policy and approach. The campus or county 3R project is at least to imitate a sustainable function and is to abandon a kind of baroque European or informal romanticism of China common recently.

The schematic design of approach is preliminarily to divide the campus into ten (10) voluntary participation parcels. Each parcel-zoning is therefore based on the maximum of a sixty- (60-) student recollecting, recycling, and reprocessing (3R) garbage every day. In addition, 3R for

the individual food waste is focused on students and teachers' during lunch and after dinner time within campus food court surroundings, and student-shopping strip areas. See figures 7, 8, 9. The process of making composts and manures for campus and community use is pending. So does the collecting and storage procedure. The samples showing campus contamination ascending and descending indication will then be designated and located. See the preliminary total C, Total NO₃ and Total P results of the location shown at Figure 4.

4. Developed Study and Discussion

The study is to judge storm and runoff water quantity and quality by cultivating campus users' campus-universes attitude, similar to or equivalent to the promotion of Olmsted's "communitiveness" idea ^[4] since 1857 by promptly initiating- recycling programs. It is at all ethics viewpoint with urban storm and runoff water management. Studying and living in the university, the groups of student, teacher and staff are assured to be persistent and continuously applying spongy city concept for flexibility yet indiscriminately apply into unconstructed approach and save his or her environments together. This is in reality to assume that existing approaches can normally be evolved rest upon a single premise: the individual is a member of a community of interdependent. People instincts prompt individual including students, teachers and staff, to compete for his or her place in the community; that is, in this study, studying or educating the place in the campus, his or her esthetics prompt he or she to cooperate perhaps in order that there be a place to compete for.

The universes campus' esthetics simply enlarges the boundaries of the university field with the community surrounding to include not only physical or natural factor of soil, water, plant, and collectively, the campus land, pond, garbage, food and food waste as well. Unless the assumption extends students, teachers and staff's morality in this way, the study is not not validated and to risk dooming and missing the point of people to live in an unhealthy or unappealing biotic community.

The study assumes that we students, teachers and staff are all quite willing to or recognize obligations to protect the university campus and the community resource such as transportation roads and specified college- schools. Yet there is assumed the schools are far less responsible when they come to protecting ecological systems in which "other people" and all creatures live. The environment will not be kept in good repair unless our ethical sensibilities changes. The problems this study is in reality to face or to solve is the extension of social conscience, the awareness of a moral or ethical aspect to one's conduct together with the urge to prefer right over wrong from people to the land of the university campus^[5]. Therefore, the study will further test whether the students, teachers and staff are taking responsible for cleaning, collecting and recycling "their" own garbage, food and food waste; The test of ideal eco- or natural storm and runoff water quantity and quality which could be sustained.

Finally, the discussion for eco- or nature campus is to get to the bottom through solving its surrounding storm and runoff water quantity and quality. It is necessary to

organize the independent variables such as “communityiveness” or “campus-ness” sense and or attitude, with dependable variables such as collecting garbage and or recycling food and food wastes, and to test the hypotheses in respect to the following storm management strategies: first, to launch watershed-based water management which includes, but is not limited to, how to apply site planning and quality improvement by an unconstructed policy or measure, and second, how to apply to reduce possible imperviousness of the campus if needed ^[6].

The former, the university or any scale of educational campus, is the appropriate object of site, yet it may not have always adequately addressed downstream flooding or water quality and non-point sources of pollution as well; The later, the campus’ retention or detention basins or facilities basically are established or located at most campus constructions on a site-by-site basis. The basins are in fact actually increasing flooding potential based on the possible simultaneous timing of peak discharges.

In addition, there are increased maintenance requirements and associated high costs of individual social interaction and site management revisions; As a result, many campus retention or detention basins systems are not properly maintained or worsen effectiveness. Thus, based on ecological adaption, mitigation, and reduction of campus environment, the students, teachers, and staff in campus shall take care of their eating, drinking, and save energy cooking at home and adjust to less expansive and energy-consuming taking out habits. It is that the spongy or eco- campus practice is the case at Fujian Agriculture and Forestry University at Fuzhou.

This study emphasizes that an eco- or nature environment of university campus is applicable, and the study of relationship between ecological system and human welfare is not solely reliant on structure constructed approach but on un- constructed policy or on programming as one as applied in this preliminary hypothesis of study. The proposed results are to significantly be expected ^[7]. In-field and in-person participation in improving the ecological campus shall not be a strict constraint but an opportunity for the society. Students, teachers and staff themselves, shall be able to pay more attention to “communitiveness” participation associated with performing in rewarded effectiveness ^[4]: That is, a sense of shared community and dedicated services among students, teachers, staffer and community residents, and it is a present, a gift reward to an alternate from a concept of solely unconstructed methodology into an improving campus reconstruction and or construction as well.

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Development Considerations For Edge Protection: A Case Study Of The Central Catchment Nature Reserve (CCNR)

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Abstract

Land-use changes adjacent to urban forests highly affect the edge conditions of the forest and either introduce more disturbances or improve the ecological connectivity of the forest patch. These are key issues faced by forests in the compact city-state of Singapore, especially the largest of the nature reserves of Singapore, the Central Catchment Nature Reserve (CCNR) in the heart of the state. Apart from the adjacent Bukit Timah Nature Reserve (BTNR), it contains the only remnants of the native primary vegetation from pre-development Singapore.

Rapid urban development since the 1980s fragmented the CCNR through infrastructure and urban development across and around it. The presence of habitat destruction and biodiversity loss caused by land-use changes within and around the CCNR despite conservation laws in Singapore expresses a dichotomy. To gain an understanding of the situation, the spatial changes of and around the central catchment and consequential fragmentation effects are studied in detail. The study is divided into three parts according to magnitude of scale:

1. An examination of the current and future land-uses adjacent to the CCNR (Fig 1),
2. The assessment of surrounding green patches and
3. The study of edge conditions,

executed through a collection of government master plans, field observations, reports, news articles, blogs and literature to provide a holistic understanding of the site and its future interventions. Speculation of the effects and proposed mitigating measures are generated through a combination of site observations and reference to case studies.

This paper seeks to fill the knowledge gap of the threats faced by the urban forests due to encroaching development, in particular, fragmentation and edge effect, addressing the Central Catchment and surrounding areas as a region of study. Applying ecological models and design principles to the case, it presents development considerations and design potentials for habitat conservation, connectivity and edge protection of green spaces to mitigate edge effects to ensure the long-term existence of the nature reserves.

Keywords: Fragmentation; Edge Effect; Land-use changes, Systematic Conservation Planning

1. Introduction

1.1 Development and Landscape changes inducing fragmentation in Singapore

Developmental pressures of a densely populated, land-scarce city-state of 719.2km² supporting a population of 5.6 million [1] has led to the inevitable extermination of the natural vegetation that once enveloped the island. Urban development in Singapore is largely executed through the tabular rasa (a clean slate) method - the clearance of the previous land-use to make way for the new development. Primary rainforest cover was depleted to less than 0.5%, or 192 hectares, scattered within the Central Catchment Nature Reserve (CCNR), Bukit Timah Nature Reserve (BTNR) and Singapore Botanic Gardens [2]. Secondary forests, deemed to have less ecological value, were usually designated as developable land. Large patches like the Tengah forest, Tagore and plots in expanding estates of Punggol and Pasir Ris are gradually being cleared for development. The resulting loss in ecosystem services and biodiversity cannot be substituted by the insertion of artificial manicured parks.

Although Singapore has established legal protection for the protection and conservation of nature reserves (Table 1), these policies are often loosely enacted [3], insufficient to overcome the threats caused by urbanization [4]. One apparent shortcoming is that there are still no laws mandating Environmental Impact Assessments (EIA) for development projects that affect the environment [5][6][7], which

was an aspect emphasized by the Rio Declaration, in the Convention of Biological Diversity [5].

Table 1: Changing levels of Forest Protection in Singapore [8].

Changing levels of forest protection in Singapore				
Date	No. of Reserve	Total area ha (acres)	Percentage of land	Name
1886	13	4, 676 (11, 554)	9.0 %	Forest reserves
1907	8	6, 033 (14, 907)	11.3 %	Forest reserves
1930	9	6, 570 (16, 234)	11.7%	Forest reserves
1951	5	3, 419 (8, 448)	5.4 %	Forest reserves
1991	2	2, 417 (5, 972)	3.8 %	Nature reserves
2011 ¹	4	3, 343 (8, 260)	4.6 %	Nature reserves

1.2 Central Catchment Nature Reserve

The CCNR is the largest of the four nature reserves designated in Singapore today, occupying over 2000 hectares of forest cover [9]. It comprises predominantly mature secondary forest, interspersed with some primary forest patches [2]. These plots are home to more than 1000 flowering plant species, 100 ferns, 222 species of birds, 44 mammals, 100 reptiles and amphibians, and 34 native species of freshwater fish [10], constituting one of the most biodiverse areas in the world. The CCNR is also a protected water catchment containing the four main reservoirs of Singapore: MacRitchie, Upper Pierce, Lower Pierce and Seletar, providing a raw source of water supply for Singapore.

¹ In 2001, Sungei Buloh Nature Park and Labrador Park were converted to nature reserves (MEWR, 2002).

1.3 Fragmentation of the CCNR

The CCNR comprises of a total of 24 fragments, disjointed by the presence of reservoirs, utility pipelines, roads, military amenities and security fences [9]. The maps (Fig 2, 3) show the areas of hard and soft fragmentation zones, according to the adjacent land-use.

Once patches of wooded, agricultural and low-rise residential areas, they are now high-density residential, industrial and manicured golf courses [11]. The effect of transport infrastructure; particularly the Bukit Timah Expressway (BKE), Pan-Island Expressway, Lornie Road and Mandai Road, fragments this precious forest resource. Most mammals that make the attempt to cross result in roadkill. The fragmentation limits species distribution, preventing the spread of primary biodiversity across the fragments [9] and also leads to an increase in perimeter ratio, higher exposure to the invasion by urban and exotic species, and increase of human access and activity that can disrupt the natural habitat [4]. The boundaries of the CCNR have transformed substantially since independence.

These were mitigated by an ecological corridor, Eco-link@BKE, in 2013 to restore ecological balance between the CCNR and BTNR [12]. NParks has also increased the size of the reserves and the recreational buffer area near the reserves from 63 hectares in 2009 to almost 300 hectares in 2019 [13].

1.3.1 Insufficient edge consideration in surrounding Land-use planning and development

As the CCNR is not an isolated patch but part of a diverse matrix system of habitats, any changes in land-use, eg. removing a patch for urban development, could present adjacency effects - the effect of the adjoining area on the patch habitat [14] that threatens the biodiversity in CCNR. Some major threats today include the controversial alignment of the Cross Island Line and the continued expansion of Mandai Nature Hub. The Nature Society Singapore (NSS) and conservationists have fought hard to minimize damage to the reserve, through evaluating the EIA [15]. Public outcry had also successfully lobbied for more transparency and accountability in the planning of infrastructure. Yet, the final outcomes and impact remain a mystery.

The land-use near the perimeter is also critical in influencing species movement and degree of *edge effects*- the differences in environmental conditions of the outer portion of a patch compared to the interior of the patch [16]. Apart from buffer green areas protecting some of the edges of the CCNR, there are dense residential estates are located within 1km proximity from it. Surrounding green spaces, with the exception of BTNR and nature parks, are highly manicured with limited ecological function. Adjacent biodiversity-rich forests like the Lentor forest [14] are slated for future development [17]. Such interventions pose a challenge in protecting the nature reserve in the long run.

Majority of the edges created around the CCNR are artificial- determined by administrative boundaries planned by URA. Residential developments, major expressways, transport infrastructure and utility lines adjacent to the it become a critical zone for nature-human interaction [15], potentially contributing to loss in biodiversity and reduction in ecosystem services.

1.3.2 Fragmentation: Long-term Edge effect on CCNR

One of the largest threats to biodiversity is the isolation of forests due to land-use changes [18]. The extent of edge effects depends on the fragment size, shape and the nature of the edge [19]. Smaller fragments of the forest experience a higher proportion of edge effect [13] due to a higher edge-to-interior ratio. Observing from Fig 2, much of the northern and southern parts of the CCNR comprise of relatively small fragments. Most of the edges of the CCNR are hard and straight-edged, as per in most urban areas [13][20]. This includes expressways, roads, utilities, residential areas, open spaces, waterbodies, golf courses and nature park trails.

This paper seeks to address the lack of understanding on the fragmentation and edge situations in the urban context, with focus on the largest nature reserve, CCNR. This paper will highlight the effects of urban development in adjacent and surrounding areas to identify potential threats to be mitigated, and opportunities of enhancement to ensure the long-term existence of the nature reserves.

2. Research Methodology

2.1. Study Boundary and Scope

The region of study is the Central Catchment Nature Reserve (2114 hectares) and the surrounding areas within 1km buffer of the defined perimeter, which includes adjacent Bukit Timah Nature Reserve and forests adjacent to it (Fig 1).

2.2. Assessment & Analysis (Land-use, Green space, Edge)

A mixture of both quantitative and qualitative aspects is used in the collection of data. A repository of news articles, online commentaries, discussion papers and governmental reports were used as reference alongside the fieldwork done on site. Spatial analysis were recorded and analyzed in ARCGIS and referenced with Google Earth satellite imagery and Openstreetmaps. The spatial changes, particularly fragmentation, are generated using FRAGSTATS 4.0. The metrics are selected to highlight the loss in green space, patch disconnectivity and isolation to identify areas of around the boundary of CCNR that may face edge disconnectivity.

3. Land-use and Development around the CCNR

3.1. Ongoing and future Land-use changes (MP2014)

Fig 4 illustrates the distribution and percentage of various land-use within the study boundary, comparing the situation today (2017) and as proposed in the URA 2014 Master Plan. Table 2 reveals that residential, followed by military, open spaces and golf courses are the predominant land-uses, together constituting half of the total area of land-use studied. The areas north of the CCNR and scattered plots within and around the CCNR (Mandai, Nee Soon, Sembawang) are restricted for military training and a large plot of 222.2ha for the Military Industrial Complex located west of Upper Pierce Reservoir. There are 9 golf courses scattered around the CCNR. Open spaces are currently unoccupied forested areas that can be found at Mandai and Upper Bukit Timah near the old Turf club.

According to the URA Master Plan 2014, which guides Singapore's development in the next 10-15 years, there are a few designated sites to undergo land-use conversions, which are highlighted in Fig 8. Table 2 and 3 shows the changes in area by the type of land-use, through which we can determine that the largest conversion in land-use is from open spaces to residential areas.

Table 2: Current land-use area calculation

Current Land-use	Sub-total Area (Ha)	Percentage of Total area (%)
Business	32.2	1.0%
Cemetery	98.75	3.0%
Civic	40.98	1.2%
Commercial	5.11	0.2%
Institution	50.38	1.5%
Nature Reserve	129.65	3.9%
Open Space	519.89	15.6%
Others (Military)	535.78	16.1%
Park	295.26	8.9%
Reserve Site	358.82	10.8%
Residential	606.42	18.2%
Residential & Commercial	11.9	0.4%
Sport & Recreation	402.9	12.1%
Transport	2.84	0.1%
Utilities	45.19	1.4%
Construction	190.38	5.7%
TOTAL AREA	3326.45	100.0%
BUILT-UP AREA	1084.15	32.6%
GREEN AREA	2242.3	67.4%

Table 3: Future land-use area calculation (Author, 2017)

MP2014 Land-use	Sub-total Area (Ha)	Percentage of Total area (%)
Business	42.87	1.3% ↑
Cemetery	98.75	3.0%
Civic	48.13	1.4% ↑
Commercial	5.11	0.2%
Institution	62.81	1.9% ↑
Nature Reserve	129.65	3.9%
Open Space	268.82	8.1% ↓↓
Others (Military)	535.78	16.1%
Park	(259.27) 289.27*	(7.8%) 8.7%* ↓
Reserve Site	382.45	11.5% □
Residential	(992.38) 962.38*	(29.8%) 28.9%* ↑↑
Residential & Commercial	17.49	0.5% ↑
Sport & Recreation	388.48	11.7% ↓
Transport	39.87	1.2% ↑
Utilities	54.59	1.6% ↑
TOTAL AREA	3326.45	100.0%
BUILT-UP AREA	1362	40.9% ↑

* Fields adjusted according to projected park provision in the new residential estates.

While green areas are maintained above half of the total area around the edge, a decrease in green area from 67.4% to 59.1% is observed (Table 2, 3). Correspondingly, built-up areas increase from 32.6% to 40.9%. These additional 278ha are a mixture of business, civic, institutional, mixed residential developments, transport and utility infrastructure.

Fig 5 and Table 4 illustrate the specific areas of land-use conversions that will face development. As a result of these land-use changes, landscape modifications of patch loss, degradation, and fragmentation are observed. These have varying degree of implications on biodiversity and ecological processes, with habitat loss as the most severe, followed by degradation then fragmentation [13].

Table 4: Key development areas² based on 2014 URA Master Plan

<p>(1) Mandai Nature Hub (Completing in 2021)</p> <p>Previously the Mandai Orchid Garden and an abandoned village/ farmland, two plots of regenerated secondary forest are gazetted to be developed as two new attractions Rainforest Park and Bird Park, which together with the existing Singapore Zoological Gardens, Night Safari and River Safari, constitutes the Mandai Nature Hub. The close proximity to the boundary of the CCNR led to some controversy that led to the conducting of an EIA, and the publishing of the NSS Position Paper on the development plans.</p>
<p>(2) Mandai Depot (Completing in 2019)</p> <p>A train depot occupying 32ha in Mandai serves the upcoming Thomson-East Coast MRT Line, accommodating up to 90 trains. It was previously occupied by Orchidville, the largest orchid farm in Singapore.</p>
<p>(3) Tagore/ Lentor Forest (Expected completion 2021)</p> <p>The 20-year-old forest, marked as a biodiversity-rich area in the NSS's Position Paper, is designated as a residential area in the 2014 Master Plan. Authorities have since modified their plans to conserve two green plots and implement a wildlife management plan to relocate wildlife into the CCNR or other forested areas.</p>

(4) Upper Thomson/ Windsor Nature Park
(Completed in mid-2017)

This 75ha nature park area serves as a buffer for the CCNR, providing an alternative natural recreational venue to relieve visitorship to the CCNR. It is forested and rich in biodiversity. Amenities and boardwalks are being built to support its recreational function. This is one of the sites considered as interim greens, maintained for as long as possible but will be removed if development is required.

(5) Upper Bukit Timah/ Old Turf City
(Subject to detail planning)

3.2. Threats and potential effects

An analysis of the landscape changes (Table 5) as a result of the land-use plans is conducted through Fragstats 4.0, comparing the patch dynamics between the two scenarios, as shown in Fig 6.

The results collectively illustrate signs of fragmentation, including the decrease in number of patches, increased level of isolation, and a decrease in connectivity. The ENN-MN showed an increase in value, which demonstrates a larger average distance between the patches, and the drop in PROX_MN demonstrates higher isolation of patches (Table 5). The loss and increased isolation of green patches will hamper the ability of surrounding areas to serve as a buffer to the CCNR.

Table 5: Analysis of landscape changes by land-use change

Landscape Metric	Significance (Rendenieks et al., 2015)	Current (2017)	Future (2030?)
Total Area (CA/TA)	Indicates the total amount of habitat in the landscape.	2315.9	1964.8 ↓
Percentage of Landscape (PLAND)	Indicates the relative area of particular habitats within the landscape.	6.3	5.3 ↓
Patch Density (PD)	Fraction of patch expressed as part of the total landscape area.	0.31	0.28 ↓
No. of Patches (NP)	Shows the number of habitat or disturbance patches of particular category or in landscape as whole.	116	105 ↓
Mean Euclidean Nearest-Neighbour Distance (ENN-MN)	Simple measure of habitat patch isolation that evaluates straight interpatch distances across the landscape.	64.3	93.1 ↑
Mean Patch Proximity (PROX_MN)	Indicates the level of habitat patch isolation within the defined threshold distance. Higher proximity values represent lower isolation, which is beneficial for species migration.	909.1	558.8 ↓
Mean Contiguity (CONTIG_MN)	Measures forest matrix connectivity, based on configuration.	0.87	0.84 ↓

4. Distribution of Green spaces around the CCNR

4.1. Physical attributes of Green spaces

An inventory of green spaces was used to create the chart (Fig 7) comparing the relative area of surrounding green patches to their relative proximity from CCNR. Most of the green spaces larger than 100ha are located within 50m of the nature reserve, including the military areas, Military Complex, Sembawang Air base, golf courses and the 163ha Bukit Timah Nature Reserve. Sites larger than 40ha are scattered within 100m of the CCNR, with the exception of Turf City and a military site at Mandai West, and a reserve site near BTNR. The green spaces that are planned for development are circled (eg. Windsor Nature Park, Turf City, Future Mandai parks etc.).

According to the Theory of Island Biogeography-postulating that larger green patches support a greater variety of habitats and species, and the closer the patch “islands” to the CCNR “mainland”, the higher the species richness, Fig 7 and Table 6 provides a general ranking of the value of the patches in terms of supporting biodiversity. The loss of patches larger and of closer proximity to CCNR are suggested to pose the highest ecological threat to CCNR, and the severity of impact depends on whether it is habitat loss, degradation or fragmentation that is induced. Table 6 summarizes the severity of ecological impact on CCNR by the physical attributes of the green patch and consequence with the

planned land-use change (according to URA 2014 Master Plan). This however, does not consider the urban matrix³, which could also support urban biodiversity. The two main areas, which have the largest impact, are the conversion of Windsor Nature Park and the area of Turf City.

Table 6: Ranking of threats to CCNR

Green Space	Area (Ha)	Proximity to CCNR (m)	Land-use change (MP2014)	Ecological threat
Windsor Nature Park	74.1	0	Residential	Habitat Loss
Mandai Orchid Garden	21.2	0	Mandai Nature hub: Bird Park	Habitat Degradation
Secondary forest	14.39	0	Mandai Nature hub: Rainforest Park	Habitat Degradation
Reserve site	8.3	50.91	Mandai Park	Habitat Degradation
Forested Turf City area	159.2	50 - 300	Residential	Habitat Loss
Forest	6.68	508.74	Sports & Recreation	Habitat Loss
Dairy Farm Nature Park	6.42	551.10	Reserve Site	-
Forest	0.92	584.85	Open space	Habitat Loss
Forest	3.24	588.60	Reserve Site	Habitat Degradation
Forest	0.43	639.21	Reserve Site	Habitat Degradation
Forest	1.57	724.27	Park	Habitat Degradation
Forest	0.71	742.07	Park	Habitat Degradation

The managed green spaces in the surrounding urban context are studied to be artificial re-insertions after an urban

³ Includes roadside greenery, trees planted within the urban development, green roofs, potted plants and small pocket green areas

development is complete. Early park developments were described as ‘mostly unplanned and cosmetic’ [21][22]. These spaces are mostly mono-functional, have highly manicured vegetation or high-maintenance turf grass. While designs of parks today are aiming to be more multi-functional, most of the existing spaces are designed for human recreation and aesthetic appreciation. They include existing parks like Springleaf Nature Park, open spaces including school fields and golf courses.

5. Edge Treatment and Protection





5.1. Adjacent Edge conditions



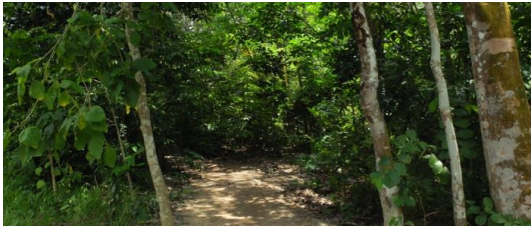
The edges found in the CCNR are classified according to the adjacent land-use, the degree of hardness/ softness of the edge according to edge principles in Landscape Ecology Principles in Landscape Architecture and Land-use Planning⁴ [15]. This follows studies that illustrate that species composition and richness varies mainly by edge type rather than length of edge [13]. ‘Hard-edged boundaries’ bring greater ecological impact than ‘more natural, transitional edges’ [23][24]. Seven edge types, determined preliminarily by the degree of hardness to softness (Table 7) were identified spatially in Fig 8 and their proportional composition recorded in Table 8. A summary of their attributes and

⁴ Some of the principles that define the degree of ecological function are adopted and interpreted to evaluate the harshness of the edges. These include: (1) Structural diversity of edge (2) Density of edge (3) Abruptness of edge (4) Degree of curvilinearity of edge [15] (5) The presence of human disturbance and activities (Collinge, 1996 & Chatterjea 2012) [17][18].

predicted edge effect is compiled in Table 10.

Table 7: Classification of CCNR Edge Types

<p>(1) Forest – Hardscape Infrastructure <i>Utilities, PUB Waterworks, Carparks, separated by fence and/or retaining wall. Little amount of human activity or noise.</i></p> 
<p>(2) Forest – Road Infrastructure <i>Expressways, secondary roads, with planted roadside verge, high volume of vehicular traffic brings noise, increased wind velocity and sun exposure, air & water pollution, prone to roadkill.</i></p> 
<p>(3) Forest – Residential <i>Ends facing the backyard of private housing, separated by canal, fence, and/or retaining wall. Residents “expand” territory by growing food trees beyond backyard, occasional wildlife visits.</i></p> 
<p>(4) Forest – Water <i>Mainly the central catchment reservoirs, some areas boardwalk skirting the edge for running, nature walks, bird-watching, fishing along permitted areas.</i></p> 

<p>(5) Forest – Open Ground <i>Mostly open spaces, gaming greens and golf courses, with moderate activity and noise, but frequent maintenance - mowing of grass, irrigation, presence of vehicles (buggy, lawn-mower).</i></p> 
<p>(6) Forest – Managed Green <i>Mostly parks and manicured landscapes, with high human activity; jogging, cycling, chatting, picnic-goers, walking the dog, simple sport activities.</i></p> 
<p>(7) Forest – Nature Area <i>Nature Parks, parks, seamless integration, providing unpaved paths or rocky pavements for pedestrian circulation, disturbance level low unless large groups and insensitive behavior eg. Littering</i></p> 

The predominant edge interface is water, constituting more than 50% of the entire boundary of the CCNR. This is followed by the interface with nature areas, including nature parks and unmanaged secondary forests (military training grounds or reserve sites). Residential areas occupy a substantial percentage in this study; built-up areas together form almost 1/5 (20%) of the edges.

Table 8: Classification of Edges around CCNR (Author, 2017)

	Types of Edge	Type No.	Sub-total length (m)	Percentage of Total Perimeter (%)
	Infrastructure Hardscape	0	4267.28	4.2%
	Infrastructure Road	1	13380.74	13.2%
	Residential	2	2294.88	2.3%
	Water	3	57643.99	56.9%
	Open Ground	4	5769.66	5.7%
	Managed Green	5	2724.26	2.7%
	Nature Area	6	15181.35	15.0%
	TOTAL PERIMETER		101262.16	100%

5.2. Edge effects

As Murcia (1995) guides, forest edges experience altered microclimatic conditions including: increased sun exposure, higher wind velocities, increase in soil temperatures, overall temperature, and decrease in humidity [17][23][25][26]. These abiotic effects subsequently leads to a change in species composition and behaviors, causing tree failures, presence of edge-tolerant species like generalist predators, exotic, invasive species, weeds [13] etc. The presence of human activities, domestic animals, landscaping or growing of crops along the edges also poses significant disturbance to the forest [10][17]. Roads and construction sites bring air, water and noise pollution to the nature reserve that affects the nutrient availability and fauna behavior [23]. Table 9 speculates the edge effects faced by each of the seven types of edges of CCNR through field observations and references to case studies. The edge effects can extend up to 50m into the forest interior, or more depending on the type of effect [23].

Comparing the edge effects of the types, as well as their length, areas highly threatened by edge issues are marked out in boxes in Fig 8. Highways including the BKE, PIE, SLE, and primary roads Mandai Road, Lornie Road poses a significant threat to the CCNR fragments. The high volume of traffic in these roads necessitates the presence of vegetated buffers, which are missing in many of these situations. In addition, the interface with private residential areas has to be treated, as these zones induce human-wildlife interactions that should be strengthened in selected areas and prohibited in others.

6. Discussion

6.1. Systematic Conservation Planning and Development recommendations

Chapters 3 and 4 have surfaced the need to harness multiple tools to read the systems of the landscape (ie. the relationship of patches). Quantitative tools and analytical tools like Geographic Information Systems (GIS) should be employed in the process to study the priority areas for protection, ranking sites by species richness, presence of endangered species, to qualities like ‘irreplaceability’ [27][28].

Additionally, the landscape configuration should be read as a system of green spaces where each patch is unique, contributing to the mosaic system [15]. The protection of one patch, like the CCNR, should be based on identifying and understanding the critical habitat linkages within a reserve network.

This can be carried out through *Systematic conservation planning*⁵ [26][29] which includes working with different layers of species prioritization, different scales and incorporating selective approaches at specific stages of the development process. Factors like biodiversity values need to be considered even in the planting scale [26][30]. Edge vulnerability can be addressed through the use of vegetation modelling tools to generate detailed planting designs to ensure habitat creation and edge protection at the implementation scale [31]. This way, conservation principles are met and applied throughout the entire process of land-use planning.

6.1.1. Recommendations for Conservation and Selective Development (Fig 17):

1. To conserve green spaces critical to CCNR

Areas that are found to have a critical ecological function to the CCNR should be prohibited from development, or be designated as buffer parks to complete the ring of buffer parks around the CCNR. Winsor Nature Park, for instance, should be kept designated as a permanent nature park to relieve visitorship of the CCNR as well as provide buffering function. Likewise, Upper Turf City area should also maintain its forested quality to protect the smaller fragments along the south boundary.

2. To develop selectively and sensitively

Areas that are less of a threat to the habitat configuration are suggested for

controlled development. This refers to conducting habitat analysis on the plots of forests to identify areas that should be preferentially preserved, which can later serve as the park provision of the development. This was also suggested by the NSS in the development proposal of Senoko [3]. This could be carried out in lower Turf City area, Mandai and parts of Bukit Timah and Tagore. Existing trees should also be conserved as far as possible.

3. To intensify built-up areas

As for areas that pose comparatively little threat to the habitat network (ie. distant, small plots or patches), those currently cleared in preparation for groundwork and existing built-up areas could be intensified in terms of plot ratio and density. In particular, the loosely scattered private housing estates are in the areas of Bukit Timah and Upper Thomson, marketed as being ‘close to nature’, are found to have high impact on CCNR. The intensification of the land-use in these areas can prevent development from further encroaching the nature reserve.

6.1.2. Strengthening laws protecting Nature Reserves, Mandating EIA

In order for the continued existence of the CCNR, there needs to be consensus amongst the government agencies involved in planning to put biodiversity conservation as one of the goals for sustainability. There should not be loopholes for agencies to work their way through and cause disturbance to the natural environment. For instance, should the laws protecting CCNR be strengthened, there will not be the situation

⁵ Refers to a ‘suite of methods used determine, implement, and manage’ areas that contain ‘desired conservation targets with the minimum expenditure of resources’. [28]

of LTA executing ground testing works in CCNR. Some educated members of the public questioned their legal rights and whether ministers had the power to approve these acts, or amend these laws. In addition, the state should adopt a policy of mandatory environment impact assessment (EIA).

6.2. Retrofitting current Green spaces

The studies done on managed green spaces show that they are dedicated primarily for recreation [32]. In order to maximize the ecological function of these green spaces as a supporting matrix, Table 9 proposes strategies that promote creation of habitat; supports landscape connectivity and provide an ecological context [33].

Table 9: Recommendations for retrofitting managed green spaces

Managed Green Space typology	Strategies to enhance ecological function
Parks	Identify critical and suitable areas for enhancing the vegetation structure and species composition (forest structure + native planting palette) (Lindenmayer et al., 2006) to better function as a stepping-stone/ connecting green space.
Open Space	In areas that allow for tree planting , presence of canopy can serve as a stepping-stone for birds in the urban matrix (Lindenmayer et al., 2006). The trees can also provide shade for the open fields.
Sports & Recreation	Create vegetated corridor along or within selected axis of the compound to facilitate species movement across the plot of land. Use native forest species to create habitats (Lindenmayer et al., 2006).
Cemetery	Filling the gaps in the canopy through supplementary tree planting provides a connecting landscape for animals and insects, while providing shade for visitors. Dense planting of shrubs (Perkl, 2016) can act as a buffer to prevent monkeys from entering the tomb areas to steal food.

Existing efforts have been ongoing in Singapore to enhance the habitat functions

of parks. The butterfly habitat enhancement and naturalization of the canal in Bishan Park created habitats for various flora and fauna. Blue Hills Country Club in Kansas City is an exemplar of a multifunctional golf course. By providing nest boxes, native flowering shrubs and wildlife refuge areas, it provided a habitat for many birds and insects [34].

6.3. Measures/ Recommendations to ameliorate Edge effects

Microclimatic alterations are found to be the key cause of edge effects, which can be tackled through modifying vegetation configuration [30]. Forman (2014) suggests enhancing the vegetation structure and treatment of the edge to reduce the edge-to-interior ratio. Such measures protect the interior species as well as promote or discourage fauna movement to manage human-wildlife interactions [30]. Table 10 shows the recommendations for retrofitting edges.

6.3.1. Improving on-going/ Future Development proposals

Recognizing that there are developments taking place adjacent to the nature reserve in future, the following recommendations are proposed to minimize effects of edge creation.

- Edges with higher structural density support a larger variety of edge species [15][35]. Supplementary planting of a mixture of canopy, understory and undergrowth layers helps to reduce exposure to harsh microclimate conditions by increasing vegetation density and

structure. This is especially crucial for boundaries with hardscape infrastructure like the Mandai Depot where noise and high radiant temperatures can be screened out through mixed plantings.

2. Convoluted/Curvilinear boundary vs Straight boundary: Curvilinear boundaries facilitate fauna movement across the edge while straight boundaries facilitates parallel movement [13][15]. The edge pattern can be designed according to the desirability of fauna entering the matrix.
3. Increasing softness of edge can have ecological benefits like preventing soil erosion and enhancing edge species richness. The planting palette should prioritize native forest species to support the continuation of interior habitats [24][32].

For instance, the upcoming Mandai attractions could include vegetated buffers or vegetated façades of the buildings to soften the edges and prevent microclimatic exposure. Softer edges should be used where wildlife is encouraged to permeate while landscaped barriers should be used to prevent human access into the protected areas. Vegetation models and simulation can help designers plan the edge treatment and protect species-specific habitats in CCNR. While adjacent developments maintain a 50m buffer along the CCNR boundary, the effectiveness of this buffer should be studied without delay for the long-term sustainability of the CCNR fragments.

7. Conclusion

While being designated as a “nature reserve” gives the CCNR some level of protection, its existence within in an urban context creates a complex situation of threats that undermine its long-term sustenance. Apart from improving the understanding of the edge condition of the CCNR, this paper hopes to bring to light the vulnerabilities faced by the nature reserves to urban development. Practical considerations and recommendations are provided to guide future planning and development strategies, working across scales from examining landscape patterns to edge planting. The fate of the CCNR, as well as that of our unique local fauna populations- the endangered Banded leaf monkeys, Pangolins, Leopard cat and Seraya tree (etc.) lies in our hands, for we do have the means to advocate its protection.

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Appendix



Fig 1: Boundary of the study area, containing the CCNR.

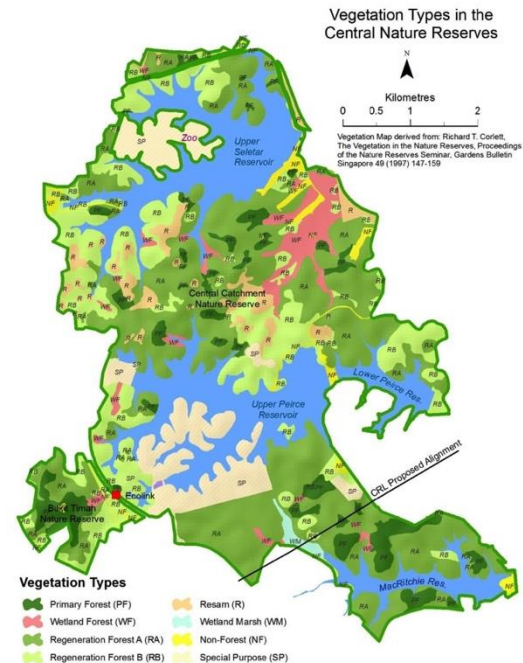


Fig 2: Map of Vegetation Types in the CCNR [9]

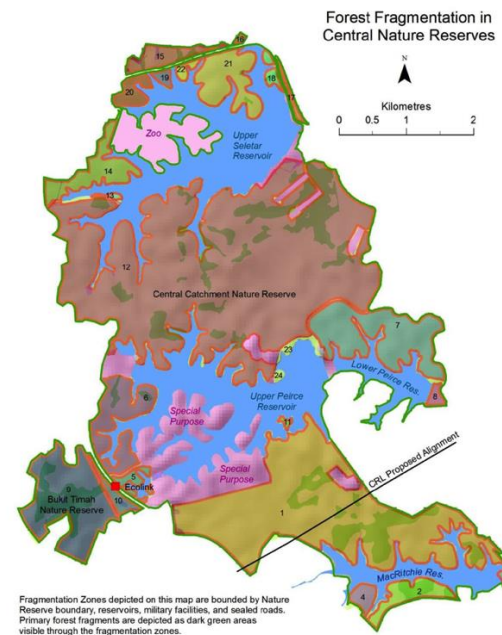


Fig 3: Map of Fragments of the CCNR [9]

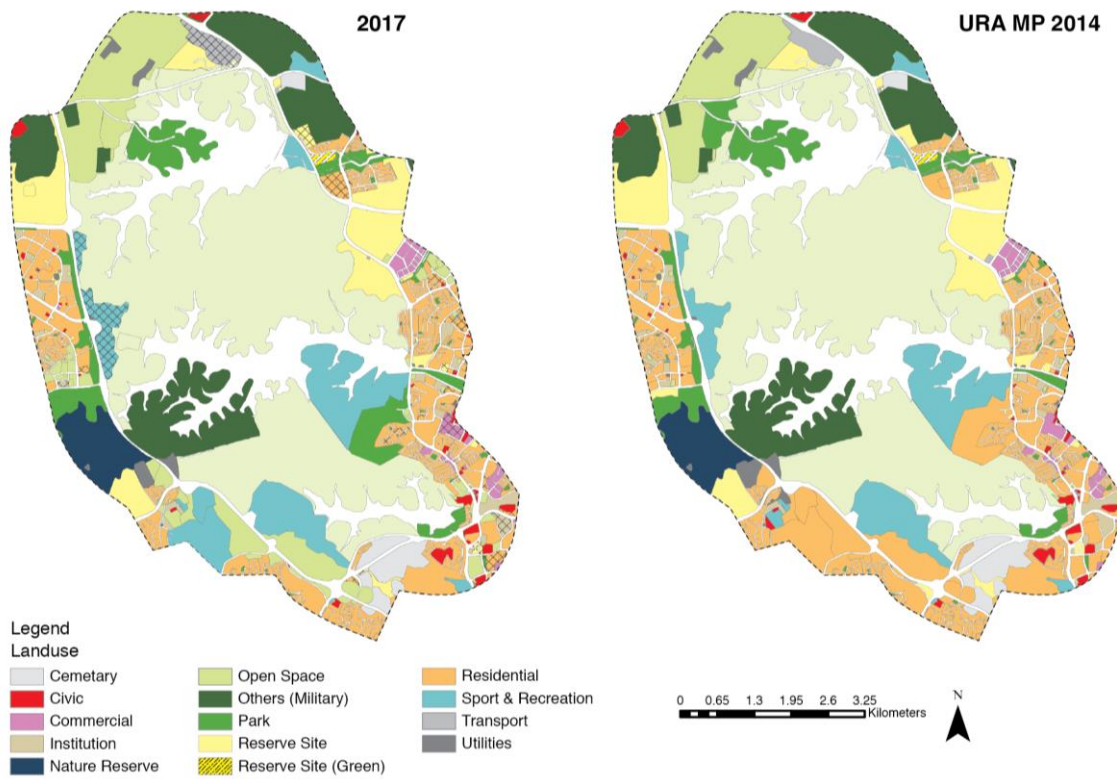


Fig 4: Comparison of Land-use in 2017 and future (2025-2030+) based on the 2014 URA Master Plan

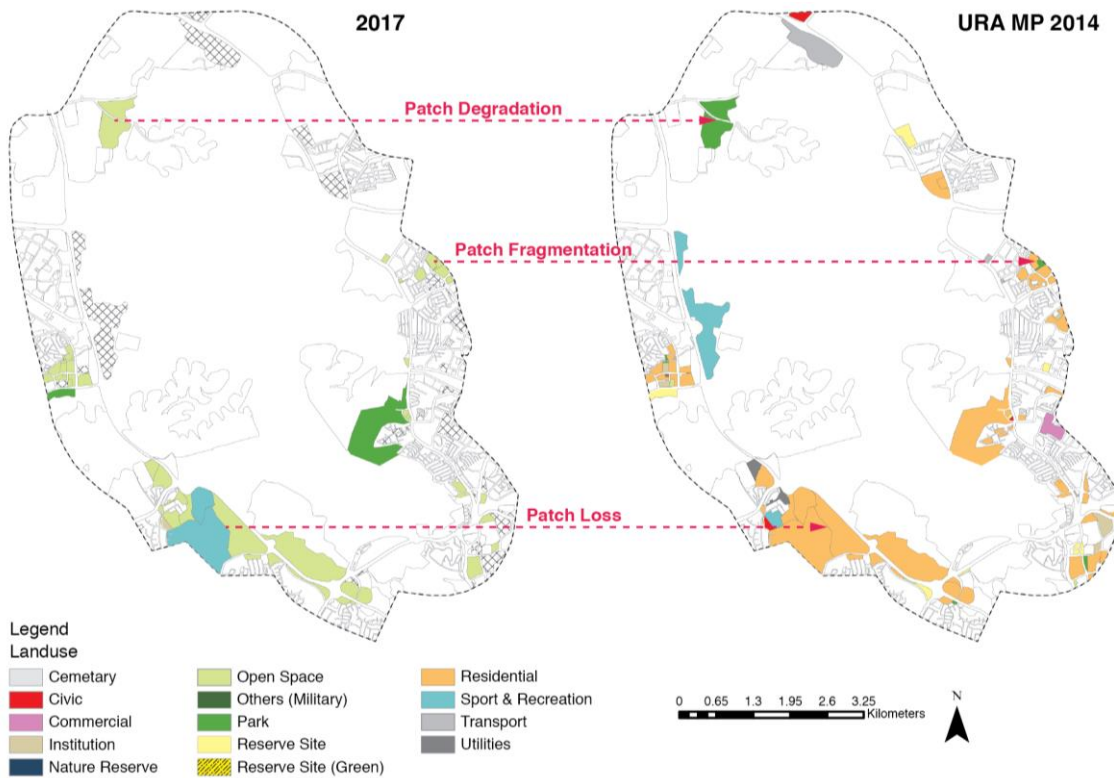


Fig 5: Changes in land-use in 2017 and future (2025-2030+) based on the 2014 URA Master Plan

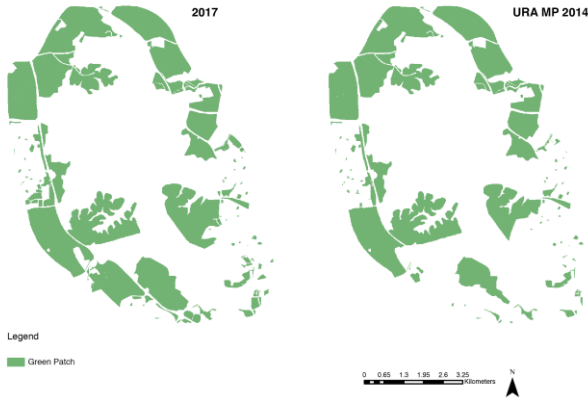


Fig 6: Comparison of green spaces in 2017 and future (2030+)

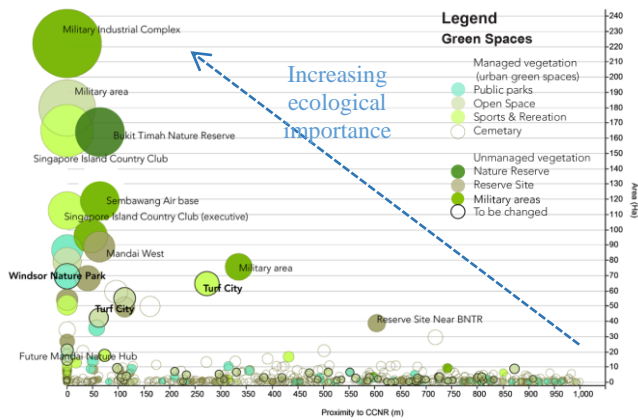


Fig 7: Chart of green spaces around the CCNR according to area and proximity.

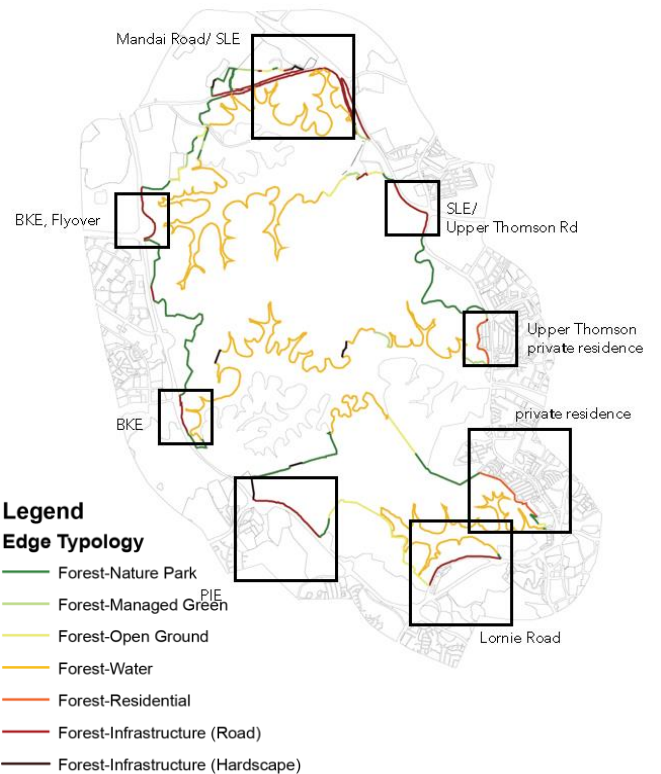


Fig 8: Identification of areas vulnerable to edge effects

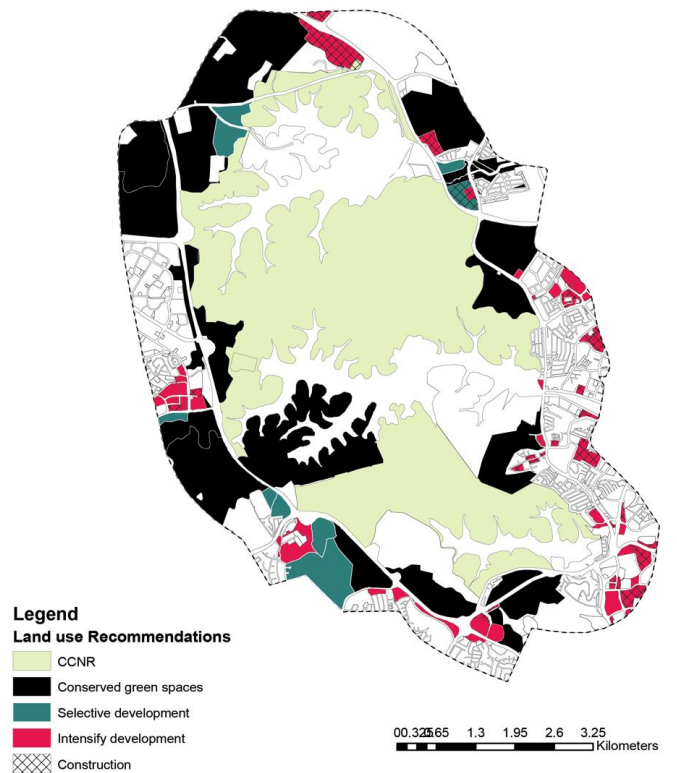


Fig 9: Recommendations for land-use

Table 10: Recommendations for retrofitting edges

Edge type	Relative / Comparative edge effect	Potential for retrofit
Infrastructure Hardscape	<p>Abiotic</p> <p>Light penetration</p> <p>Temperature increase</p> <p>Humidity decrease</p> <p>Higher wind velocity</p> <p>Biotic</p> <p>Soil erosion</p> <p>Loss in biodiversity</p> <p>Change in vegetation structure (presence of shrub and herbaceous)</p> <p>Change in vegetation composition (presence of invasives, exotics)</p>	<p>Planting a straight, dense buffer (Forman, 2014; Dramstad et. al, 1996) along the edge of the forests can minimize movement across the edge, preventing disruption to the utility and infrastructural operations. Species selection should be non-intrusive (Didham, 1999), like <i>baphia nitida</i> or <i>syzigium campanulata</i>.</p> <p>For roadside plantings, additional consideration for the aesthetics and the rhythmic composition of vegetation will influence driver behavior and vehicular speeds.</p>
Infrastructure Road	<p>Abiotic</p> <p>Light penetration</p> <p>Temperature increase (albedo effect)</p> <p>Humidity decrease</p> <p>Higher wind velocity</p> <p>Biotic</p> <p>Soil erosion</p> <p>Loss in biodiversity</p> <p>Change in vegetation structure (presence of shrub and herbaceous)</p> <p>Change in vegetation composition (presence of invasives, exotics)</p>	
Residential	<p>Abiotic</p> <p>Light penetration</p> <p>Temperature increase</p> <p>Humidity decrease</p> <p>Higher wind velocity</p> <p>Biotic</p> <p>Loss in biodiversity</p> <p>Change in vegetation structure (presence of shrub and herbaceous)</p> <p>Change in vegetation composition (presence of invasives, exotics)</p>	<p>In residential areas where wildlife are undesired, planting a straight, dense buffer with non-intrusive species (Forman, 2014; Dramstad et. al, 1996) will be a more ecological edge than a retaining wall or fence.</p> <p>The planting of fruit crops will encourage wildlife to approach.</p>
Water	<p>Abiotic</p> <p>Light penetration</p> <p>Temperature increase</p> <p>Humidity decrease</p> <p>Higher wind velocity</p> <p>Biotic</p> <p>Soil erosion</p> <p>Change in vegetation structure (presence of shrub and herbaceous)</p> <p>Change in vegetation composition (presence of invasives, exotics)</p>	<p>These boundaries should be kept as natural as possible, preventing excessive human disturbance. Supplementary plantings can provide habitat support for waterfowl like <i>kingfishers</i>.</p>
Open Ground	<p>Abiotic</p> <p>Light penetration</p> <p>Temperature increase</p> <p>Humidity decrease</p> <p>Higher wind velocity</p> <p>Biotic</p> <p>Loss in biodiversity</p> <p>Change in vegetation structure (presence of shrub and herbaceous)</p> <p>Change in vegetation composition (presence of invasives, exotics)</p>	<p>The structural diversity of the edge vegetation can be enhanced (Dramstad et. al, 1996) to mitigate the microclimatic effects. However, instead of introducing exotic species for aesthetics, native edge-tolerant forest vegetation can be planted (Lindenmayer et al., 2006) to support the continuation of interior species to its edge.</p>
Managed Green	<p>Abiotic</p> <p>Light penetration</p> <p>Temperature increase</p> <p>Humidity decrease</p> <p>Higher wind velocity</p> <p>Biotic</p> <p>Loss in biodiversity</p> <p>Change in vegetation structure (presence of shrub and herbaceous)</p> <p>Change in vegetation composition (presence of invasives, exotics)</p>	<p>The boundary along a path, plaza or shrub area can be made more convoluted (eg. Using curvilinear edge patterns) (Dramstad et. al, 1996) to serve as an extension of the forest. Fauna can use these green spaces as a connecting matrix to move between green patches (Lindenmayer et al., 2006), and also can encourage human interactions (Perkl, 2016) with wildlife.</p>

Creating a resilient and biophilic cityscape in a concrete jungle through highways landscape in Hong Kong

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Abstract

The identity and image of a city are always associated with the landscape along the carriageway; and the greenery of the roadside landscape is also one of the key elements of green infrastructure and an indicator of a resilient and biophilic city. Hong Kong is one of most densely populated city in the world. The challenge and need of creating a resilient and biophilic Hong Kong is both pressing and important. Due to the scope and the high volume of pedestrian and vehicular traffic (about 12.6 million average daily passenger trips by public transport with a population of over 7 million), and the large number of trees i.e. over 0.6 million being maintained by Highways Department in Hong Kong, its landscape initiatives and proactive urban forestry management contribute directly to creating a safe, healthy and resilient city.

Highways Department aims at providing an efficient transport network and enhancing the quality of living. The department has been progressively moving towards the direction in enhancing the resilience as illustrated by our *Acacia* slopes enhancement programme, proactive vegetation management, green finger linkage enhancement by strengthening green corridors along road network, and providing more enjoyable environment to the public in streets, promenades and other highway structures; which in parallel promotes the contact of the community with nature.

To illustrate the above, we will share our experience in enhancing the biodiversity and safety of the *Acacia* slopes. Over the past decades, the Hong Kong Government has carried out large-scale afforestation on slopes to prevent soil erosion. Fast growing exotic pioneer species such as *Acacia confusa*, have been extensively planted. In recent years, *Acacia confusa*, which has low ecological value, has reached its senescent stage and the poor health and structure has been posing risk to the public. Hence, an enhancement scheme was formulated to replace the senescent *Acacia* gradually along the roads by a palette of native and naturalised plant species to improve the biodiversity and resilience in the long run. To further connect nature with the

community, various measures were implemented on upcycling wood logs generated from the scheme to bring benefits to the community, for example, through using logs for educational use, art work and other uses.

To further enhance the resilience of our green network, we are applying various innovative measures to proactively manage highways' vegetation including the extensive use of technology for monitoring the health and structure of the trees and develop management plans and cycles. To strengthen green corridors along road network, green finger linkage enhancement is used to connect the highways landscape in urban area with countryside or country parks through robust planting to enhance wildlife niches and the green network.

To provide more enjoyable environment to the public in streets, promenades and other highway structures; landscape initiatives are being implemented to create pleasant public spaces to promote social interaction and contact with nature.

Keywords: Biodiversity, green finger enhancement, highway landscape, proactive urban forestry management, streetscape

1. Introduction

The identity and image of a city are often associated with the landscape along its carriageway. The pollarded Horse Chestnut trees (*Aesculus hippocastanum*) along Champs-Elysees in Paris or the golden Ginkgo trees (*Ginkgo biloba*) in autumn in Beijing or Seoul are some of the exemplary cases. The greenery of the roadside landscape is also one of the key components of the urban green network and an indicator of a biophilic and resilient city; as illustrated by the integration of road network with the sustainable stormwater management system in a growing number of cities.

Hong Kong is one of most compact cities in the world. The challenge in creating a biophilic and resilient environment for the public is both pressing and challenging for the government of Hong Kong. The Highways Department is responsible for the planning, design, construction and maintenance of public road systems and implementation of new highway and railway infrastructure projects in Hong Kong. The department plays an increasingly significant

role in creating a safe, healthy and resilient cityscape.

2. Background

Hong Kong is a highly compact city with over seven million people in only 1110 km² of land [1]. It is one of the most densely populated cities in the world with an average of over 6,690 persons/km², and district such as Kwun Tong has a density as high as 57,300 persons/km² [2]. For comparison, the population density of London was around 5,600 persons/km² and that of Berlin was 4100 persons/km² [3][4].

Apart from maintaining over 2,100 kilometres of roads, Highways Department currently manages the largest number of trees in the urban areas, amounting to 0.6 million as of 2017. Due to the high volume of pedestrian and vehicular traffic (about 12.6 million average daily passenger trips by public transport [5]), the department's work on landscape and vegetation management contributes directly to enhancing public safety and building a biophilic and resilient environment.

Highways Department aims at providing an efficient transport network. In parallel, through the network, we strive to enhance the quality of living environment. As such, the department has been progressively moving towards the direction in building a biophilic and resilient environment as illustrated by our proactive urban forestry management and landscape design work. Some recent initiatives include the rejuvenation programme of senescent *Acacia* slopes, fostering innovation and leveraging research and technologies on tree asset management, green-finger linkage enhancement, and thematic approach in enhancing our streetscape and walkability.

3. Proactive urban forestry management

3.1. Rejuvenation programme of senescent *Acacia* slopes along highways in Hong Kong

Over the past half century, Hong Kong has undergone rapid economic development. Due to the hilly terrain of the territory, large scale site formation was required. As a result, many man made slopes had been formed on which large-scale afforestation were carried out to prevent soil erosion. *Acacia confusa* (*Acacia*) being a tree species that can grow rapidly on dry and poor soil and was therefore chosen as the one of the key pioneer species for extensive planting on slopes along roadsides in Hong Kong for achieving slope greening [6].

With an average life span of approximately 50 to 60 years, the majority of the *Acacia* trees planted in Hong Kong over the past decades have gradually reached their

senescent stage. They have become more susceptible to drought, compaction and secondary pathogens when injury occurs [7]. Furthermore, the *Acacia* in Hong Kong have been very densely planted. As a result, the stem taper of these trees in close stands has not been well developed. This impacts the ability of the trees to be self-supporting [8]. They are also even-aged which tend to grow uniformly tall and generally have little diameter growth with small live crowns. These trees with high height-to-diameter ratios and poor stem tapers are more susceptible to wind thrown [9]. The situation is aggravated by the fact the *Acacia* on slopes tend to be slanting seriously in particular for those at the lower part of slopes (figure 1). In many situations they are arching directly over pavements and carriageways. The deteriorating health problems and declining structural stability have been posing a significant threat to public safety (figure 2).



Fig.1. *Acacia* with severely leaning is commonly found on slopes in Hong Kong



Fig.2. *Acacia* failure poses threat to the public

The maintenance record showed that the number of *Acacia* with poor health and structure in need of removal by Highways Department alone has been increasing steadily each year since 2010 (figure 3). According to the reports on tree failure cases from the local authority in November 2012, *Acacia*-related cases constituted 35% of the reported total [10].

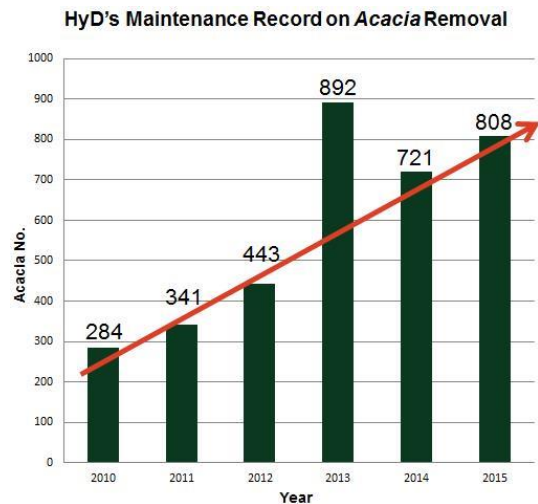


Fig.3. The number of *Acacia* in need of removal has been increasing steadily

Moreover, *Acacia*, being an exotic tree species to Hong Kong, has a lower ecological value than most native species. It releases detrimental biochemical (allelopathy) to understorey plants [11][12], and the densely planted clumps hinders the natural propagation and growth of other plants due to the reduction of light, moisture, nutrients and space available (figure 4). Also, it disrupts the ecology of natural ecosystems by displacing native plants and the animal species that depend upon them [13].



Fig.4. The densely planted *Acacia* hinders the natural propagation and growth of other plants

In order to reduce the risk and safeguard the public and promote the long-term sustainability of highways landscape, a six-stage landscape improvement and habitat restoration programme known as ‘Rejuvenation programme of senescent *Acacia* slopes’ (Programme), has been developed and led by a team of landscape architects in Highways Department and will continue to evolve and develop in the coming decade. This territory-wide Programme is the first of its kind in Hong Kong, in form of its scale and comprehensiveness. The objectives are:

- to create a biophilic and resilient cityscape;
- to better safeguard public safety; and
- to promote the long-term sustainability of highways landscape via biodiversity enhancement.

The Programme evolved from a risk management plan in the original inception to an all rounded long term sustainable development. Its systematic and holistic six-stage approach (figure 5) covers the ‘Planning and consultations’, ‘Work prioritisation’, ‘Public Engagement’, ‘Implementation’, ‘Upcycling of *Acacia* woods, and ‘Monitoring, evaluation and improvement’.

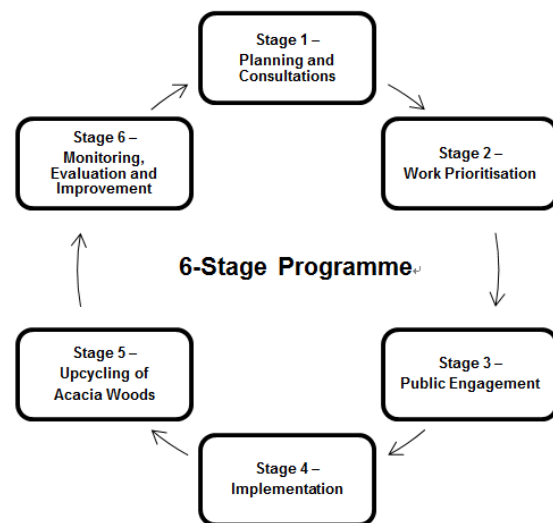


Fig.5. A holistic 6-stage restorative programme

Stage 1 – Planning and consultations

Extensive consultation is essential. We obtained expert views from academia, local and overseas tree experts, the Tree Management Office and the Expert Panel of Tree Management of the local authority. Highways Department has been communicating with the local residents through the District Councils.

Stage 2 – Work prioritisation

We have been carrying out systematic surveys with a scoring system to assess the current tree health, structure and habitat conditions, and setting the order of work priority. In determining the schedule for gradually phasing out the senescent *Acacia* trees, a basket of factors (figure 6), such as target rating, failure potential, size of *Acacia*, site conditions and site sensitivity are duly considered with reference to the international guidelines on tree risk assessment [14].

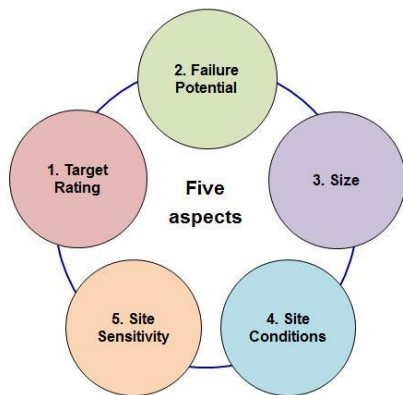


Fig.6. Five factors for work prioritisation

Stage 3 –Public engagement

While we have managed to gain support from the academia and the tree experts on the Programme, it is equally important for the community to understand and support it. We have been providing information of the Programme through website information, video clips, radio interviews and leaflets to the general public. In addition, we promote more interactive publicity activities such as educational talks (figure 7), wood sculpture exhibition and live demonstration (figure 8), and engagement with local District Council members. We are planning for wood upcycling workshops and hands-on activities where community can experience “grow–learn–play” for promoting public awareness on the benefits of the Programme and further connect nature with the community.



Fig.7. Academic outreach programme



Fig.8. Live demonstration on wood upcycling connect the community with the nature

Stage 4 – Implementation

Prior to the replacement on site, we will strike a balance between public safety and social impacts, an optimum replacement arrangement will be carefully developed for each chosen site, with due consideration given to biophilic design, traffic impact, visual impact and site sensitivity (figure 9).

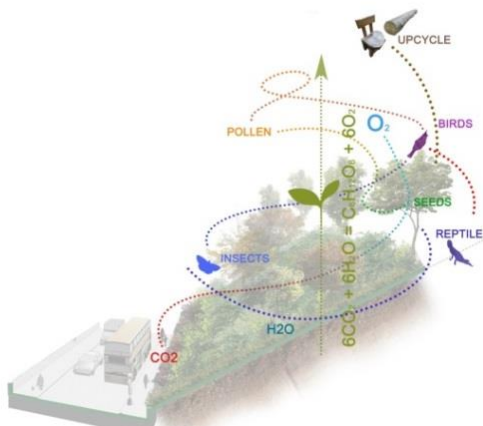


Fig.9. Biodiversity enhancement

We follow the principle of "the Right Plant at the Right Place" in plant selection. Factors such as design theme, biodiversity, landscape character, environmental factors (i.e. soil conditions, microclimate, traffic, spatial factors, plant characteristics, etc.) are taken into account in determining the appropriate species, for replanting. A palette of native and naturalised plant species is selected to improve the biodiversity and to establish a self-sustaining urban forest with multiple strata and higher ecological value [15][16]. Furthermore, we also strike a balance in providing different host plants and nectar plants for butterflies and selecting plant species with fruits and seeds for the wildlife (figure 10) in order to promote self-succession in the restored habitat via natural dispersion.

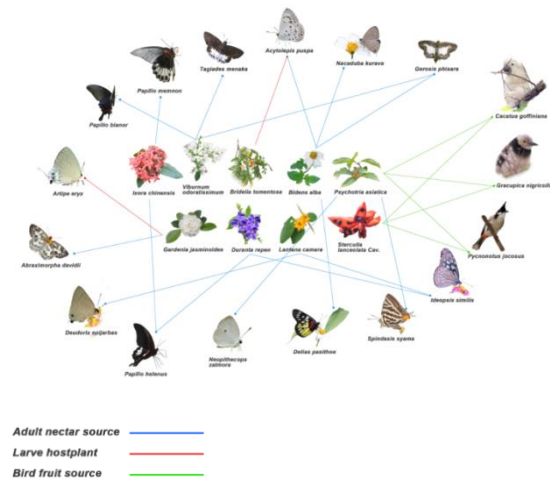


Fig.10. Ecological network

Native species to Hong Kong, such as Wild Pear (*Pyrus calleryana*), Hong Kong Gordonia (*Gordonia axillaris*), Pop-gun Seed (*Bridelia tomentosa*), Holly (*Ilex*) species, *Machilus* species, Buch-like Reevesia (*Reevesia thyrsoidea*), Hong Kong Hawthorn (*Raphiolepis indica*), Rose Myrtle (*Rhodomyrtus tomentosa*), etc., are extensively used together with some naturalised species, such as Camel's Foot Tree (*Bauhinia variegata*), *Camellia* species, Azalea (*Rhododendron* species), Golden Dewdrops (*Duranta repens*), Chinese Privet (*Ligustrum sinense*), Pagoda Flower (*Clerodendrum japonicum*) etc., so as to establish an urban forest of higher ecological and aesthetic value, and to promote local district character with seasonal effects (figure 11), and to attract the community to enjoy the outdoor space.



Fig.11. A palette of native and naturalised plant species is selected to improve the biodiversity

A four-year pilot study was carried out in Pui Man Street in Wong Tai Sin, Hong Kong since 2012 prior to the full launch of the Programme (figures 12a & 12b).



Fig.12a. Before restoration in 2012: Monoculture of *Acacia*



Fig.12b. After restoration in 2015: Lush vegetation with multiple strata of high ecological value

The results of the biodiversity index, performance and survival rate of native plants were compiled. Wildlife such as birds and insects were attracted as seed dispersers in the process that had greatly enhanced the richness of biodiversity. A sharp increase in native species from 5 to 20 and naturalised species from 9 to 16 were recorded in the study site from 2012 to 2016 (figures 13a & 13b).

Native	Planted in 2012 and recorded in 2016	Canopy	<i>Bauhinia x blakeana</i> <i>Ficus microcarpa</i> <i>Liquidambar formosana</i>
		Understorey	<i>Rhaphiolepis indica</i> <i>Nephrolepis auriculata</i>
Newly Recorded in 2016	Canopy	<i>Ficus virens var. sublancoolata</i> <i>Ficus hispida</i> <i>Morus alba</i> <i>Ilex rotunda var. microcarpa</i> <i>Bridelia tomentosa</i> <i>Celtis sinensis</i>	
		Understorey	<i>Melastoma candidum</i> <i>Emilia sonchifolia</i> <i>Desmodium triflorum</i> <i>Sida cordata</i> <i>Lygodium japonicum</i> <i>Kyllinga nemoralis</i> <i>Phyllanthus urinaria</i> <i>Alysicarpus vaginalis</i> <i>Cocculus orbiculatus</i>

Fig.13a. Twenty native plant species were recorded after four years of restoration

Localized	Planted in 2012 and recorded in 2016	Canopy	<i>Bauhinia variegata</i> <i>Delonix regia</i>
		Understorey	<i>Ligustrum sinense</i> <i>Duranta erecta</i> <i>Rhododendron pulchrum</i> <i>Rhododendron mucronatum</i> <i>Rhododendron pulchrum var. phoeniceum</i> <i>Schefflera arboricola</i> <i>Nerium indicum</i>
Newly Recorded in 2016	Canopy	<i>Bombax ceiba</i> <i>Melia azedarach</i>	
		Understorey	<i>Lantana camara</i> <i>Bidens alba</i> <i>Euphorbia prostrata Aiton</i> <i>Oxalis debilis Kunth subsp. corymbosa</i> <i>Scoparia dulcis</i>

Fig.13b. Sixteen naturalised plant species were recorded after four years of restoration

A robust vegetation cover with high ecological value has been established on the man-made slope with low maintenance. These findings were analysed along with the feedbacks from stakeholders for refining the

replacement plans of subsequent pilot schemes. The pilot study offers an opportunity to gain practical knowledge and experience to build on. After the completion of the pilot study, the programme was completed in other 16 sites in various districts in 2016 and 2017. More than 100,000 native shrubs and 300 native trees were planted.

On reviewing the above completed work in the initial phase, it is concluded that the objectives have been successfully accomplished. The landscape with diversified flora and fauna are seen in the restored habitats (figure 14) and at the same time the tree risk level has been substantially reduced.



Fig.14. Diversified flora and fauna are seen in the restored habitats

Stage 5 – Upcycling of *Acacia* logs

We manage the life cycle of the Programme namely from inception and implementation to the post planting work. In line with the government policy of waste reduction, we target to make meaningful use of the materials generated from the replacement work instead of adding burden to the landfill sites. We upcycle the *Acacia* logs generated from the Programme to bring benefits to the community. For example, through using logs for educational use, art work and other uses (figures 15a & 15b). We continue to explore more means to reuse or upcycle the logs.

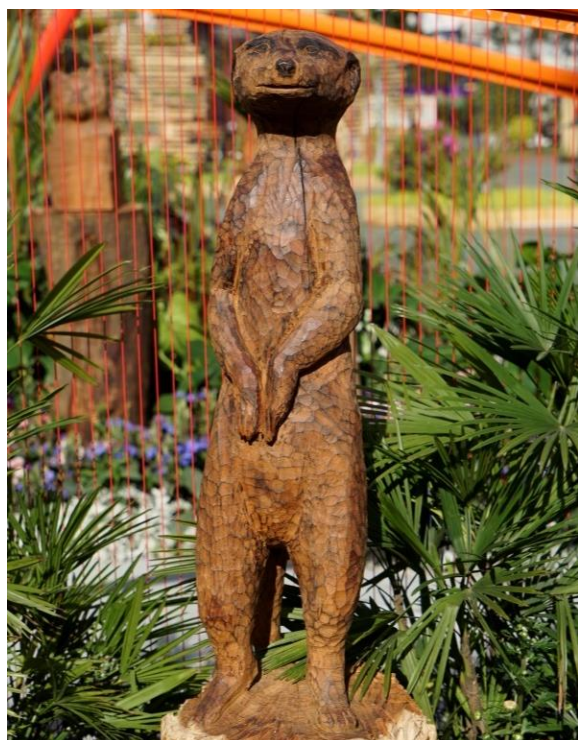


Fig.15a. *Acacia* woods are upcycled into art works for public enjoyment



Fig.15b. *Acacia* woods are upcycled into stools for public use

Stage 6 – Monitoring, evaluation and improvement

Continuous improvement of the Programme requires feedback, monitoring and evaluation. We are collaborating with the academia to track the biodiversity and quantify the performance of different composition of species and methodology. Based on the findings, we aim to further refine the overall plan for its further advancement.

3.2. *Green-finger Linkage Enhancement*

In a less tangible dimension, the green space network contributes to the physical and psychological health and well-being of individuals. It is believed that biophilic cities in which design of the cities includes natural elements and green space network as a crucial element can build resilience and benefit the well-being and health of the population. Numerous international research studies confirmed the positive contribution of green spaces to mental health in relieving stress [17][18], giving relief and providing recreational spaces and opportunities

[19][20]. There is growing recognition among international communities that mental health is one of the most neglected and pressing development issues [21]. In an increasingly compact Hong Kong, the green space network plays an indispensable role in enhancing both physical and mental health of our population. Both the quantity and quality of green spaces are essential in providing the necessary venues for developing and enriching social cohesion and interaction which are fundamentals to a quality living environment. Providing green spaces close to living spaces and making them accessible also helps provide restorative environments. As such, there is a strong case to promote communal green spaces in the neighbourhood at multiple levels and scales, and to facilitate recreational and leisure functions.

Highways Department is launching the green-finger linkage enhancement scheme to link green spaces by making use of the greenery under its management and reinforcing the landscape character of roadside planting. For example, the autumn colour of Chinese Sweet Gum (*Liquidambar formosana*) in Tai Lam Country Park (figure 16) has become very popular, and the green-finger linkage enhancement in this area will strengthen the landscape character of the place by planting the same native species along the roads leading to the country park.



Fig.16. The stunning autumn colour of Chinese Sweet Gum in Tai Lam Country Park is a hot spot for tourists to take photos

In Tsuen Wan and Route Twisk area where the spring blossom of Camel's Foot Tree (*Bauhinia variegata*) gives a sense of place (figure 17), the green-finger in the area will link up the fragmented locations under the theme of the spring bloom. These green-fingers in various districts will also become effective eco-corridors along carriageways as native and naturalised species will be planted. These green-fingers connect the originally fragmented patches of greenery and therefore nurture a biophilic environment that is conducive to the sustainability of natural habitats.



Fig.17. Enhancement of the driving experience during the spring blossom in Route Twisk

3.3. *Fostering innovation and leveraging research and technologies on tree asset management*

Trees growing in urban and surrounding areas are subject to considerable environmental stress. It is therefore essential to properly maintain them and upkeep their health and structure and avoid potential hazard to life and property. These trees are important components in the urban forestry and the sustainable urban ecology. Tree management in Hong Kong faces the challenges of the lack of space for tree growth in the urban area and in addition there are typhoons and torrential rain in summer that may cause damage or collapse of trees. Moreover, Highways Department is managing trees on slopes and along expressways where inspection and maintenance work alongside busy traffic is not easy. On-site inspection of the tree though provides in-depth assessment of tree conditions is labour extensive and the result is dependent on the expertise of the personnel. For the management of large number of trees, it would be beneficial to make use of technology and innovation to complement the on-site inspection work.

For the effective management of trees over the whole territory, Highways Department aims at developing a tree asset management system to plan and prioritise work. An updated GIS-based tree database and management system for analysing data to effectively plan for tree management work is therefore necessary. The location of trees, distribution of species and dimensions, and complaint hot spots are useful information in planning work flow and prioritising

operations, and devising a rapid response management plan.

We are keen to explore fit-for-purpose technologies for application in tree asset management. Apart from making use of data captured by Mobile Mapping System (MMS), the latest collaboration with research institutions include making use of remote sensing techniques to monitor tree health over time as the early warning of anomalies detected can complement on-site tree inspections to better identify trees with deteriorating health conditions or under stress (figure 18).

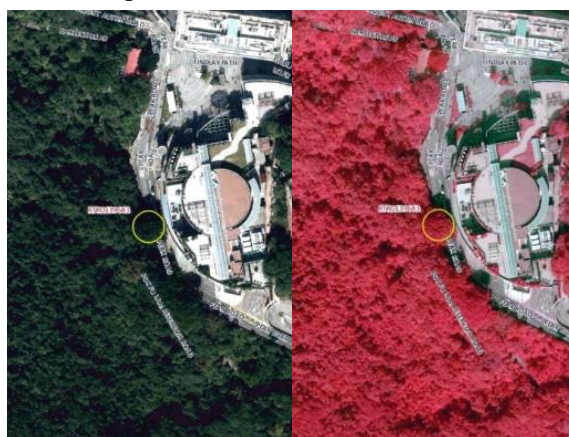


Fig.18. An application of remote sensing technology with the use of Infra-red image in vegetation management (source: Lands Department)

Other current research topics include the use of remote sensing data in capturing tree locations and dimensions. This would be useful for managing trees in locations with difficulty in access.

The GIS based spatial information facilitates planning and maintenance work, management decisions and long-term

preservation of trees. By fostering innovation and leveraging research and technologies, we aim to enhance and manage the valuable green assets more efficiently.

4. Pedestrian-friendly design along highway landscape

Promoting walkability in the urban environment should form an integral part of the green space planning framework, and is a key element for sustainable cities. A comprehensive development of a pedestrian-friendly walkway system can help reduce the reliance on road-based transport, which in turn alleviates the demands put on the transport system and lessens the impact on the environment. It can reduce the number of short motorised trips and the conflict between pedestrians and vehicles. This will increase mobility, enhance road safety and improve local air quality.

It is desirable to promote walkability and applying a pedestrian-oriented approach in streetscape design that encourages community interaction and street life to replace that of ‘car-based’ approach (figure 19).



Fig.19. Enhancing the streetscape of our community through greening, design and selection of paving patterns and street furniture commensurate with the environment

It was under such background that Highways Department has been launching some streetscape improvement schemes that promote walkability and build the identity of a place (figure 20). A recent example is the thematic design to highway structures under the theme of ‘Appreciate. Life. Colours’, which aimed to bring interest to the walking experience. Inspired by elements found in the nature and our daily lives, the design re-created delightful scenes such as walking the dog in the woods, watching wild birds with the family in the country, and the first time being in an aquarium as a child, in the style of simple silhouettes. All these happy scenes in the memories serve to slow down the pace and brighten up the mood of the passers-by (figures 21).

These improvement works have given new energy and rejuvenated the otherwise underused spaces (figure 22).



Fig.20. To create a sense of place via streetscape enhancement



Fig.21. Brightening the walking experience



Fig.22. Transformation of the underused space to popular gathering spot

5. Conclusion

In a compact city such as Hong Kong, the green assets along highways should be leveraged to enhance livability. Through the above proactive urban forestry management strategy and landscape initiatives on pedestrian-friendly environment, Highways Department has demonstrated the recent progress and initial steps in creating a resilient and biophilic cityscape in a concrete jungle for the benefits of the community and the environment.

Acknowledgments

We have to express our sincere gratitude to the visionary guidance and enormous support of the senior management of the Highways Department without which the proactive initiatives in creating a resilient and biophilic cityscape would not be successfully launched. We also express our gratitude to Lands Department for the permission of our use of the aerial photo (figure 18) and to Parry Ling, wood sculpture demonstrator, from Hong Kong Baptist University for the support of our public engagement events.

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AGROSUPERBLOCK: Comprehensive Multifunctional Area by Integrated Agriculture and Energy Efficiency

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Abstract

Indonesia is the fourth most populous country in the world and city population by 2017 reached 54.8% and is expected to increase every year. Population growth and development in urban areas are rapidly followed by an increase in demand for land. This condition will encourage the conversion of land, especially the conversion of agricultural land to non-agricultural land. Urban development requires a solution so that the agricultural sector can be integrated into other sectors in the design of the development. AGROSUPERBLOCK concept is the idea to be a solution in overcoming the problems of urban areas. This concept is an integration between integrated urban farming and superbloc city concept. The techniques used in the implementation of Agrosuperblock can be done in cooperation with related parties especially among professionals, bussinessmen, community and government. In addition, the delivery of Agrosuperblock related information is very important. Information provided on the benefits derived from the Agrosuperblock concept, particularly in terms of creating urban areas as as comfortable residence and mixed use center in urban areas through sustainable development by promoting ecological and environmental sustainability with the integration of multifunctional and agricultural sectors. In addition, urban development currently focuses on the concept of 'green' strongly supports the implementation of Agrosuperblock. As a key stakeholder and regulator, the government is also responsible for ensuring the concept of Agrosuperblock can benefit all parties without emphasizing only certain aspects or parties. If the concept idea of Agrosuperblock is applied consistently, it will create an independent city through sustainable development by promoting ecological and environmental sustainability and land and energy efficiency.

Keywords: Agrosuperblock, agriculture; efficient; mixed use center; multifunctional; urban area

1. Introduction

The major urban areas in Indonesia have a problem in the formulation of policy and strategy urban development. One of them is the population density and carrying capacity of the urban area. The Statistics Indonesia (2014) showed that the population density level increased in 2010 is 124 people/km² to 132 people/km² in 2014. The growing population and development in urban areas quickly followed by an increasing in demand

for land, this will encourage the conversion of agriculture land to non-agriculture land.

The alteration agriculture land in urban areas can lead to problem in the economic, social, cultural, and environmental sectors. This condition has worsened with the government policy to development-oriented in urban area. Data from The Ministry of Agriculture (2014) mentioned that the decrease of agriculture land area by 25 % at year 2012-2013. Development of city need a solution for integrated multifunctional sector in development planning.

Government efforts in the development or urban areas are written in Law of The Republic of Indonesia Number 26 of 2007 concerning Spatial Planning and Government Regulation Number 34 of 2009 concerning Guidelines of Urban Area's Management. In accordance with these laws, urban areas are the main non-agricultural activities with the function of the area as urban settlements, centralization and distribution of government services, social services, and economic activities. Urban development planning is based on condition, potential, characteristic, and relatedness with

surrounding area. This regulation doesn't support the sustainability of the agricultural sector in the urban areas. This condition is exacerbated by the policy of designing new urban areas from rural areas. The problem cause land conversion function of agricultural land. The conversion of agricultural land in urban areas needs to be avoided because the existence of agricultural land will always exist and when converted agricultural phenomenon will penetrate the forest which resulted in other polemics. Therefore, urban farming needs to be implemented to be more effective and efficient.

Urban Farming becomes a solution for the agricultural sector in urban area. The benefits of urban farming are to improve environment quality, social cohesiveness, cultural, economy community, value aesthetic urban area and food security (Arifin, 2016). However, it is necessary to develop urban farming with integrated management to make it more efficient in economic, technology, and energy.

Beside it, urban development also focus on integration various sectors in a complex areas. Kamil (2008) said that the source of city's problems is due to the inability of the city system to control the growth and change of the city. Human civilization, lifestyle, and physical aspect of the city are so rapidly changing, while the controlling of the city's system get slowly, so the big cities in Indonesia are experiencing this problem. The problem can be solved through the concept of superblock city. Superblock is an area in urban contexts are designed in integrated development, high enough

density in land use mixed-use concept. This area is a multifunctional complex (commercial area, office, residential, and entertainment) into one unity. The disadvantage of this concept has not yet include urban farming, actually agriculture sector become an important part of sustainable urban development particularly in food security that gaining the independence mixed-use center.

Agrosuperblock is solution in overcoming urban area problem. This concept is an integration urban farming and integrated city or mixed-use development. The objective of this study is planning and designing the development of urban areas through sustainability development by increase ecological and enviromental with integration of multifunctional sectors. It's expected to become a reference or model for the government in implementing urban development with the concept of Agrosuperblock.

2. Methods

2.1 Study design

We employed the case study, literature review, and qualitative method from the development of urban areas in Cibinong Raya, Bogor Regency. Cibinong Raya, Bogor Regency is one of the centers of urban areas in Indonesia that included Jabodetabek (Jakarta, Bogor, Depok, Tangerang, and Bekasi). The city located in 40 km south of Jakarta, the capital of Indonesia. Based on Regional Spatial Planning Policy (2016), role and function of Bogor regency consist of the settlement's population of Jabodetabek, provision of agricultural land to support the availability of food supplies, and conservation

protection area in the middle and upstream region.

2.2 Case selection

Cibinong Raya is the capital city of Bogor Regency. Cibinong Raya is the urbanized area in Bogor Regency that connected to Jakarta by railway (2 stations), arterial road and highway road with three entrance. The growth of Cibinong Raya is mostly caused by the orientation of public services in this area as a capital city, high accessibility to core city; and availability and high quality of land. The rapid growth of Cibinong Raya is indicating by high growth in population: 1.3 million inhabitants with growth rate by 3.99%, rapid development of built-up area, 38.77% of built up area with growth rate by 3.46%, and rapid development of infrastructure (Regional Spatial Planning Policy of Bogor Regency, 2016).

The study is focused on Cibinong Situ Front City (*situ means lake in local language*) as a pilot project of the Agrosuperblock. Cibinong Situ Front City is one of the most potential resources to develop. The goverment has announced that Cibinong Situ Front City will be a new icon and promotion spot for Cibinong Raya and tried to focus on developing two main lake Situ Cikaret and Situ Kabantenan (Kompas, 2016). Figure 1 show the existing of Situ

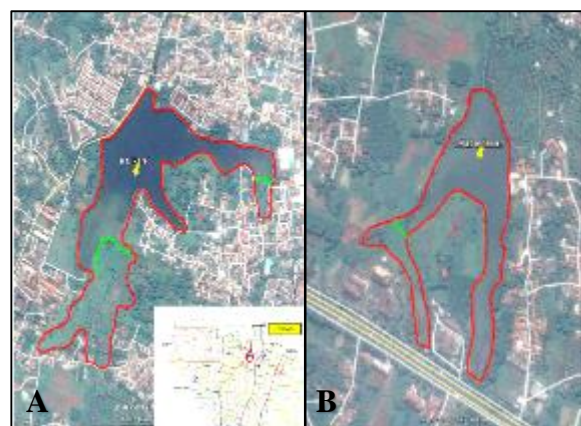


Figure 1 Cibinong Situ Front City:
 A.Situ Cikaret; B. Situ Kabantenan

Cikaret and Situ Kabantenan.

2.3 Analysis

Analysis of the Agrosuperblock's concept consists of agricultural context and superblock context. Agricultural context describes the application of urban farming, permaculture, and green city to support the Agrosuperblock's concept in Cibinong Situ Front City. The analysis of urban farming and permaculture will be conducted through a literature study to search the suitable application and calculate the estimation of food needs and production for the Agrosuperblock's concept. While, green city's analysed is based on eight indicators, there are green planning and design, green open space, green building, green waste, green transportation, green water, green energy, and green community. Superblock context is focused on developing Cibinong Situ Front City as superblock area. The analyse for this context is begin with identifying the overall area in Cibinong Situ Front City by site analysis.

2.5 Concept

The concept of this study refers to the Agrosuperblock's concept that integrated multifunctional area (superblock) and agricultural area. After the Agrosuperblock's concept created, we established the zoning concept and function.

2.6 Site planning

Site planning is built from all concept and result of the analysis. The output of this step is the siteplan of the Agrosuperblock's concept in Cibinong Raya, Bogor Regency.

3. Results

Cibinong Situ Front City consist of Situ Cikaret and Situ Kabantenan. Both are part of Ciliwung river stream. Situ Cikaret has 29.5 Ha areas while Situ Kabantenan has 4.5 ha areas. Based on the government policy, the planning of this site is connecting Situ Cikaret and Situ Kabantenan (Figure 2). The

planning aims to revitalization area of Cibinong Situ Front City, integration green and blue open spaces, and increase waterbody for water management. The study of Puspita (2017) showed that Situ Cikaret has a good landscape condition and Situ Kabantenan has passably condition to development.

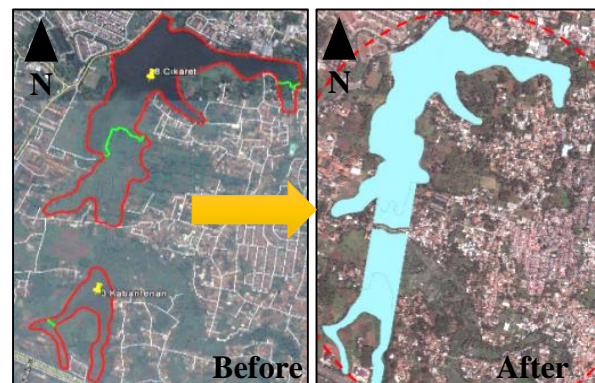


Figure 2 The connecting of Situ Cikaret and Situ Kabantenan

3.1 Analysis

Permaculture and urban farming combined to support the Agrosuperblock concept. Permaculture is linked agricultural productivity based on socio-economic, and ecological has a big chance to be applied (Nabilah, 2017). To implemented permaculture and urban farming concept, it's important to know the estimation of food needs. Food needs are analyzed by some assumptions based on Priandono (2006), there are:

1. the population around Cibinong Situ Front City is 3,500 peoples (15% of total population);
2. calory need per days is 2,500 kkal;
3. the one day meal menu of population same as the 2006 data; and
4. the conversion of the food menu into agricultural commodities is the same as the 2006 data.

The food needs which is analyzed consist of vegetable and animal food. The commodity that is the priority of vegetable food needs is rice, soybeans, sweet corn,

papaya, kale, chili, spinach, beans, tomatoes, potatoes, carrots, cabbage, leaves onion, celery. Animal food is needed milk, chicken, eggs, and fish (Priandono 2006). The result showed that the estimation of food need is 6,386.5 kg/day and the food production area need 1,188,361 m² (Table 1).

Table 1 The estimation food need and production area need

Type of food	Need per portion	Convert to	Needs per day (kg)	Land area required (m ²)
Rice	400 g	Rice	2153.0	583000
Tempe	25 g	Soy	175.0	320800
Corn	150 g	Corn	450.0	96250
Papaya	100 g	Papaya	350.0	64200
Chicken	60 g	Chicken	210.0	560
Kale	100 g	Kale	350.0	14000
Chili	1 g	Chili	3.5	420
Spinach	100 g	Spinach	350.0	21000
Bean	75 g	Bean	262.5	47800
Tomato	100	Tomato	350.0	39700
Egg	1 unit	Egg	3500.0	280
Fish	100 g	Fish	350.0	10
Leek	40 g	Leek	140.0	5.6
Celery	15 g	Celery	52.5	10.5
Milk	0.1 L	Milk	350.0	350
Total			6386.5	1183361

Source: Analysis, 2018

The analysis of green city is based on 8 indicator's evaluation. Green city is a concept of health city considering ecological aspect. The results of the study from Desdyanza (2014) showed that Bogor has had a city development plan towards sustainable city, but the implementations still haven't been maximized. As a reference, Table 2 showed the result of evaluation Green City in Bogor City.

Table 2 The result of Green City's evaluation in Bogor City

Indicator	Ideal Criteria for Implementation	Score
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		(%)
Green Planning and Design	• Compact city	
	• Mixed use development	12.5
	• Pedestrian area	0
	• Transit oriented development	
Green Open Space	• Neighborhood park	
	• City park	
	• Green corridor in street and river	50.0
	• Urban forest	0
Green Building	• Urban farm	
	• Cemetary	
	• Energy efficient and enviromental quality of building	0.00
Green Waste	• Implementation of 3R's concept	31.25
	• Waste management	
Green Transportation	• Pedestrian track	
	• Bicycle track	
	• Public transportation	37.50
	• High occupancy vehicle	
Green Water	• Biopori	25.00
	• Low impact development	0
Green Energy	• Solar energy	20.00
	• Wind energy	0
	• Water energy	
Green Community	• Participation of community	37.50
	• Community members	0

Source: Desdyanza (2014)

Table 2 knew that implementation of green open spaces's indicator has the maximum percentage in amount of 50%. While green building's indicator has the minimum percentage in amount of 0%. The result showed that implementation of Green City in Bogor has still not maximally done.

3.1 Concept

The concept of this study refers to the Agrosuperblock's concept. Agrosuperblock is an integration permaculture, urban farming, green city and mixed-use development (superblock). The integration aims improve land and energy efficiency, reduce the conversion of natural land and forests, promote the diversity of activities in an integrated manner and synergies, efficiency of movement, reduce congestion, improve urban spatial, supply the food needs, the improvement of the quality of environment, and the avoidance of community gaps and small blocks so that the creation of sustainable self-sustainable cities with land and energy efficiency. Agrosuperblock is illustrated in Figure 3.

In practice, permaculture is integration between agricultural, livestock, fisheries, and human in the symbiotic system of products (Morrow, 1993). Permaculture is implemented in landed farm that consists of a fish pond, livestock, and paddy field. Permaculture as production system concept in the site aims to sustainability uses.

Implementation of urban farming in Agrosuperblock implemented through Vertical Farm Centre. The design of Vertical Farm Centre places agricultural land specifically vegetables and fruits as a component of the superblock building. This

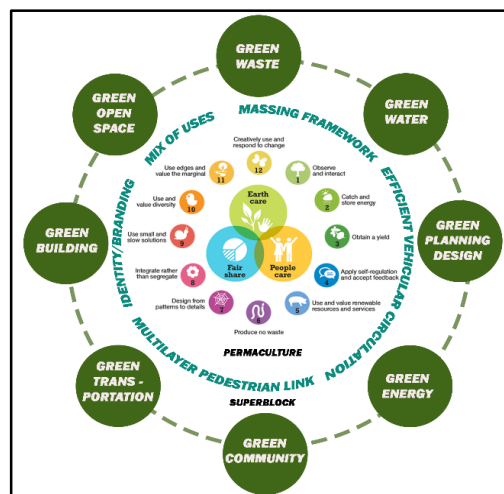


Figure 3 Agrosuperblock concept

component is based on a vertical farming system that is divided into greenhouse and intensive agriculture with integration with fish pond, and livestock.

Green city concept in Agrosuperblock implemented based on the criteria of green city, there are:

1. Green planning and design implemented through mixed use development in superblock.
2. Green open spaces is supported by implementation of permaculture and urban farm. Beside it, blue open spaces available as lake or *Situ* that has function water supply and water catchment in around Cibinong Situ Front City.
3. Green building implemented through environmentally friendly building structures and decrease uses of air conditioner.
4. Green waste and green water is combined through water management of blue water, grey water, black water, and green water. Implementation of 3R (Reduce, Reuse, and Recycle) is supported by waste processed technology that environmental friendly.

5. Green transportation is developed through increase pedestrian way, bicycle way, and public transportation.
6. Green energy is implemented through solar panel to harvesting solar energy. It's so potential cause the site located in tropical climate that has high solar radiation.
7. Green community is developed by collaboration between stakeholders.

Development of Agrosuperblock is developed by the main concept of superblock according Wibisono (2010) said that the concept of superblock can develop and respond positively by the community if in superblock design has five the main concept of the planning process until it becomes a ready product marketed, among others identity/branding, mix of uses, massing framework, efficient vehicular circulation, and multilayers pedestrian linkage.

3.2 Site planning

Agrosuperblock is implemented in Cibinong Situ Front City consist of Situ Cikaret and Situ Kabantenan. The design of this study area considered the potential area which is planning as superblock development. Agrosuperblock in Cibinong Situ Front City is applied consider:

1. Identity/branding of Cibinong Front City
 - a. Green and blue open spaces: Situ Cikaret and Situ Kabantenan

- b. Buffer zone of city center
 - c. Water catchment in upstream area
 - d. Center of government activity
2. Mixed of use
 1. Government office zone
 2. Park and open space
 3. Commercial and shopping zone
 4. Residential zone
 5. Urban farm zone
3. Massing framework
 - a. Adaptive from characteristic and function of building
 - b. Consider focal point and landscape view around the site
 - c. Consider of wind and sun direction
 - d. Make the building facing towards Situ Cikaret and Situ Kabantenan.
4. Efficient vehicular circulation
 - a. Pedestrian way
 - b. Bicycle track
 - c. Vehicle way
5. Multilayer pedestrian linkage is applied by presenting a comfortable pedestrian, accessible to various buildings, safe, and close to nature.

Figure 4 showed site plan of Cibinong Situ Front City based on Agrosuperblock. The design effort to supply land area required for permaculture and urban farming. The availability of land for permaculture and urban farming can be seen in table 3. The total land can supply 19% of the urban farming requirement.

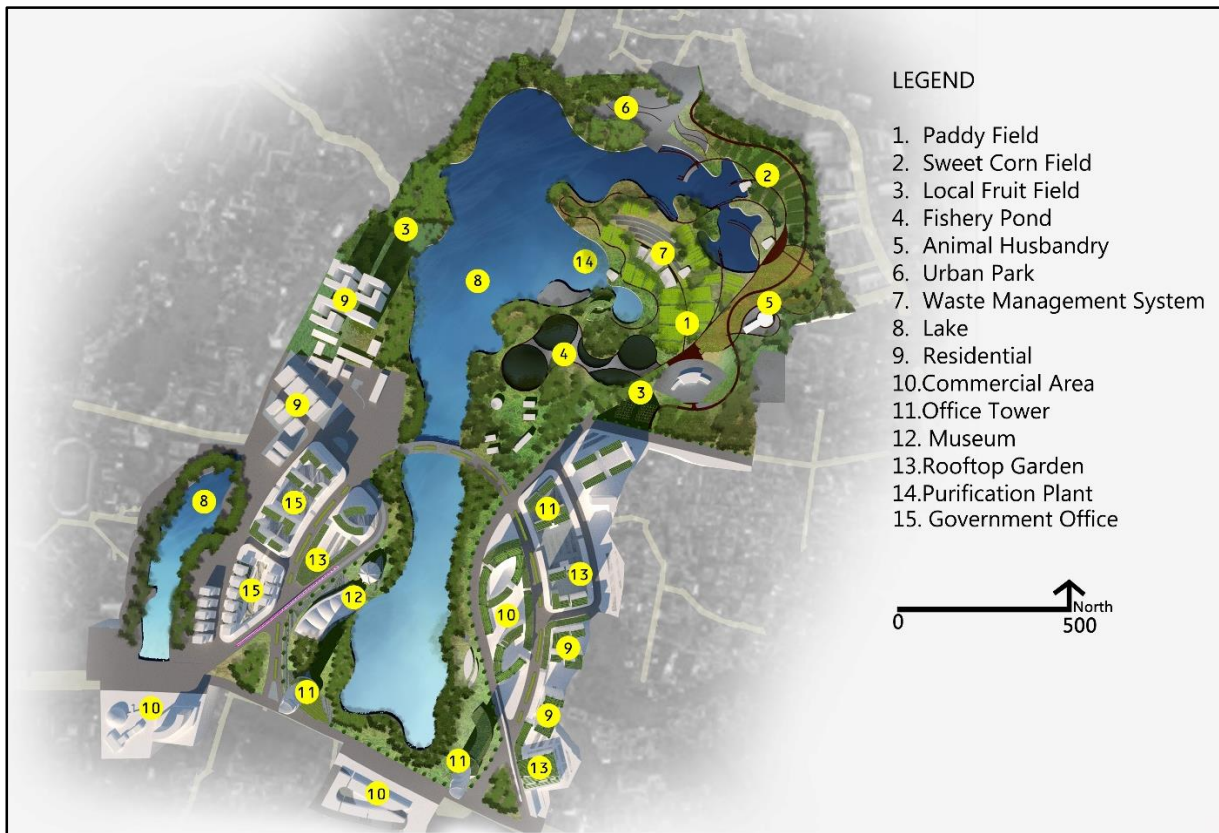


Figure 4 Siteplan of Agrosuperblock in Cibinong Situ Front City

Table 3 Availability of land for permaculture and urban farming

Type Of Land Use	Area (m ²)
Rice	141,000
Sweet Corn	80,000
Fishery	31,000
Chicken	2,500
Cow	40,000
Goat	10,000
Jack Fruit	5,000
Manggo	3,000
Coconut	5,000
Banana	8,000
Casava	9,022
Taro	5,000
Waste Management System	2,000
Total	341,522

Source: Analysis, 2018

3.3 Program development

Development of Agrosuperblock in Cibinong Situ Front City requires collaborative role of various element such as academic, professional, business, government, and communities. This collaboration named Pentahelix collaboration. Each element has its own function and capability that affect the implementation of Agrosuperblock. The collaboration will great with the support of communities as a main goal and who benefit from the implementation. For example, government can consider tax, an academic can consider about research and innovation for Agrosuperblock, professional can be consider availability of the implementation, and business sector can be an investor. For

more detail the schematic can be seen in Figure 5.

The other strategy is concerning about

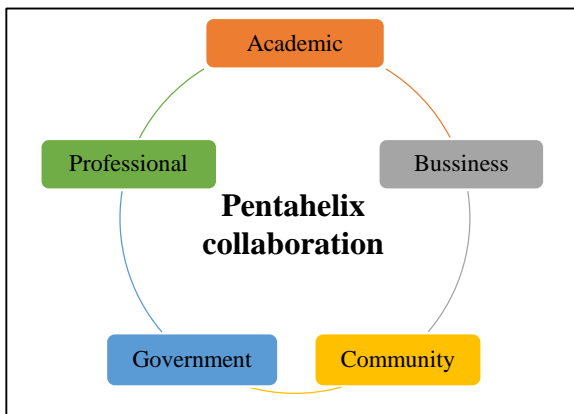


Figure 5 Pentahelix collaboration in Agrosuperblock

Agrosuperblock scheme. The integration between permaculture, urban farming, green city, and superblock is connected to each other. The scheme is illustrated input-output of the process and benefit from each cycle.

product like compos and biogas recycle can use for other needs. The schematic diagram shows in Figure 6.

Conclusion

The study in one of the new approach concerning agricultural and urban problems. Agrosuperblock is an integration between permaculture, urban farming, green city and mixed-use development (superblock). The study is focused to Cibinong Situ Front City (Situ Cikaret and Situ Kabantenan) as a pilot project and case study of the Agrosuperblock. The result of food need's analysis showed that the estimation of food need is 6,386 kg/day and the food production area needs 1,188,361 m². The design of Agrosuperblock effort supply 19% or 341,522 m² of land area required for permaculture and urban farming in superblock area. If the concept of Agrosuperblock is applied consistently, it will create an independent city through

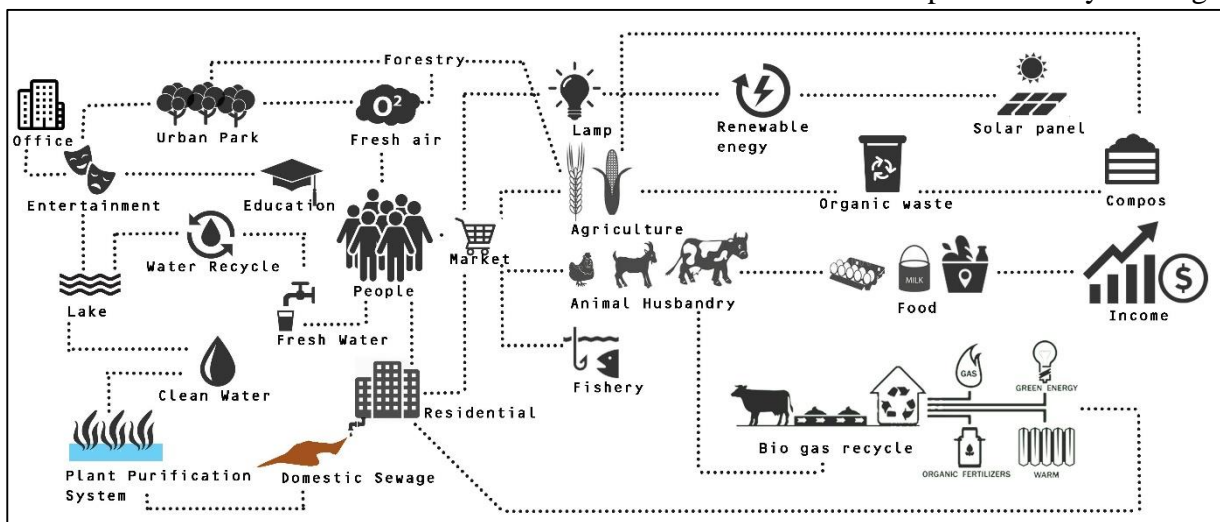


Figure 6 Scheme of Agrosuperblock

All the program have functions that support environmental sustainability. For example, permaculture produces food, but others

sustainable development by promoting ecological, environmental sustainability, land and energy efficiency.

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Evaluating the Impact of Urban Green Space and Landscape Design Parameters on Particulate Matter Air Pollution

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Abstract

Urban green space (UGS) can help to moderate particulate matter air pollution through the impact of landscape design parameters. The current work investigates the particulate matter modification potential of urban block (1 km) in Wuhan, China and the effects of its landscape parameters by field measured data. Bivariate relationship is evaluated between the particulate matter concentration and landscape parameters. Strong positive correlation is found between the percentage of vegetation and PM₁₀, PM_{2.5} concentration, and strong negative correlation is found between the percentage of hardened ground and PM₁₀ concentration. Meanwhile, weak negative relationship between the percentage of building and PM_{2.5} can be observed. The impacts of water body on particulate matter modification are found to be uncertain to some extent. Stepwise multivariate regression analyses show that the most significant influential factor on the moderation of particulate matter is the vegetation, 10% increase of the area of vegetation will decrease about 9.1% and 10.2% in PM₁₀ and PM_{2.5} concentrations, while the hardened ground and building exhibit negative effects. The outcome of the current work can provide evidential bases and available knowledge for the landscape architects to improve the urban air quality by means of urban green space.

Keywords: urban green space; landscape design parameters; PM₁₀; PM_{2.5}

1. Introduction

Rapid urbanization has changed urban underlying surface and had a significant impact on the urban climate, such as the serious particulate matter air pollution. In recent years, PM₁₀ and PM_{2.5} became the main pollutants, which refer to particulate matter in air that is less than 10 µm and 2.5 µm in aerodynamic diameter respectively. This kind of air pollution became the focus all over the world and the experts and scholars from various fields are trying to find solutions.

Urban green space (UGS) can help to moderate particulate matter air pollution through the impact of landscape design parameters. Those landscape parameters include vegetation, water body, hardened ground (walking path and plaza) and building. The vegetation components of the UGS like lawn and trees can reduce particulate matter concentration^[1]. The water body such as lakes can also reduce particulate matter by increasing air humidity^[2]. However, highly constructed cities experience higher concentrations of PM₁₀, which are composed of buildings^[3]. Nonetheless, these has not been taken into account in current urban planning or landscape design guide. With the continuous reduction and fragmentation of UGS in modern cities, it is important to further reveal and emphasize the positive effects of UGS, such as the particulate matter modification potential, and put forth a series of measures aimed at minimizing particulate matter.

Previous works focused on the effect of limited numbers of selected landscape parameters on particulate matter modification effect, but no available information on the comprehensive contributions of various parameters in an UGS can be found so far.

The current work investigates the particulate matter modification potential of urban block (1 km) in Wuhan, China, and the effects of its landscape parameters by field measured data. The main aim of this work is to reveal the influence factor of landscape parameters on particulate matter air pollution and influence degree. The outcome of the current work can provide evidential bases and available knowledge for the landscape architects to improve the urban air quality by means of urban green space.

2. Methods

2.1. Study area

Wuhan (113°41'-115°05'E, 29°58'-31°22'N), 8494.41 square kilometers in area, is the largest city in central China. It is located at the intersection of the Yangtze and Han Rivers, and is divided by the two rivers into Wuchang, Hankou and Hanyang. In recent years, Wuhan's urban population and yearly construction area have been gradually increasing, which resulted in serious particulate matter air pollution. According to

the 2016 global air pollution database published by the world health organization, Wuhan was the 12th worst particulate matter air pollution in 210 cities in China. Thereby, it becomes a target site of many studies relevant to urban particulate matter air pollution^[4-5].

The interest domains of the current study, 14 air quality monitoring stations, are relatively evenly spread around the main city of Wuhan, including 8 national automatic monitoring stations, 4 urban national automatic monitoring stations and 2 self monitoring stations set by research group.

Table 1. Attributes of the 14 blocks.

No	Site	Coordinates	General land use	UGS composition
1	Zhuankou New area	(30.4753, 114.1525)	Commercial area	Street trees
2	Hankou Huaqiao	(30.6197, 114.2836)	Residential area	Street trees and planted residential areas
3	East lake Pear orchard	(30.5719, 114.3672)	Parkland area	Parkland
4	Hankou Marshland	(30.5947, 114.3008)	Residential and parkland area	Parkland, planted public facilities areas and street trees
5	Ganghua, Qingshan	(30.6103, 114.4272)	Residential and commercial area	Street trees and planted residential areas
6	East lake High-tech area	(30.4822, 114.3894)	Residential area	Street trees and planted



Fig. 1. Distribution of 14 monitoring stations in the main city of Wuhan. Diagram by the author.

Taking these 14 blocks of 500m's radius for the study subjects, with the center of each monitoring station (Fig.1, Table.1).

				residential areas
7	Yuehu Lake, Hanyang	(30.5514, 114.2511)	Residential and parkland area	Parkland and planted residential areas
8	Ziyang, Wuchang	(30.5494, 114.3006)	Residential area	Parkland and planted residential areas
9	Nansi, Huazhong	(30.5113, 114.4050)	Educational and residential area	Street trees, planted residential and public facilities areas
10	Design Institute, Huazhong	(30.5162, 114.4085)	Educational area	Street trees and planted public facilities areas
11	Geological University	(30.5162, 114.4085)	Educational area	Street trees and planted public facilities areas
12	Southern part of Jiangnan District	(30.5162, 114.4085)	Commercial area	Street trees and parkland
13	Red scarf school	(30.5162, 114.4085)	Educational area	Street trees and planted residential areas
14	Gutian, Qiaokou Distric	(30.5162, 114.4085)	Commercial area and residential area	Street trees

2.2. Particulate matter measurement

Based on the 14 air quality monitoring station in main city of Wuhan, PM₁₀ and PM_{2.5} sample data of 4 months from June to September 2016 was averaged respectively. These data was selected on the sunny and breezy condition when UGS play a better ecological benefits. The data of national and urban automatic monitoring stations originated from Wuhan Environmental Protection Bureau (<http://hbj.wuhan.gov.cn/?COLLCC=1182685071&>), where we can get daily data of PM₁₀ and PM_{2.5} concentration. The data of self monitoring stations was measured by LD-5S laser dust meter and hourly data can be obtained.

2.3. Landscape parameters

Four type landscape parameters including vegetation, water body, hardened ground, and building were obtained by remote sense image (GF2, September 1, 2016) and field survey. Based on the object-oriented classification techniques, ENVI (The Environment for Visualizing Images) can achieve the automatic recognition and extraction of vegetation target from high-resolution remotely sensed imagery. NDVI was used to distinguish vegetation, and NDWI was used to distinguish water body. Hardened ground and building were obtained by artificial depiction. Moreover, combined with artificial visual interpretation, the results of extraction were optimized. The output results are shown in Table 2.

2.4. Statistical analyses

Bivariate relationship is evaluated between the particulate matter concentration and landscape parameters including vegetation (VE), water body (WB), hardened ground (HG) and building (BU). The analysis results show the different effects of various landscape parameters in the block. Moreover, stepwise multivariate regression analysis is conducted to assess the contribution of those landscape parameters to particulate matter quantitatively, according to a predictive equation (Eq.1):

$$Y = a_0 + a_1VE + a_2WB + a_3HG + a_4BU \quad (1)$$

Where Y stands for the values of PM₁₀, PM_{2.5} concentration; VE, WB, HG and BU are the percentages of each landscape parameter as previously described; a₀ is the constant; a₁-a₄ are the coefficients for each variable. The statistical analysis are carried out using SPSS 19.0 software.

Table 2. Percentage of landscape parameters for the 14 blocks.

No	VE/%	WB/%	HG/%	BU/%
1	18.74	0	50.33	22.96
2	21.66	0	36.87	37.15
3	22.69	67.38	5.86	1.95

4	24.72	30.06	27.14	13.04
5	25.43	0	36.96	31.74
6	27.39	0	44.10	26.08
7	32.21	40.22	22.70	4.87
8	34.39	14.75	29.19	19.94
9	54.83	1.39	22.14	18.28
10	65.63	1.02	12.00	21.35
11	33.32	0.73	35.06	26.64
12	7.75	21.93	28.25	40.00
13	23.59	0	43.03	29.51
14	21.25	0	36.09	39.51

3. Results

3.1. The distribution of PM₁₀ and PM_{2.5} in different blocks

In the form of high density city, the concentrations of PM₁₀ and PM_{2.5} in different blocks are significant difference, and the trends for PM₁₀ and PM_{2.5} concentration are similar (Fig.2). On the whole, the highest concentration of PM₁₀ and PM_{2.5} is East lake High-tech area, and the lowest is Design Institute, Huazhong and Nansi Huazhong, which is significantly lower than other sites. Apart from these sites, the concentration of PM₁₀ varies from 60 $\mu\text{g}/\text{m}^3$ to 70 $\mu\text{g}/\text{m}^3$, and the concentration of PM_{2.5} varies from 50 $\mu\text{g}/\text{m}^3$ to 60 $\mu\text{g}/\text{m}^3$.

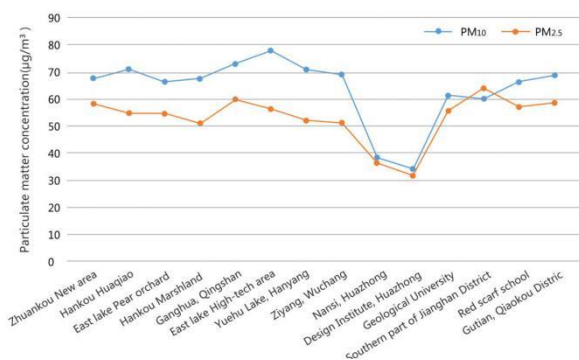


Figure 2. Differences in concentration of PM₁₀ and PM_{2.5} in different blocks. Diagram by the author.

3.2. Relationship between landscape parameters and particulate matter

There was a certain relationship between different landscape parameters and concentrations of PM₁₀ and PM_{2.5} (Tab.3). Strong negative correlation is found between

the percentage of vegetation and PM₁₀, PM_{2.5} concentration, and strong positive correlation is found between the percentage of hardened ground and PM₁₀ concentration, but hardened ground seems to have weak positive relationship with PM_{2.5}. Meanwhile, weak positive relationship between the percentage of building and PM_{2.5} can be observed. The impacts of water body on particulate matter modification are found to be uncertain to some extent.

According to the correlation between these landscape parameters and PM₁₀, PM_{2.5}, some regularities can be obtained. First of all, the more the vegetation is, the lower the PM₁₀ and PM_{2.5} concentrations there are.

Secondly, the more the hardened ground is, the higher the PM₁₀ and PM_{2.5} concentrations there are. However, water body and building in urban blocks has little effect on PM₁₀ and PM_{2.5}.

Table 3. The correlation coefficient (r) and P-value between landscape parameters and particulate matter.

	VE	WB	HG	BU
PM ₁₀	-0.775**	0.153	0.559*	0.097
P-value	0.001	0.601	0.038	0.743
PM _{2.5}	-0.952**	0.079	0.527	0.397
P-value	0.000	0.788	0.053	0.160

*Stands for significance at the 0.05 level, **Stands for significance at the 0.01 level.

3.3. The kind of landscape parameters that significantly influence on PM₁₀ and PM_{2.5}

Stepwise multiple regression analysis of those aforementioned landscape parameters on PM₁₀ and PM_{2.5} concentrations were conducted to evaluate the contributions of those parameters on the air quality modification effect. Results is displayed in Table 4. The correlation coefficient (R²) serves to describe the proportion that can be explained by the variables (difference landscape parameters) of the regression model. The coefficient (B, Beta) of each variable allows assessing the variation and contributions extent of the target parameters

(i.e. PM₁₀ and PM_{2.5} values in the current case) upon the corresponding variable^[6]. The results show that only vegetation is included in the regression model of PM₁₀ and PM_{2.5}. According to the stepwise multiple regression, the relationship between particulate matter and these landscape parameters can be expressed by $Y_{PM_{10}}=82.821-65.353VE$ (P=0.001), and $Y_{PM_{2.5}}=69.433-56.520VE$ (P=0.000). 60.1% of the variation in PM₁₀ concentrations can be explained by vegetation, and 90.7% of the variation in PM_{2.5} concentrations can be explained by vegetation, since the R² value is 0.601 and 0.907, respectively. Although water body, hardened ground, and building are not included in the regression model, the impact of them on PM₁₀ and PM_{2.5} can also be obtained through the coefficient (Beta).

The most significant influential factor on the moderation of particulate matter is the vegetation (P<0.01). Relatively speaking, the contribution of vegetation percentage to PM₁₀ and PM_{2.5} concentration is 67.8% and 71.8%, respectively. The values of B coefficient of the vegetation is -65.35 and -56.52 respectively, which can be revealed that 10% increase of the area of vegetation will decrease about 9.1% and 10.2% in PM₁₀ and PM_{2.5} concentrations, relative to the Wuhan average PM₁₀ and PM_{2.5} concentration. Hardened ground is the second significant influential factor, which contributes 17.3% and 11.3% to PM₁₀ and PM_{2.5} concentration. The increase of hardened ground will also increase PM₁₀ and PM_{2.5} concentration. The impact of water body and building on the PM₁₀ and PM_{2.5} concentration is relatively weak.

Table 4. Stepwise multiple regression profiles of landscape parameters with regard to PM₁₀ and PM_{2.5} concentrations.

PM ₁₀	Variables	Coefficient		Sig.	R ²
		B	Beta		
	Constant	82.82		0.000	
	VE	-65.35	-0.84	0.001	0.601
	WB		-0.01	0.960	
	HG		0.21	0.320	
	BU		-0.17	0.390	
	Constant	69.43		0.000	
	VE	-56.52	-0.95	0.000	0.907
	WB		-0.13	0.169	
	HG		0.15	0.138	
	BU		0.10	0.316	
	Constant				

4. Discussion

4.1. The impact of vegetation on PM₁₀ and PM_{2.5}

The current work shows that vegetation plays positive effects on particulate matter air pollution. There are two aspects of the impact mechanism. On the one hand, vegetation can decrease particulate matter air pollution through its deposition. The secretion of vegetation leaves can adhere particulate matter in air, and the roughness of vegetation leaves and the length of the leaves villi are the main influential factor of adhesion effect^[7]. What's more, in the space constructed by vegetation, the changes in the air flow drive the particles to disperse, which increase the opportunity for the particulate matter to contact the vegetation^[8]. The adhesion effect can be repeatedly realized during rain. On the other hand, the transpiration of vegetation can create a relatively humid and low temperature environment, which is beneficial to the settlement of particulate matter in the atmosphere^[9]. Through these comprehensive effects, the effect of the vegetation to reduce the atmospheric particles is particularly significant.

4.2. The impact of hardened ground on PM₁₀ and PM_{2.5}

In the 14 blocks, the main hardened ground is composed of different degrees of urban road, which is the main source of particulate matter. Therefore, the larger the area of the road, the higher the concentration of particulate matter. This also reveals that the main pollutant is from car exhaust, and it is also consistent with the traditional cognition and results from many other studies^[10]. Apart from that, road is often

regarded as gray space in urban area. Compared with urban green space, this kind of space only influence the disperse of particulate matter, but can not decrease the particulate matter concentration through deposition like vegetation. In the actual planning and design, in order to ensure that the road can be opened normally and the concentration of particles can be effectively reduced, the reasonable road area rate should be determined.

4.3. The impact of other landscape parameters on PM₁₀ and PM_{2.5}

The water body and building are considered to have almost no effect on particulate matter. But some studies show that highly constructed cities experience higher concentrations of PM₁₀^[3]. It shows the variation of particulate matter in different scales. The reason may be related to the difference of the study area and the resolution of the data. Water body plays an important role in reduction of particulate matter through wet deposition^[2]. In current work, due to the research object are the urban blocks, there are no water bodies in many blocks. Besides, these water bodies are greatly different among the type and scale. Therefore the water body has almost no impact on particulate matter.

5. Conclusion and outlook

5.1. Conclusion

The current work investigates the effects of urban green space on thermal comfort in views of the common urban blocks and the individual landscape design parameters. The effect of landscape design parameters on particulate matter air pollution is found through high resolution remote sense image and 14 air quality monitors. Vegetation and hardened ground are the two main influential factors, which contribute 60.1% and 90.7% to PM₁₀ and PM_{2.5} respectively. 10% increase of the area of vegetation will decrease about 9.1% and 10.2% in PM₁₀ and PM_{2.5} concentrations. However, hardened ground has negative impact on PM₁₀ and PM_{2.5}. Building and water body are found to be uncertain to some extent.

Based on the results of the current work, for improving the urban air quality, it is suggested for the landscape designers, policy makers and city managers that:

1) Increase the area of vegetation. Among the green coverage rate and green space rate, the increase of green coverage rate is easier to implement relatively. Designers can protect the huge trees, and construct the tree-dimensional greening including vertical greening, green roofs.

2) Decrease the area of hardened ground. The results yielded from the present work show a negative correlation of the percentage of hardened ground with particulate matter. Designers can use lawn or other kinds of vegetation to replace

hardened ground to the largest acceptable extent. Besides, reduce the road area without affecting normal traffic is also a practical approach.

5.2. Outlook

The current work only focus on the percentage of these landscape parameters, and the further research will take their spatial form into account. Moreover, other influential factor such as temperature, relative humidity, wind speed should also be taken into considered.

Acknowledgments

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Development of Green Roof Design Elements against Urban Flooding

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Abstract

The increase in impermeable areas of land due to urbanization causes problems such as overflow and inundation during rainfall. Green roof reduces the speed of rainfall on the roofs. As a way of assisting in stormwater management to protect against urban flooding, it is necessary to develop green roof design elements, which contribute not only to the delay of stormwater runoff but vegetation growth, which benefits the ecological system. The purpose of this study is to develop the design elements for green roofs by evaluating both the stormwater runoff delay function and the plant growth function.

According to Korean landscape design standards (2013), green roof design elements include a green roof module, soil, and plants for stormwater management. First, using system dynamics modeling, a simulation is made of the effects of stormwater runoff delay on a building where a green roof module is installed. With evapotranspiration and infiltration as parameters, a stock-flow diagram is drawn to depict the stormwater runoff delay effect. Using the main parameters of the amount of evapotranspiration and infiltration, a stock-flow diagram is created showing the stormwater runoff effect. The temporal range of the model is 23 hours. Second, the content of the bottom ash that has a delaying effect on stormwater runoff is evaluated. This can also provide a plant growth function. For this study, green roof modules were installed in a greenhouse, and the differences in the growth of *Vitex rotundifolia* Linne fil., *Pennisetum alopecuroides* (L.) Sprengel, and *Sedum takesimense* Nakai in conventional soils (with a bottom ash content of 15% bottom ash and 30%) were analyzed. The plants were randomly arranged, and the greenhouse was monitored from 8 weeks in 2017. The statistical analysis of plant growth (leaf length, leaf width, height, plant height, chlorophyll content) was carried out using SPSS Ver. 23.0 at 5% significance level.

The result of this study: First, comparing the cumulative rainfall and stormwater runoff using the green roof module, it can be seen that the rainfall occurs constantly at a slower rate than the existing rainfall after the end of the rainfall event. It was shown that the delay effect was about 16 hours. Second, in an analysis of effects of soil material on the differences in plant growth, a difference in length growth was observed, but there was no difference in chlorophyll content, leaf length, and leaf width. Therefore, 15% bottom ash for all three plant types was the design element for both stormwater runoff delay and plant growth.

This study suggested green roof design elements to prevent flooding. Through the use of developed design elements, green roof is significant in that it is considered a social-ecological system in terms of flood prevention and plant growth. This study has limitations in that it does not provide logical modeling for the case in which the stormwater runoff delay effect for soil and plant materials is applied to the module. However, the study can contribute to the working design of a green roof as a practical way to improve urban resilience in the future.

Keywords: Resilience; Green infrastructure; Infiltration; Rainfall

1. Introduction

An increase in impermeable areas of land due to urbanization causes a decrease in the space where rainwater can penetrate the ground. This leads to a decrease in the peak runoff time and an overloading of the overflow path. In other words, the increase of impermeable land areas causes disturbances such as flooding in urban areas. The 259.5 millimeters of rainfall that hit Seoul in 2010 was the largest amount in 102 years [1]. The biggest cause of flooding was load due to the increase of the urban pavement, which is impermeable by rainwater. To solve this problem, local governments such as Seoul City are expanding the application of small-scale green infrastructure aimed at infiltrating urban areas. In the landscaping field, the LID facility is naturally constructed to induce penetration of the ground by rainwater. One example is the green roof. A green roof can cope with flooding by reducing the speed at which rainwater falls on the roof.

According to Korea Landscape Design Standards [2], the design elements of green roofs are categorized as facilities (modules), soil, and vegetation. In order to design a successful photovoltaic recording system, it is necessary to confirm how much delay there can be in the green roof recording module. The delay effect of a storm drain can be verified by a simulation model. Logical modeling can be performed using

computer software such as STELLA, VENSIM, and Powersim to evaluate the main phenomenon of the system over time [3]. Modeling is expected to simplify complex systems related to storm drainage in urban areas and to quantify the effects of planned sites by identifying the impact variables. In addition, soil technology should be presented to ensure that drainage and growth conditions are good. In connection with this, a vegetation soil for rain gardens (Application No. 10-1674126) has been developed. This soil can delay the storm drainage time in artificial ground, such as in a green roof system [4]. Vegetation soil for rain gardens is a soil developed to improve permeability by controlling the mixing ratio of inorganic materials (bottom ash, vermiculite), which increases the porosity of the soil to the organic material (coco feet) of the soil. It is necessary to develop green roof design elements which include not only the stormwater runoff delay function in the social system but the vegetation growth in the ecological system. Most of the developed soils have been proven effective in improving permeability but have not been validated with regard to their use in growing plants.

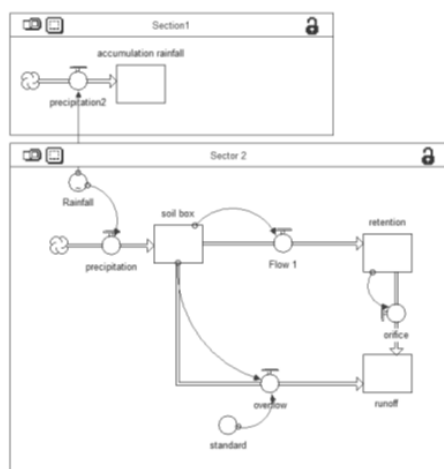
According to Korea Landscape Design Standards [2], the organic matter content standard of general soil is classified as good (more than 5%), normal (3 ~ 5%) and low (less than 3%). However, this criterion is not the standard for artificial soil, and there is no proper standard for organic matter content of

lightweight artificial soil such as green roof. The research on plant growth in artificial soil for rain gardens according to the organic compounding ratio is insufficient as compared with the study on proper water and salt [5]. Therefore, the purpose of this study is to develop the design elements for green roof by evaluating the stormwater runoff delay function and plant growth function. The results of this study can be applied to project implementation, which can improve urban regeneration from flood.

2. Methods

2.1. Stormwater runoff delay formulation

The indoor model was constructed to analyze the delay effect of stormwater runoff. The objective of the indoor model is to establish a basic model for evaluating the stormwater runoff delay performance of the storm drain module with the exception of environmental factors, such as monthly average temperature, wind speed, relative humidity, atmospheric pressure, and latitude. Stock-flow diagram of indoor models and values are shown in Fig. 1 and



Tab. 1.

Tab. 1. Values of stock-flow diagram

Type of values	Values
Stock	accumulation rainfall, soil box, retention, runoff
Inflow	precipitation(mm)
Outflow	orifice, overflow
Time scale	Changes in rainfall from 00:00 on July 11, 2010 to 10:30 on July 12, 2010

2.2. Study area of plant growth by soil types

The study area was the greenhouse of Korea University. The experiment period was the eight weeks from May 15, 2017 to July 14, 2017.

2.3. Research design

2.3.1. Soil

The pre-test was performed to determine the mixing ratio of the LID soil to the soil condition and plant growth. Tab. 2 shows soil properties including coco peat, peat moss, bottom ash, vermiculite, fertilizer / compost.

Tab. 2. LID soil physical properties

Soil	Sand(%)	Silt(%)
LID Soil	87.96	7.68
Clay(%)	Soil Texture	OM(%)
4.36	Loamy Sand	21.59

The bottom ash content of the treatment group was adjusted to 0%, 15%, and 30% based on the literature review (Tab. 3) [6].

Fig. 1. A stock-flow diagram

Tab. 3. Soil mixture ratio

Variable	Soil mixture ratio
Control	LID Soil + Bottom ash 0%
Treatment 1	LID Soil + Bottom ash 15%
Treatment 2	LID Soil + Bottom ash 30%

2.3.2. Plant materials

The plant material was selected in four stages. First, 58 kinds of plants were selected through literature review. Second, 18 plants selected more than 2 times in the literature were selected and their growth characteristics were investigated. Third, seven kinds of plants applicable to use in green roof systems were selected according to OECD guideline 227. Then expert opinion was collated, and finally *Vitex rotundifolia* Linne fil., *Pennisetum alopecuroides* (L.) Sprengel and *Sedum takesimense* Nakai were selected.

The selected plants were planted on the module and directly irrigated through water irrigation, and they were observed through continuous monitoring once or twice a week. The temperature and humidity were adjusted to be equal to room temperature during the experiment. During the experimental period, the plant growth was measured with regard to plant height, leaf length, leaf width, and chlorophyll content. Leaf length and leaf width were measured

by selecting 10 standard leaves in each experimental group, and the chlorophyll content was determined as an average value of 5 repeated measurements with portable chlorophyllometer (SPAD). Statistical analysis of each measurement data was performed by using the ANOVA test at 5% significance level using SPSS Ver.23.0.

3. Results

3.1. Stormwater runoff delay effect of LID module

In this study, the model was analyzed under the conditions of two rainfall events with 10-minute rainfall change from 00:00 on July 11, 2010 to 10:30 on July 12, 2010. The flow rate is set to 1 (mm / 10 min.) If the amount of storage in the module is 0, the flow rate is set to 0 if the storage amount is in the module. If the amount of rainwater stored in the module exceeds 100 mm. Finally, when there is no storm drain module, rainfall accumulated as rainfall, and 170 mm of rainfall was leaked for about 8 hours from 10:00 am to 17:50 pm, when rain first came down. The overflow occurred twice, at 13:20 and 17:50, and the efflux delay was 16 hours longer than the control.

3.2. Relationship between soil mixture ratio and plant growth

3.2.1. Difference in *Vitex rotundifolia* Linne fil plant growth according to soil mixture ratio

A one-way ANOVA was used to investigate the differences in *Vitex rotundifolia* Linne fil according to soil mixture ratio (Tab. 4).

Tab. 4. Result for difference in *Vitex rotundifolia* Linne fil plant length according to soil mixture ratio

Division	Mean	Standard Deviation	Tukey HSD	F	P-value
0%	4498	7.709	a	7.996	.001
15%	3541	11.145	b		
30%	3180	8.796	b		

*p>.05

It revealed significant preferences for plant height ($F=7.996$, $p=0.001$). A Tukey post-hoc comparison was used to determine whether or not there were any differences between specific groups. Differences were found between the bottom ash 0%, 15%, and 30%; however, there was no difference between soils containing 15% and 30% of bottom ash. Soil mixture ratio had no significant influence on leaf length ($F=1.654$, $p=0.204$). Also soil mixture ratio had no significant influence on leaf width ($F=1.541$, $p=0.226$). Finally, soil mixture ratio had no significant influence on chlorophyll content ($F=1.279$, $p=0.289$).

3.2.2. Difference in *Pennisetum alopecuroides* (L.) Sprengel plant growth according to soil mixture ratio

A one-way ANOVA was used to investigate the differences in *Pennisetum alopecuroides* (L.) Sprengel according to soil mixture ratio (Tab. 5).

Tab. 5. Result for difference in *Pennisetum alopecuroides* (L.) Sprengel leaf length according to soil mixture ratio

Division	Mean	Standard Deviation	Tukey HSD	F	P-value
0%	92.67	16.124	a	6.016	.005
15%	85.33	12.556	b		
30%	75.25	12.430	c		

*p>.05

The ANOVA revealed significant preferences for leaf length ($F=6.016$,

$p=0.005$). A Tukey post-hoc comparison was used to determine whether there were any differences between specific groups. Differences were found between the bottom ash 0%, 15%, and 30%. Soil mixture ratio had no significant influence on chlorophyll content ($F=1.223$, $p=0.305$).

3.2.3. Difference in *Sedum takesimensense* Nakai plant growth according to soil mixture ratio

A one-way ANOVA was used to investigate the differences in *Pennisetum alopecuroides* (L.) Sprengel according to soil mixture ratio (Tab. 6).

Tab. 6. Result for difference in *Sedum takesimensense* Nakai Sprengel plant height according to soil mixture ratio

Division	Mean	Standard Deviation	Tukey HSD	F	P-value
0%	23.05	4.373	a	3.677	.034
15%	21.32	4.274	b		
30%	18.09	3.939	c		

*p>.05

The ANOVA revealed significant preferences for plant height ($F=3.677$, $p=0.034$). A Tukey post-hoc comparison was used to determine whether there were any differences between specific groups. Differences were found between the bottom ash 0%, 15%, and 30%. Soil mixture ratio had no significant influence on leaf length ($F=0.501$, $p=0.209$). Also soil mixture ratio had no significant influence on leaf width ($F=0.227$, $p=0.798$). Finally, soil mixture ratio had no significant influence on chlorophyll content ($F=2.562$, $p=0.089$).

In case of three plants, there was difference in plant height growth, but there was no difference in leaf length, leaf width, and chlorophyll content. The length of the plant can affect the green roof landscape. It can be interpreted that the remaining growth

is due to the green roof system because there is no difference between the control soil and the treatment soils. In particular, soil with 15% bottom ash was the most similar to the control group.

4. Discussion

As a result of the study, it was confirmed that the green roof module is effective in delaying storm drainage. The difference of length growth was also observed to be in accordance with the proportion of bottom ash as a result of the analysis of plant growth difference according to soil composition ratio. The bottom soil which added the bottom ash which can delay the storm drainage was finally selected as the improvement material for soil with excellent length growth (bottom ash added 15%). When the proposed soil modifier was applied to the rooftop greening, natural pressure was not generated and an excellent permeation rate could be provided. Soil modifiers containing 15% of bottom ash were also effective in promoting biodiversity.

This study can improve environmental ecology by selecting soil with an excellent plant growth rate. Also, it was possible to establish a design standard suitable for light green roof technology. Finally, there are two social implications. First, flood prevention and local water circulation recovery are

possible through the effect of storm drainage delay. Second, to provide a space where people can relax and enjoy themselves, a beautiful soil improvement material can be developed to form a landscape.

However, there is a limitation to this study, in that the monitoring result and the simulation result cannot be converged on the bottom part. In further studies, the effects of plant growth should be included in the simulation model to verify more quantitative effects.

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Re-branding Landscapes of Forgotten Resorts.

Case of the Healing Resort Kemeris in Latvia

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Abstract

The health resorts have been important landscape identity elements and economy drivers in European cities since the beginning of their development. The sea coastal area in Latvia is rich in sulphur springs that have been used for health procedures since 19th century. Kemeris resort in Jurmala City is known as unique place that got its name from the foresters house Kemeris where the first health procedures were performed by using sulphur spring mud. In the 1836 Kemeris was declared as a resort and became known in whole Russian Empire and later also in Soviet Union. There were significant landscape changes occurred after Latvia regaining independence in 1990, when ownership of the land changed from the state to the private. Affected by disagreements between the new owners, lack of private and state investments, decrease of visitors from former Soviet Republics, insufficient capacity for competing with European resorts, the resorts in Latvia often became abandoned and forgotten. Historically valuable buildings and parks of the resorts were degraded, number of inhabitants and visitors decrease. Today the regional government found opportunities for re-development of Kemeris resort by searching for the new identity and re-branding of the place. Re-branding has been used to enhance attractiveness of the place and increase economic benefits. Therefore the aim of the study is to identify historic heritage values suitable for the re-branding of the place and to analyse potential development of the resort Kemeris. Assessment part of the article is based on historic heritage study by comparison of historic and today photography, field surveys to identify historic heritage values of the place and their influence on possible development scenarios. Historic heritage values were identified according to the Historicity and authenticity; Aesthetic quality and integrity; Social meaning. Other part of the article is addressed to the re-branding of the place that includes involvement of identified historic heritage values into the new identity to enhance functionality, recognisability and attractiveness of the resort Kemeris.

Keywords: forgotten places; health resorts; landscape revitalization

1. Introduction

Due to the impact of political and natural processes cities can become abandoned [1]. As the result population is decreasing, places are becoming forgotten and degraded. Most of cases it is caused by different political events – change of political power and regime, land reforms, wars; or natural factors – natural disasters, forest fires, flooding etc. [2]. Revitalization of forgotten and degraded places is a great challenge for local governments [3]. The article reflects revitalization project of the former health resort Kemeris in Jurmala City, Latvia by using re-branding principles.

1.1. Re-branding places

The common definition found in the different resources states that a brand is something that distinguishes one product from another in eyes of the customer [4]. This could be name, style, symbol, quality of product, process etc. [5] and involves some degree of expectations and imaginations. Place, city or town branding is a complex of activities – planning, producing, governing and promoting specific and unique objects, products, activities in order to compete with other places in attracting of tourists, investments, new residents, national and global events etc. [6].

The re-branding is more related to the territories that have lost their identity and attractiveness due to some specific reasons. Therefore the main aim of the re-branding of

places is to shape a new identity and to promote economic potential of the area [4]. There are different types of re-branding according to the scale of the place (national, city, town, village, and place) or some specific values of the area (agriculture, nature, healing potential etc.) [6].

1.2. Forgotten health resorts in Latvia and the need for re-branding

Mud and hydrotherapeutic resorts in Latvia have more than hundred-year history. Till the 90s of the 20th century most of them were oriented to the tourists from the Soviet Union. There were operated 9 resorts, more than 30 sanatoriums and spa institutions in the coastal city Jurmala. After Latvia regained independence in 1990 the business of health resorts decrease. Today we can found only 4 actively functioning specialized sanatoriums in Jurmala. Reasons of the decline mostly connected with political factors [2]. Those are change of ownership from the state in Soviet period to private, political decisions about non-investment of EU funds into re-branding and redevelopment of Latvian health resorts, low competitiveness with European resorts due to the poor comfort level that required major repairs of buildings and infrastructure [7].

The aim of the particular study is to identify nature, culture and social values suitable for the place re-branding and to analyse potential development of the resort Kemeris in correlation with the main principles of re-branding.

2. Materials and methods

2.1. The research area

The study observes former health resort Kemerī in Latvia. Kemerī resort is a part of Jūrmala city located in the sea coastal area of the Gulf of Riga (Appendix 1). Total area is 13,8 km², inhabitants - 1962. Kemerī resort has important mineral water and therapeutic mud resources that were economic drivers for the resort since the end of the 19th century [7].

Since 1836 Kemerī was well known as the healing resort in whole Russian Empire and later in Soviet Union. Number of visitors reached 21 000 in 1965, when there were 8 sanatoriums and 29 operating sulphur springs [10].

After Latvia left USSR in 1990 Kemerī resort met the same problems as all resorts in Latvia, and soon it became forgotten and started to get degraded [2]. Today Kemerī resort is facing new challenges to become one of the brands of Latvia again.

Kemerī resort has several statuses. It is a monument of the state importance of city building. Park of Kemerī resort and several historic buildings and elements located in the park are monuments of the state importance of architecture [10].

2.2. Methodology

The re-branding of Kemerī resort is based on enhancement of economic potential of the place by promoting its visibility in local and national market, attracting tourists, investors and potential inhabitants. The methodology of the re-branding of Kemerī resort included:

1. Identification of nature, culture and

social values of the place existed in the past and today by comparison of historic photography and maps with today's situation in Kemerī resort [1][11][12]. The aim of this activity is to evaluate potential impact of detected values on the development of the place and possibility to use them into re-branding of Kemerī resort. Values were evaluated according to the attributes [8] [9]:

1.1. historicity / authenticity represents connection between the past and today. Those are all elements that are representing important nature processes (example, still existing oak forest, swamp, sulphur springs) or human activities (buildings, network of streets, artificial water elements, terrain, greenery etc.) and still can be found in the area.

1.2. integrity and aesthetic quality represents harmony of historic elements especially from different historic periods. Activity includes evaluation of composition, scale, proportions etc. of materials, greenery system / design, architectural elements, landscape spatial structure remained from different periods. Activity helps to find out best solutions for the development of place and to detect which elements should be highlighted and used for re-branding of the place.

1.3. social importance shows to what extent the place symbolizes events, elements, activities and traditions important for local / national community. Social importance is evaluated in the context of similar places of local, regional or national importance. What was more different and unique in development of particular place and how to make it more visible? The most difficult part of this activity is to choose which of historic periods will be base for

the new face of the place. Will those be elements most remained for one of the historic periods or some specific and unique separate elements?

2. Use of identified nature, culture and social values in addition with new functions for development of new image, identity of the place, re-branding of Kemerī resort.

Each of identified values are evaluated according the main principles of re-branding – to promote place as tourist destinations, attractive place for investors and potential inhabitants. How detected values are important in re-branding process? And how they could be used to make the re-branding more effective? [1][3][4][6].

3. Results and discussion

3.1. Key elements for re-branding Kemerī resort

Key elements for re-branding Kemerī resort are grounded in the origin of the resort. The research on historic information showed that the key elements of the origin and development of the resort were in Latvia unique sulphur springs, as well as natural environment and elements – forests with oak-trees (*Quercus robur*), linden (*Tilia cordata*), elm trees (*Ulmus glabra*; *Ulmus laevis*), and ash trees (*Fraxinus excelsior*), small rivers, lakes and swamps. First healing activities with the use of mud and mineral water from sulphur springs were dated to the beginning of the 19th century. At that time patients also used local forests for walks and other activities¹. Based on the long history of use of nature resources in Kemerī area they are highlined as identity and brand elements of the place

also in the revitalization and re-branding project of Kemerī resort.

3.2. Old streets and directions – the base for the main axes of the resort landscape

Till the end of the 20th century Kemerī resort has grown from a few buildings into a town with good infrastructure and connectivity with the largest cities of Latvia. Old streets became important landscape elements as they represented history of development of Kemerī, marked main directions and determined the compositional structure of the landscape [10][11]. It is possible to find remains of the town structure also in nowadays (Appendix 2). One of the important axis in the past and also today is Tukuma Street. It was the main linkage to the rail way that connected Kemerī to the Riga (capital of Latvia) and even Russia. Also today Tukuma Street is one of the central compositional axes in Kemerī resort complex. Robezu (in English - Border) Street represents old border area between Courland Governorate and Livland Governorate (1795-1918). We can find Director's Street in the Kemerī park area. In the 19th century it directed visitors of the resort to the main building and divided central park of the resort into wild and "cultivated" parts. Alley Street is reflecting long history of planting alleys in Kemerī resort.

The main old axes and directions are kept as linkages with the history and roots of the place also in the revitalization project of Kemerī resort.

3.3. Historic buildings with new functions

Kemerī town got its status as a resort in 1836, but development peak of the town was the beginning of 20th century. At that

time there were different type and size bath buildings, post office, Catholic, Lutheran and Orthodox churches for visitors of different confessions, more than 200 summer cottages, 12 pensions and hotels [10].

After World War I most of buildings and park were destroyed, but very soon the resort again was one of the most demanded in the Latvia. At that time Kemeris has own power and water supply, sewerage system. Also, today one of the landmarks of the resort is 45 meters high water tower. In the past water tower had two reservoirs for drinking and sulphur water, and sightseeing platform on the top [10] (Fig. 1.).



Fig. 1. Bath buildings and water tower on Tukuma Street, 1936 [11]



Fig. 2. White building of the Kemeris hotel, 1936 [10][12] and 2017

Other land mark of Kemeris resort is Kemeris hotel's white building that was built in 1936 and provided different activities throughout the year (Fig. 2.). When number of visitors from former Soviet Republics decreased, most of buildings for sulphur spring mud therapies were not used anymore and become

degraded [10].

There are several architectural elements that are promoting attractiveness of Kemeris resort. Those are pavilions, small bridges, benches, sculptures etc. (Fig. 3). One of the most famous architectural elements of the Kemeris park is monument (1896) in shape of the tree dedicated for the first directors and developers of Kemeris resort (Fig. 4.).

In the revitalization project of Kemeris resort main important buildings are planned to use as visual landmarks of the place. Functions of building will be supplemented or change to new according to the arrival of new technologies and needs of visitors.



Fig. 3. Love Island with rotunda pavilion, 1936-[10] and 2017.



Fig. 4. Love oak tree (not exists)[10]¹ and monument for the first developers and directors of the resort Kemeris, 2017

In the revitalization project the water tower will not be used as water reservoirs anymore, but provide tourists information

centre, exhibition place and a view platform. Kemerı hotel besides hotel functions will serve new ones – place for conferences and seminars, spa and sports area etc.

3.3. Green spaces with high biodiversity symbolizing environmental quality for good health

Positive effects on patients from forests of Kemerı resort are described by several authors. Forests of Kemerı resort were formed as landscape parks by supplementing them with a large number of introduced species of trees, shrubs and perennial plants. Diversity of plant material was initiated and provided by first gardener of Kemerı resort, owner of the Riga nursery - K.H. Vagners (1785.-1846.) [10]. Diversity of plant species is kept also in the revitalization project of Kemerı resort for better connection with existing nature of this place.

Other important elements are alleys and hedgerows. In analyses of historic literature and photos it was found that almost all streets and pedestrian trails are enclosed with alleys and hedgerows of different species of trees, shrubs and perennial plants (Fig. 5.). Today old alleys and hedgerows are in low quality because of poor maintenance during last 25 years.



Fig.5. Alleys of the Kemerı park in historic pictures [10] and today (Director`s Street)

Historic materials show that since the beginning of 20th century there were two types of green spaces in Kemerı resort – urban forest with pedestrian trails and wild vegetation; and “cultivated park” with a large number of introduced plants. Trends of that period were thuja trees (*Thuja*) and white robinia trees (*Robinia pseudoacacia*) that can still be found in the park areas of Kemerı resort. Diversity and colourfulness of the Kemerı park`s greenery as positive and unforgettable elements are highlined in many evidences of that time [10].

New tendencies in the design and composition of the Kemerı park arrived together with Kemerı hotel built in 1936. According to the architectural style of the building the composition of the plantings is developed in the style of classicism with symmetrical design of ornamental parterre in front of the hotel and bath buildings. Plantings of the style of classicism could be read only from historic photography. Today in the park and near buildings we can find plantings designed in 1960. They have typical for that time attributes – large and irregular areas with perennials, ground covered by concrete plates, decorative retaining walls from stone (Fig. 6.).

Last 25 years Kemerı resort was left without any significant interruption to its development. It is affected the green spaces of Kemerı resort both ways.

It is positively that we can find old, beautiful trees and great biodiversity, but there are also many problematic places – broken and unsafe infrastructure elements, overgrown plantings, tree seedlings have grown as big trees and overshadow park area.



Fig. 6. Design and plantings of the ornamental parterre part, 1936 [10][12] and 1960 [10]

The revitalization project of the park of Kemeru resort is based on compromise between design of the classicism that is more appropriate for the architectural style of the Kemeru hotel, and existing diversity of plants that can be found in the park area nowadays.

3.4. Landscape for active participation

Kemeru resort since its foundations had not only healing function, but also provided different activities for patients after their therapies. First of all those were activities in the nature – walks in the forests, sunbathing, sport activities etc.

Since the end of the 19th century there were developed indoor and outdoor spaces also for entertainment activities, music, dancing, reading, gaming, restaurant and

library [10].

After World War I the café was located on the Love Island with access to the water channels. At that time channels of small river Versupite were suitable for boating. The set of water sluice gates was built for this purpose. Today this system is not working anymore (Appendix 3).

In 30th of the 19th century international chess competitions were organizing to promote Kemeru resort. In historic materials we can find that social activities were important elements of the identity and recognisability of Kemeru resort (Fig. 7.).



Fig. 7. Set of photography representing activities of Kemeru resort, 193-. [12]

3.5. Revitalization and re-branding project of Kemeru resort and its park

Due to specific conditions of Kemeru resort that are connected with different historic landscape layers found in the area, the re-branding and revitalization project of Kemeru resort divides the area into four parts – ornamental parterre`s part in front of the Kemeru hotel building, active part, forest park part and forest wild part (Fig. 11.). Each of the parts has its own specific attributes, as well as requirements for

planning, protection and management.

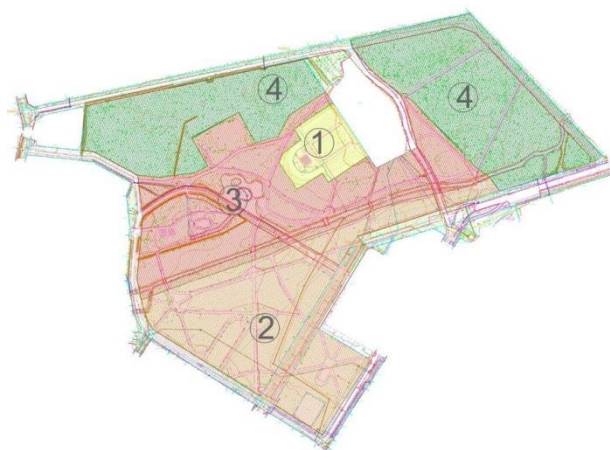


Fig. 8. Kemerı resort and park areas, where 1. - ornamental parterre, 2. – Active area, 3. – Forest park, 4. – Forest “wild” area, 2017 [13]

The Ornamental parterre is made as one unit with the Kemerı hotel and is planned as one of the landmarks of the resort. Design of the green space is based on the symmetry and includes plantings with formed hedgerows and flowering plants, as well as architectural elements – benches, sculptures etc. Flowering plants are reflecting white colour of the building of the Kemerı hotel. As compromise there are left existing old trees that were not in the original plan (1936), but now can be found in the area and influence new design of the ornamental parterre (Fig. 9.).



Fig. 9. Ornamental parterre with the symmetrical structure and a large number of perennial plants, 2017 [13]

The Active part of Kemerı resort park is more opened visually and functionally, but still has clear composition and spatial structure that corresponds to the historic period of its development. Alleys, hedgerows, flowering and colourful plantings are used to establish connection with the historic values of the place (Fig. 10.). There are new functions added to this place – exhibition and entertainment squares, recreation places, children playground.



Fig. 13. Active part with central composition axis with the water tower and alleys, 2017 [13]

The Forest park is “cultivated” part of the forest with open spaces, groups of trees, cultural heritage objects and elements – Love Island with rotunda pavilion, Orthodox church, bridges, monument for the first directors and developers of the resort.



Fig.11. . New design of Love Island with rotunda, 2017 [13]

The main function of the Forest park part is to connect the Active part and Forest “wild” part of the park.

The Forest park keeps the historic structure of the landscape and nature values – diversity of local plant species, river Versupite with natural banks, old trees and groups of trees, specific habitats for bats and insects (Fig. 11.)

The Forest “wild” part is spatially closed forest area with separate open spaces, pedestrian trails and architectural elements. This part will be kept as natural biotope for highlighting nature values of Kemeru resort.

4. Conclusions

The landscape of Kemeru resort is changed several times influenced by the political processes, ideology and trends of the historic periods. However the mental image of the place was always determined by presence of sulphur springs and their use for medical therapies, but the visual and spatial image of Kemeru resort - by nature values (a large number and diversity of plant species, where next to the native species were introduced new ones, used large number of perennial plants, alleys and formed hedgerows) and cultural heritage of the place. Therefore nature and heritage

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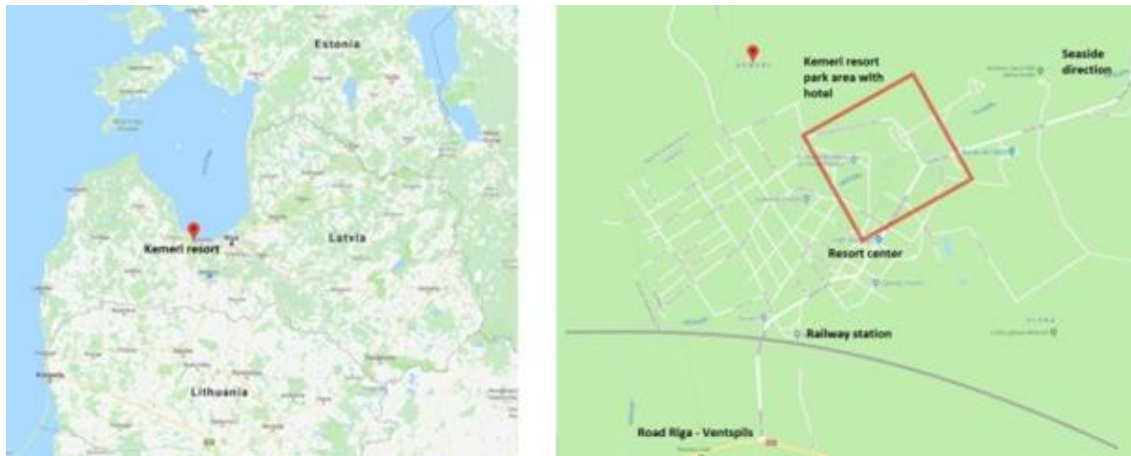
values are defined as one of the key and brand elements for new identity of the place.

Other key elements for the branding of Kemeru resort are old streets and historic directions that can be used as connection between the past and today, and base for composition and spatial structure of Kemeru resort landscape.

The most problematic issue was how to make unity between the landscape elements of different historic periods and styles. Each of the time periods has left its mental message. Therefore new image of the place is developed as a compromise between the elements of different historic periods. The composition and landscape structure is developed in the style of classicism taken from the development time of the Kemeru hotel, but principles of plantings are used from the Soviet era where large number and diversity of plant species was used.

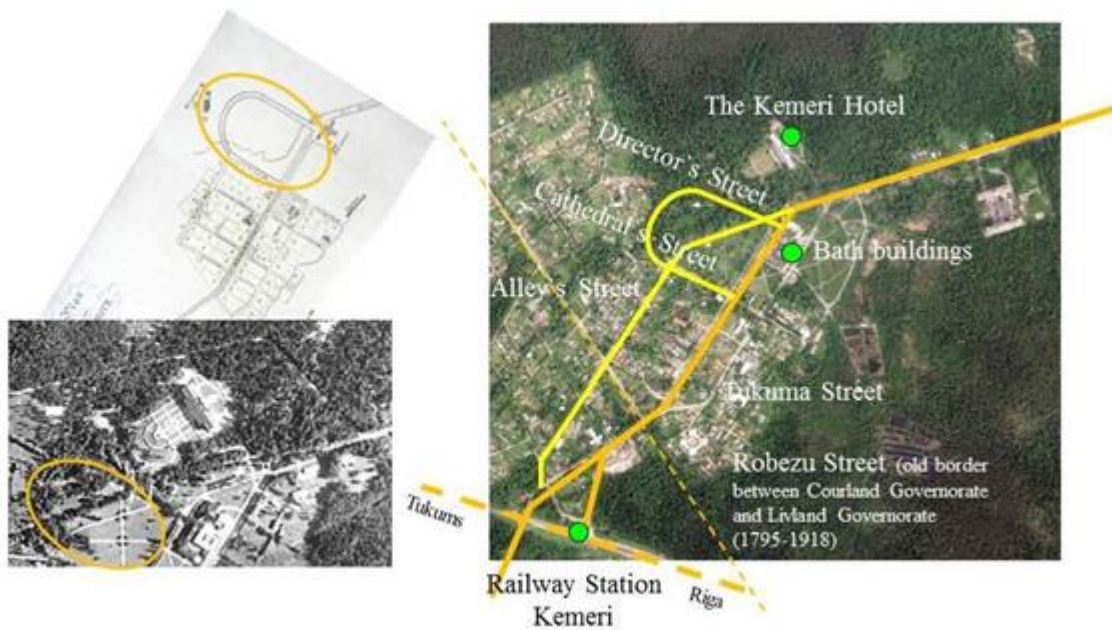
The social activities also are key elements for the re-branding of the place. We can find them already from the origins of Kemeru resort. Social activities will provide extra interest from possible visitors to experience the place not only for medical therapies but also for living and working.

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Appendix 1 Location of Kemerī resort in Latvia and Jurmala City²

² Google maps, 2018



Appendix 2 Fig. 2. Identified old streets and main directions as connecting element with historical events [10][11][12]



Appendix 3 Channels of the Versupite River. Boating (193-.) [10]. Former water sluice gate, 2017

LWCircus Shared Operative Program, Landscape Design Methods based on Social Practices for an Inclusive and Resilient Urban Future

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Abstract

The shared collective urban practices, such as opportunity on the production of symbolic space through ephemeral expressions, both in landscape and urban contexts, dominate within the research's areas that deal with project of the city. Wanting to push further along the boundaries of the disciplines directly interested on the future of our contemporary cultural landscapes, inside urban and rural contexts, during 2016 born ***LWCircus International Program***. Focused on experimental methods and strategies of design based largely on social and cultural practices on the field, LWC aims to enhance sensitive areas inside cultural heritages and redesign contemporary urban landscapes under environmental, social and economic transition. The first two editions of the *Shared-Operative Workshops* called ***LWCircus-ArnoLabs***, have been held in Florence, from 21st till 30th of September 2017 and from 23rd May till 3rd June 2018, creating ephemeral installations, as light urban furniture, staging points, temporary shelters, realized on site by the revisitation and assembling of recycled natural material transported by the changing Arno River's moods. A temporary international, multi cultural and multidisciplinary creative community has tested fruitfully on the field shared practices by using multimedia languages, artistic approaches and performative-spontaneous attitudes in the specific urban context, with the direct involvement of local actors and public institutions responsible for the River's management and safeguard, looking for a RESILIENT and INCLUSIVE urban future, in terms of responsible cultural valorization and sustainable development for the local community and the diverse minorities directly involved in each step of the operative shared process. The Shared Process among Arno river banks gave life to a series of ephemeral installations and performances realized by recycling of natural elements collected on site coming from the natural Resource and the skills and attitudes of the participants to the Activity. A group of young refugees, temporary hosted in the Florentine context, invited to join the international creative group, worked profusely highly animated to design and realize the series of installations, sharing wishing and hopes with the rest of international participants and the locals, becoming temporary part of the local community and starting a process of social inclusion that gave life to successive opportunity for further inclusion on the local realities. The locals sharing the process in conceiving and realizing the works, started in look at the others in different way, transmuting the concept of others in the feeling of us, by the sharing of the entire process. Work reported would love to give a contribute inside the evolving of the traditional figure of the landscape architect to a sort of "landscape facilitator" as well as to the Landscape Architecture Discipline, underling the operative shared method as fundamental and intrinsic part of the design process in itself.

Resilient Inclusive Urban Future; Operative Landscape Design Method; Social Practices

1. Introduction

Nowadays, where we are even more called to manage complexity, made by crossing confused fluxes of people, goods, informations and energies that provokes irreversible changes affecting our planet, the landscape itself becomes the unintentional protagonist suffering the imminence of the events.

Thanks to these events, that contribute to the depletion of the resources and to the increasing soils's impoverishment, the landscape could be considered a privileged point of view from where to study all the consequences that those changes provokes in terms of transformation and proliferations of opportunities, as well as a value for the landscape itself, for the people and for the resultant new cultural landscapes, be they new energy or emergency landscapes, composed by their new temporary communities.

Among the swirling whirl of these flows and changes, I think that an interesting and in some how "salvific" attitude, as a regained point o reference, would be to try to rediscover the sense of the places, even inside the immanence of the temporariness. This will permit to read trough different layers that contribute composing the sophisticated mosaic that makes the place itself, deeply understanding its *genius loci* to valorize and manage the new cultural landscape in its complexity. Doing this, it will be fundamental to understand the deep sense of the quite abused word sustainability, to learn how to manage the

landscapes together with either locals or temporary inhabitants.

To achieve the results in this process of understanding the dynamics, relationships, customs and traditions that deeply link the locals or the temporary inhabitants to their landscapes, it will be fundamental in the field of our discipline to undertake, as much as possible, an operative, spontaneous, multicultural and multi disciplinary, ephemeral approach, all as precious and useful attitudes able to solve the problems linked to the complexity of our new contemporary transitional landscapes.

So, it will be strategically important to test the boundaries of the Discipline, trying to find as much as possible an interaction with the other correlated topics as art, design, architecture, as well as anthropology, sociology together with science, biology, geology, among the others, but it will be important also to take in consideration the politics, international cooperation and environmental and human resources management studies, that could help in shaping a new declination inside our traditional practice.

In this way, it could be possible to stimulate and activate a new perspective that approach the traditional practitioner toward a figure of a landscape's facilitator, transforming the landscape architect in a sort of translator, acting as mediator between all referents interested in the landscape, be they local people, temporary communities, local Administrations, as Civil Protection, Forest Rangers or even Military Forces.

At this time, I think that we need to look for a different method, as well as a different way of making school of landscape architecture. To satisfy another kind of request, that needs to test on site the management of the contemporary cultural landscape's complexity, conscious that nowadays there are different exigencies in reading, analyzing and redesigning the places. It will be necessary a new way of teaching how to manage and solve the problems linked to the new under-transition realities.

Then, it will be necessary to test in the field the exigency to involve different disciplines at the same time and to introduce a shared approach, involving group of experts with completely different attitudes on the landscape design, intending the operative method as an intrinsic necessity of a deep link between the theory and the practice inside our Discipline. It will be necessary to feel the urgency in solving the problem on site when it appears and when it happens, finding the best solutions as soon as possible, being able to act with a high speed proportional correlated to the dynamics and the different fluxes mentioned before.

Inside the process to define a new methodology, it will be definitely crucial the participation of the locals together with the experts, because if participation is the main strategy to achieve the best result, *a fortiori*, the sharing will be fundamental inside the particular social-economical conditions that feature the contemporary landscapes.

So, sharing the project together with all the actors interested to the investigated

places or landscapes and assigning roles and competences to let feel the project their own responsibility, until this will make feel them affection for the gained results, it could be a fruitful way in discovering an effective and virtuous new method.

Making others feel like a fundamental part of achieving the result, could be a successful strategy that could help to achieve great results in a very short time, as possible solutions for temporary or transitional situations, such as those that can generally be observed, inside of our altered and mutable contemporary landscapes, especially if addressed to urban contexts.

On the heels of the shared collective urban practices, such as opportunity on the production of symbolic space through ephemeral expressions, both in landscape and urban contexts, dominate within the research's areas that deal with project of the city and wanting to push further along the boundaries of the disciplines directly interested on the future of our contemporary cultural landscapes, inside urban and rural contexts, during the year 2016 has been created the ***LWCircus International Program***.

1.Objectives

Just as it is not possible to talk about the city without thinking of the people who compose it, in the same way it is not possible to talk about the resilience of the urban landscape, without going through social inclusion. Nowadays our cultural landscapes are not only the stratification of that sophisticated socio-ecological mosaic

that has overlapped over time, but are the result of a vortex of flows of people, goods and services that cross it, leaving a multitude of signs, open, more than ever, to multiple interpretations.

Within the disciplinary framework, we are witnessing a flourishing and proliferation of participatory urban practices, which contribute to the urgent and spasmodic search for answers regarding the community construction of places of meaning, a fundamental characteristic of the city's project. Thinking of a sort of renaissance within the urban landscape, the research at the base of the *LWCircus International Program*, with the devices of the *ArnoLabs Shared Creative Workshops* in particular, focuses on experimentation through artistic and multimedia languages, which through the medium of art in the landscape, can give back meaning to places and reconstruct those ways of living and enhancing the landscape, typical of the times when communities actively contributed to the construction of their cities.

To this direction is addressed the research within the *LWCircus Project*, deliberately based on a necessarily participatory formula, which sees through close cooperation, local communities with their minorities, to work in urban landscapes in prestigious environments, to share and build places of exchange and interaction, towards social inclusion, giving rise to ephemeral installations between art and landscape, towards what we can define *Urban Land Art*. In all this, the protagonists are the places and people who interact with it in various ways, local communities, minorities of various typologies, including political

refugees and asylum seekers, administrators appointed to their management, who are solicited by a multidisciplinary and *International Creative Community*, through the use of artistic and multimedia languages, to revisit the historical memory of the places concerned, towards a plausible future increasingly resilient and inclusive.

2. Methods

Focused on experimental methods and strategies of design based largely on social and cultural practices on the field, *LWCircus Program* aims to enhance sensitive areas inside cultural heritages and redesign contemporary urban landscapes under environmental, social and economic transition.

LWCircus Program looks for alternative tools and devices to activate sustainable development and responsible action through operative shared workshops, through the direct involvement of local communities, minorities and well known international practitioners. The workshops stimulate the interdisciplinary exchange of knowledge, information, attitudes, skills and real-world know-how through artistic expression and multiple forms of media.

LWCircus Program's outcomes aim to an integration, a cultural and economic development for local inhabitants and minorities involved.

The first two editions of the *Shared-Operative Workshops* called *LWCircus-ArnoLabs*, have been held in Florence, from 21st till 30th of September 2017 and from

23rd May till 3rd June 2018, creating ephemeral installations, as light urban furniture, staging points, temporary shelters, realized on site by the revisitation and assembling of recycled natural material transported by the changing Arno River's moods.

During both the Florentine editions, a temporary international, multi cultural and multidisciplinary creative community fruitfully tested on the field shared practices by using multimedia languages, artistic approaches and performative-spontaneous attitudes in the specific urban context, with the direct involvement of local actors and public institutions responsible for the River's management and safeguard, looking for a RESILIENT and INCLUSIVE urban future, in terms of responsible cultural valorization and sustainable development for the local community and the diverse minorities directly involved in each step of the operative shared process.

3. Results

The Shared Process among Arno river banks gave life to a series of ephemeral installations and performances realized by recycling of natural elements collected on site coming from the natural Resource, and the skills and attitudes of the participants to the Activity.

For both the editions, groups of selected young refugees, coming from Niger, Senegal, Mali (ArnoLab017), Burkina Faso, Ghana, Gambia and Bangladesh (ArnoLab018), survived crossing of Mediterranean, coming from Libya and

temporary hosted in the Florentine context, were invited to join the rest of international creative group (coming from Mexico, China, USA, Australia, Lebanon and Syria, Colombia, Venezuela UK, Holland, France, and Italy). They worked profusely highly animated in designing and realizing the series of installations, sharing wishing and hopes with the rest of international participants and the locals, becoming temporary part of the local community and starting a process of social inclusion that gave life to successive opportunity for further inclusion on the local realities.

The locals sharing the process in conceiving and realizing the works, started in look at the others in different way, transmuting the concept of others in the feeling of us, by the sharing of the entire process.

The focus of the experimentation within the *LWCircus Program* is to link the actors, for various reasons, deputies to managing the landscape component of contemporary urban contexts, through shared creative workshops, such as the *ArnoLabs* in Florence or the *MayaLabs* in Merida, Yucatan, intense experiences where the different fields of belonging of the protagonists are disparate and the multidisciplinary and multicultural component is fundamental, for the empirical experimentation on the field and the subsequent phase of observation and evaluation of the **results**: as possibility of production of symbolic space through occasions of ephemeral expressions, which contribute to generate space of knowledge and relationship, fundamental characteristics of the city's project.

4. Conclusions

Work reported would love to give a contribute inside the evolving of the traditional figure of the landscape architect to a sort of “landscape facilitator” as well as to the Landscape Architecture Discipline, underling the operative shared method as fundamental and intrinsic part of the design process in itself. Making feel the others as a fundamental part to achieve the result, it resulted a successful strategy that helped in permitting to achieve great results in really short time.

Wanting to go further, the work, by implying the sharing of the project together with all the actors interested to the investigated places or landscapes, by assigning roles and competences to let feel the project their own responsibility, until this will make feel to them affection for the gained results, contributes in illustrating a fruitful example in defining an effective and virtuous new method, that can help in approaching solutions for the under transition and mutable contemporary *cultural landscapes*, *emergency landscapes*, composed by their new temporary communities.



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Fig. 1. LWC- ArnoLab017. Working on Installation Noha’s Ark - The Red Raft. Picture by Andrea Faggioni.

Fig. 2. LWC- ArnoLab018. Installation "The Arno's Lifeguard". Picture by Andrea Faggioni.

Redefining An Abandoned Old Aqueduct System As Green Infrastructure

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Abstract

Through our research, we realize the abandoned old aqueduct system, Tamagawa aqueduct in Tokyo, has potential to play a role as green infrastructure to prevent flooding in the river, Tamagawa. Tamagawa aqueduct was used for drinking water in Edo and Tokyo city from 1653 until 1965. The water of Tamagawa aqueduct came from Tamagawa river. The aqueduct had 33 branches to offer drinking and irrigation water to center and suburb of Edo. Main stream of the aqueduct is now preserved as the national historical heritage. However, drinking water system changed to piping from open ditch so that most parts of the aqueduct lost its function. After the history of the aqueduct ended, the aqueduct ditches which treated sewage water flows through are still preserved but with not good maintenance. Actually it is not completely clear who control the aqueduct. On the other hand, recently Tama river have risks to flow over the center of Tokyo because of unexpected heavy rain. So we point out to potential to reuse the aqueduct as bypass of Tama river. The aqueduct system has not only ditches but also many garden ponds which has potential to reserve water. This proposal is important for not only flooding but also purificating dirty water in Edo castle moats as isolated water as the aqueduct connect to Edo castle from old days. This aqueduct is already lost traditional functions but still useful for future resilience in the city.

Keyword: Civil Engineering Heritage; Tamagawa aqueduct; Green infrastructure

1. Introduction

This research aims to redefine the abandoned historical water network as green infrastructure of the dense complicated city. It focuses on Tamagawa aqueduct network in Tokyo, Japan. Tamagawa aqueduct was used for drinking water in Edo and Tokyo city from 1653 until 1965. The water of Tamagawa aqueduct comes from Tama river. The aqueduct had 33 branches to offer drinking and irrigation water to center and

suburb of Edo. As drinking water system changed to piping from open ditch, most parts of the aqueduct lost its function. After the history of the aqueduct ended, the aqueduct ditches which treated sewage water flows through are still preserved but with not good maintenance. At this moment, eight branches (Tamura, Kumakawa, Haijima, Shibasaki Nobidome, Sunagawa, Shinbori, Senkawa) remain. Main stream of the aqueduct is now preserved as the national historical heritage. However, few fragments of branches are preserved by

municipalities. Actually it is not completely clear who control some sections of the aqueducts.

On the other hand, Tamagawa aqueduct network is paid attention because rare green corridors in complicated city, Tokyo. Some researcher suggest potential to purify the outer canal of Edo castle[1]. It is right now to need to redefine Tamagawa aqueduct network as green infrastructure with background Tama river increase risks to flow over the center of Tokyo because of unexpected heavy rain. So we point out to potential to reuse the aqueduct as bypass of Tama river. The aqueduct system has not only ditches but also many garden ponds which has potential to reserve water.

In history of Tokyo, actually, “Tokyo green plan in 1939” defined Tamagawa aqueduct network as green corridor as parts of green infrastructure[2]. Tamagawa

aqueduct network has potential to connect inner city to outer city of Tokyo. However, this plan was never implemented.

Most of previous research focuses on historical process of main stream and few researcher points out Tamagawa aqueduct as network. K.Kosaka point out whole network’s detailed history and K. Watabe draw sections of some branched to show us spatial composition of canals[3] [4]. However, these researches do not describe connection between canals and surroundings in terms of spatial composition.

2. Objectives

Through the observation mentioned above, this research aims to reveal spatial connection between green spaces and canals to try to recognize Tamagawa aqueduct

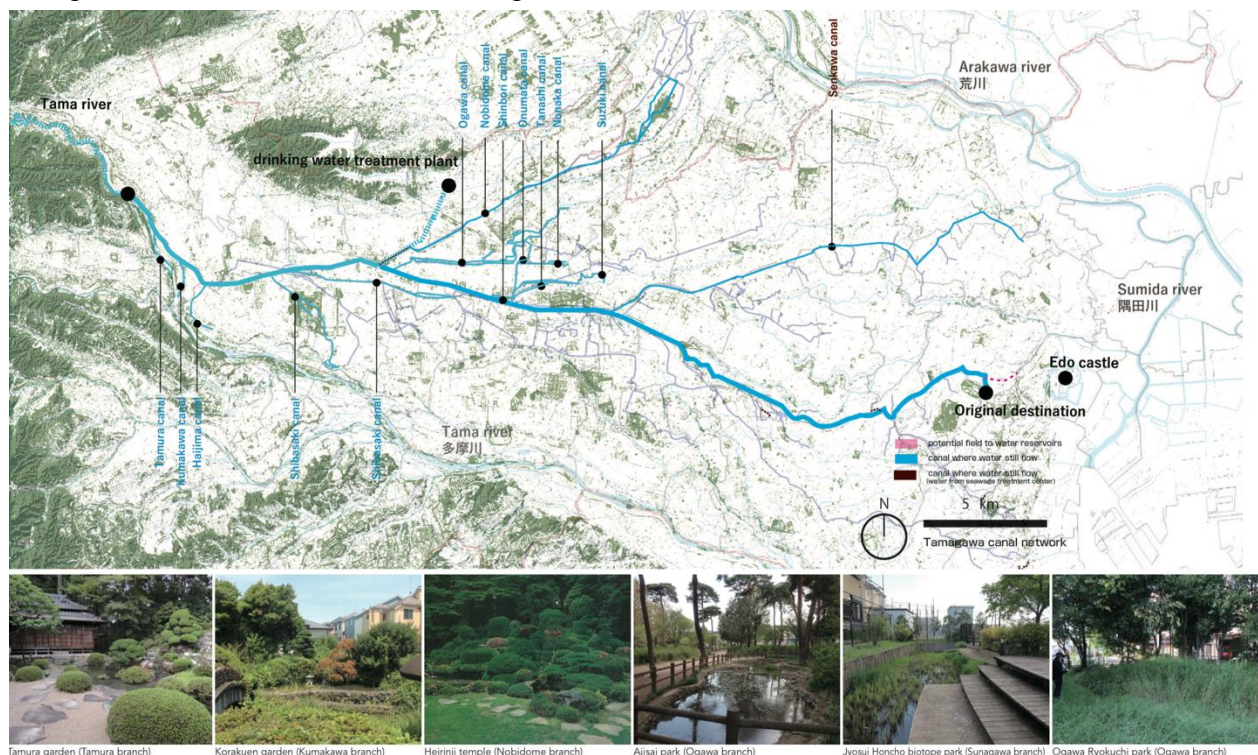


Fig. 1 Tamagawa aqueduct network

network in terms of function as green infrastructure. This research focuses on function of water network.

3. Methods

To clarify the relationship between green spaces and canals in Tamagawa aqueduct network, we take the following steps.

3.1 Surveyed site

Eight branches in Tamagawa aqueduct network are chosen for the research on the basis of existing in open ditches: Tamura, Kumakawa, Haijima, Shibasaki Nobidome, Sunagawa, Shinbori, Senkawa. Main stream is not surveyed because it is prohibited to enter and there is no park and no garden.

3.2 Surveyed green space

In this research, garden is defined as green spaces in private area. Gardens with flow of canals are selected by observation in field survey and map survey. On the other hand, park is defined by municipality information. It includes also green road in the law. Park alongside flow of a canal are selected by observation in field survey and map survey.

3.3 Field survey

The overview of these green spaces are found out from maps by the government. However, it is not clear enough for observation of detailed connection to green spaces and ponds. Some private area need permission to enter for surveys.

3.4 literature research and Interview

Literature research and interview to owners and municipality are also necessary to understand how to construct green spaces alongside a canal. Especially, we try to clarify the reason to construct ponds and history, process.

4. Connection between green spaces and the canals

Through observations, 73 parks (public green) and 16 gardens (private green) are placed alongside canals. In only 15 spots (17%) , water of canal are used to water reservoirs. In other spots, canals are ignored with fences and shrubs as spatial composition of green spaces[Table.1]. In these cases, mostly canals flow at the edge of the spaces, so that people rarely notice a canal flows there. 64% green spaces have fence between sites and a canal to prevent people from entering water to gain risk to drown[Table.1].

Now private green spaces alongside canals are less than public green spaces, however, some documents describe some gardens existed before. At this moment, it is not clear how many gardens existed where water of a canal is used because any documents describe no detail of garden. Most of cases, demolishing a branch of canal is trigger to demolish gardens.

In terms of branches, Shinbori branches ,which has also many branches, has 53% green spaces alongside the canals, especially Ogawa branch (Shinbori branch's branch) (28%)[Table.1].

Type	Name	Landowner	Name of branch	Reservoir type	Use of water	Accessibility to water		
Garden (private)	Tamura garden	Private	Tamura sake factory	Tamura	Separated pond	Garden	only garden users	
	Ishikawa garden	Private	Ishikawa sake factory	Kumakawa	Separated pond(remain)	Garden	only garden users	
	Korakuen garden	Private	Korakuen restaurant	Kumakawa	Separated pond (2)	Garden	only restaurant users	
	Fusajji temple garden	Private	Fusajji temple	Shibasaki	Separated pond (2)	Garden	open	
	-	Private	-	Shibasaki	Separated pond	Garden	only garden users	
	Heirinji temple garden	Private	Heirinji temple	Nobidome	Separated pond	Garden	only garden users	
	Shosenji temple	Private	Shosenji temple	Shibori(Ogawa)	-	-	open	
	Ogawa hiei shrine	Private	Ogawa hiei shrine	Shibori(Ogawa)	-	-	open	
	Enmeiji temple	Private	Enmeiji temple	Shibori(Ohnumata)	-	-	open	
	Suzuki inani shrine	Private	Suzuki inani shrine	Shibori(Suzuki)	-	-	open	
	Musashi so garden	Private	Kokusai Electric Techno Service	Shibori(Suzuki)	-	-	only garden users	
	Shinmyogu shrine	Private	Shinmyogu shrine	Sunagawa	-	-	open	
	Atago shrine	Private	Atago shrine	Sunagawa	-	-	open	
	Yakumo shrine	Private	Yakumo shrine	Sunagawa	-	-	open	
	Josuminamimachi inani shrine	Private	Josuminamimachi inani shrine	Sunagawa	-	-	open	
	Kumakawa shrine	Private	Kumakawa shrine	Kumakawa	-	-	open	
	Park	Ajisa park	Public	Municipality (Kodaira-City)	Shibori(Ogawa)	Separated pond	Biotope	open
		Ogawa Ryokuchi park	Public	Municipality (Kodaira-City)	Shibori(Ogawa)	Separated pond	Biotope	open
Kamijuku ryokuchi park		Public	Municipality (Kodaira-City)	Shibori(Ogawa)	Enlarged ditches	Biotope	open	
Fureaino hayashi forest		Public	Municipality (Kodaira-City)	Shibori(Ogawa)	Enlarged ditches	Biotope	open	
Happy dragonfly pond		Public	Municipality (Kodaira-City)	Shibori(Ogawa)	Separated pond	Biotope	open	
Hana roku shinsui park		Public	Municipality (Kodaira-City)	Shibori(Nonaka)	Enlarged ditches	Touchable space	open	
Jyosui Honcho biotope park		Public	Municipality (Kodaira-City)	Sunagawa	Separated pond	Biotope	open	
Namiki Library		Public	Municipality (Kokubunji-City)	Sunagawa	Enlarged ditches	Touchable space	open	
Tamagawa central park		Public	Municipality (Fussa-City)	Tamura	Enlarged ditches	Playspace	open	
Chokoku no tani road		Public	Municipality (Kodaira-City)	Shibori(Ogawa)	-	Path		
Seifu park		Public	Municipality (Kodaira-City)	Shibori(Ogawa)	-			
Onuma west park		Public	Municipality (Kodaira-City)	Shibori(Ogawa)	-			
Ogawa sanban park		Public	Municipality (Kodaira-City)	Shibori(Ogawa)	-			
Hidamari park		Public	Municipality (Kodaira-City)	Shibori(Ogawa)	-			
Sakigake no nagare		Public	Municipality (Kodaira-City)	Shibori(Ogawa)	-	Path		
Yakumo seseragimizube		Public	Municipality (Kodaira-City)	Shibori(Ogawa)	-	Path		
Tsutakabe no kei		Public	Municipality (Kodaira-City)	Shibori(Ogawa)	-	Path		
Terrace no koniwa		Public	Municipality (Kodaira-City)	Shibori(Ogawa)	-	Path		
Shinmyo east park		Public	Municipality (Kodaira-City)	Shibori(Ogawa)	-			
Sakagura park		Public	Municipality (Kodaira-City)	Shibori(Ogawa)	-			
Akashia no suiro		Public	Municipality (Kodaira-City)	Shibori(Ogawa)	-	Path		
Ajisa no shokei		Public	Municipality (Kodaira-City)	Shibori(Ogawa)	-	Path		
Sarusuberi no shokei		Public	Municipality (Kodaira-City)	Shibori(Ogawa)	-	Path		
Hana no shokei		Public	Municipality (Kodaira-City)	Shibori(Ogawa)	-	Path		
Kodaira graveyard		Public	Municipality (Kodaira-City)	Shibori(Ogawa)	-			
Onuma No.4 park		Public	Municipality (Kodaira-City)	Shibori(Ogawa)	-			
Green road shinsui park		Public	Municipality (Kodaira-City)	Shibori(Onumata)	-	Touchable space	open	
Suzuki shinsui park		Public	Municipality (Kodaira-City)	Shibori(Onumata)	-	Touchable space	open	
Takenoko park		Public	Municipality (Kodaira-City)	Shibori(Nonaka)	-			
Megurita suimon green road		Public	Municipality (Kodaira-City)	Shibori(Suzuki)	-	Path	open	
Daimonbashi green road		Public	Municipality (Kodaira-City)	Shibori(Suzuki)	-	Path	open	
Suzuki kaido park		Public	Municipality (Kodaira-City)	Shibori(Suzuki)	-			
Suzuki hidamari park		Public	Municipality (Kodaira-City)	Shibori(Suzuki)	-			
Hanakoganei hyoutan park		Public	Municipality (Kodaira-City)	Shibori(Suzuki)	-			
Suzuki local center north park		Public	Municipality (Kodaira-City)	Shibori(Tanashi)	-			
Suzukimachi No.5 park		Public	Municipality (Kodaira-City)	Shibori(Tanashi)	-			
Suzukimachi No.4 park		Public	Municipality (Kodaira-City)	Shibori(Tanashi)	-			
Komorebi no shokei		Public	Municipality (Kodaira-City)	Shibori	-	Path	open	
Takanodai No.2 park		Public	Municipality (Kodaira-City)	Shibori	-			
Josui park		Public	Municipality (Kodaira-City)	Shibori	-	Path	open	
Ohkeyakimichi park		Public	Municipality (Kodaira-City)	Shibori	-	Path	open	
Ohkeyakimichi park		Public	Municipality (Kodaira-City)	Shibori	-	Path	open	
Kitsuneppara park		Public	Municipality (Kodaira-City)	Shibori	-			
East ogawabashi bridge park		Public	Municipality (Kodaira-City)	Shibori	-			
Nakajimamachi south park		Public	Municipality (Kodaira-City)	Shibori	-			
Ogawa No.1 south park		Public	Municipality (Kodaira-City)	Shibori	-			
Kami suzuki green road		Public	Municipality (Kodaira-City)	Sunagawa	-			
Futatsuduka green road		Public	Municipality (Kodaira-City)	Sunagawa	-			
Josuihoncho No.3 park		Public	Municipality (Kodaira-City)	Sunagawa	-			
Miyoshi park		Public	Municipality (Kodaira-City)	Sunagawa	-			
Horibota park		Public	Municipality (Kodaira-City)	Sunagawa	-			
Kirinoki park		Public	Municipality (Koganei-City)	Sunagawa	-			
Zokibayashi plaza	Public	Municipality (Koganei-City)	Sunagawa	-				
Josuinami park	Public	Municipality (Musashino-City)	Sunagawa(kajinoshinden)	-				
Sakuradutomi green road	Public	Municipality (Musashino-City)	Sunagawa(kajinoshinden)	-				
Namikimachi yamamomo park	Public	Municipality (Kokubunji-City)	Sunagawa	-				
Namikimachi momiji park	Public	Municipality (Koganei-City)	Sunagawa	-				
Namikimachi park	Public	Municipality (Koganei-City)	Sunagawa	-				
Tenobashi south No.2 park	Public	Municipality (Tachikawa-City)	Shibasaki	-				
Showa memorial park	Public	Municipality (Tachikawa-City)	Shibasaki	-				
Fujimichi north park	Public	Municipality (Tachikawa-City)	Shibasaki	-				
Tachikawa park	Public	Municipality (Tachikawa-City)	Shibasaki	-				
Gateball park	Public	Municipality (Fussa-City)	Kumakawa	-				
Nabeni park	Public	Municipality (Fussa-City)	Kumakawa	-				
Nabeni park	Public	Municipality (Fussa-City)	Kumakawa	-				
Nobidome josui green road	Public	Municipality (Kodaira-City)	Nobidome	-				
Fujimicho ichome No.2 park	Public	Municipality (Higashimurayama-City)	Nobidome	-				
Nobidome plaza	Public	Municipality (Higashimurayama-City)	Nobidome	-				
Nobidome yuen park	Public	Municipality (Higashikurume-City)	Nobidome	-				
Koyama No.2 park	Public	Municipality (Higashimurayama-City)	Nobidome	-				
Koyama No.4 park	Public	Municipality (Higashimurayama-City)	Nobidome	-				
Shiseki park	Public	Municipality (Niza-City)	Nobidome	-	Path	open		
Nobidome park	Public	Municipality (Niza-City)	Nobidome	-				

5. Ponds and urban structure

Through observations, 6 ponds exist in gardens and other 9 ponds exist in parks [Table.1]. Ponds in gardens are separated from canals and water are taken from a canal at nearest points of garden and finally return to a canal as bypass. Ishikawa garden and Tamura garden were constructed to their guest to their family's Sake factory in Meiji era. Old photos and drawing of Ishikawa garden and Tamura garden and Heirinji temple garden remains. However, history of other 3 gardens is not clear.

On the other hands, ponds in parks have following 2 types; 1) separated from a canal 2) enlarged ditches with direct connect [Table.1]. These ponds are used for biotope or touchable spaces with stairs to a canal. Ajisai park and Ogawa ryokuchi park have gates to control water intake.

Analyzing relationship between these ponds and branches, branches which have ponds in gardens do not exist park with ponds, except for Tamura branch. This reason can be related to urban structure and size of lots. Tamura, Kumakawa, Haijima, Nobidome, Shibasaki, Senkawa branch flows in area of non-land readjustment. These area's lot are different size by topographical reason, so that some landowners have large enough to construct garden ponds. On the other hand, Shinbori, Sunagawa branch flows in center of area of land readjustment. These area's lot are generally narrow width to main street and a canal and long depth. It is too small to construct gardens however, it is suitable for municipality to buy land alongside canal to construct parks.

6. Planning for canals and surroundings

Through interview to municipalities, only Kodaira city has practical planning to canals in Kodaira city; Shinbori and Sunagawa. Most powerful trigger is "Kodaira city canal plan" in 1995. This plan is based on survey in 1992. The survey clarified following problems; 1) drought 2) disconnection 3) less attractive 4) water quality. Based on this results, this plan represent practical plan with many drawings at the specific sites with evaluation. Finally six proposal have completed in 18 proposal included in the plan.

7. Conclusion

Through analyzing the relationship between green spaces and canals, this research clarifies that there is different connection between green spaces and canals related to urban structure and municipality planning. More detail is the following:

1. Most of green spaces on canals are no connection to canals with fences
2. Ponds in garden with canal water are only observed in area of non-land readjustment
3. Practical planning and studies by a municipality is a trigger to make new connection between a park and canals.

The previous studies on this canal network focus on historical surveys and water quality. On the other hands, this research reveals potential sites to reserve water in the network as new definition of an abandoned aqueduct system. The aqueduct has already lost original functions, but it is

still useful for future resilience in the city. However, at this moment, as every canal just flow straightly to fields and there are few water reservoirs in the canal network to reduce risk of flooding of Tama river, it is still important to construct water reservoirs to renovate exiting parks on canals.

These results clearly indicate the necessity of concerning whole planning of network of Tamagawa aqueduct canal system to think future of Tokyo, based on researches of historical background. As S.Terai suggests in their research, if the network extends to outer canals of Edo castle, it helps to purify water quality of outer canal of Edo[1]. Increasing ponds connected to the network, it can help to preserve rare animals and plants in Tama river as S.Ito suggests in their research in Biwa lake aqueduct[5]. These research insists that it is important to approach from not only disaster reduction but also ecological viewpoints to develop planning of Tamagawa aqueduct network.

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Han river masterplan: three resilient landscape strategies

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Abstract

Three general resilient landscape strategies have been integrated into the design of a masterplan for the Han river, which runs through the Da Nang city centre over a length of seven kilometres. At this scale, a rehabilitation of the natural riverbanks will be combined with a diverse program within the public space, connected by an extensive recreational network of pedestrian paths. Using these paths on the riverbank, the deck paths over the water and the water-taxi stops, you can reach floating river nature, a floating market, a city park, an urban sport park etc. The integration of four public buildings adds to the public nature of the river as a whole: from north to south over the whole length of the river, a new opera building, a waterhub building, a redesigned market hall and a concert hall will be built. The combination of a landscape and architectural design makes for a high quality and diverse riverfront. Increasing the (semi-) public program alongside the river, creates support and involvement with the public to appreciate the investment in an ecological upgrade of the river delta. The masterplan will be the solid base to manage the rapid development of the city up to 2030.

To implement and to realize the three resilient landscape strategies the following keystones are important: set up a logical phasing with a range of short, medium and long term initiatives and identify funding resources for operational costs.

- **Phasing:** The flexibility of the vision and the planned initiatives increases as the scale and the implementation period increases. At the same time, new insights on the different scale levels can influence and interact with the other scale and implementation levels. This flexibility and interaction is important for community supported plans and projects. Design Office OMGEVING also selected a specific, strategic site to develop a catalytic project that is implementable within the short term and can kick-start long-term change.
- **Funding resources:** Design Office OMGEVING suggest some primary types of potential funding sources: enterprise revenues; local government funding; republic government funding; public-private and private funding. Each source comes with a series of challenges and opportunities.

Keywords: masterplan Han river; resilient landscape strategy; phasing; funding resources; implementation

1. Representative challenges for growing Da Nang and its Han river

Like in many South East Asian cities, Da Nang is growing fast. Vietnam's urbanization rate up to 2009 was about 30%. Several research organizations expect a rise from 35% up to 45% towards 2020. Also Da Nang's population growth was swift in the last decades. In 1999, the city counted about 687,000 inhabitants and in 2010 this was already 926,018. Until 2009, the population of Da Nang grew at an annual average rate of 5.2% [1]. Based on this fact, the population will rise to 1.56 million by 2030. Along with the fast urbanization, the city of Da Nang faces major challenges in terms of climate change, mobility and land use. These challenges are representative for many emerging countries in this region and their cities.

In response of these challenges, Design Office OMGEVING and its partners developed the resilient Han river masterplan in 2016. The masterplan was awarded the joint first prize in the prestigious international design competition for Han Riverfront Da Nang City. The jury decided to select two laureates out of seven accepted applicants. Although the masterplan contains valuable resilient strategies for the future, till now the implementation is proving difficult to achieve.

1.1. Climate challenges

Floods, increasing precipitation, extreme weather conditions, erosion and waste water are climate related problems the city of Da Nang faces, causing a need for a future

oriented strategy with long-term solutions for these increasing threats.

Floods

A combination of the challenges described below (increasing precipitation, extreme weather, sea level rise, increase of impervious surfaces etc.) is the cause of the growing problem of flooding. The aftermath of floods or flood surges is significant, with damage to public space, private homes and the natural environment. After the typhoon Ketsana in September 2009, a flood surge demonstrated the importance of coastal protection.

Precipitation

Patterns of precipitation and storm events are likely to change. Projections of the IPCC (Intergovernmental Panel on Climate Change) show that future precipitation and storm changes will vary by season and region. Some regions may have less precipitation and others more. However, the amount of rainfall and winds associated with tropical storms is likely to increase in most regions. This will be particularly distinct in tropical and high-latitude regions such as Vietnam [2].

Impervious surfaces (parking lots, roads, building, compact soil) do not allow rain to infiltrate into the ground. As a consequence, growing cities generate more and more runoff. This additional rapid flowing runoff can erode watercourses (streams and rivers), encourage weed invasion and alter natural flow as well as flooding when the storm water collection is overwhelmed by the additional flow.

Sea level rise

Warming temperatures contribute to sea level rise by expanding ocean water and melting ice caps. In 2014 the USGCRP National Climate Assessment projected that by the year 2100, the average sea level will rise up to 1,2 m since the date of the 2014 assessment [3].

Regional and local factors will influence future sea level rise for specific coastlines. Inflowing sea water will cause salinization of groundwater and the natural sweet water supply with drastic effects for the ecosystem.

Erosion

Coastal erosion is expected to increase given the fact that Vietnam is one of the countries which are severely affected by climate change and sea level rise. Coastal erosion is breaking dykes, causing floods and saltwater intrusion. Stormy weather and typhoons, regularly smash into the white beaches of Da Nang's east coast, causing damage to the coastline and touristic infrastructure.

Wastewater

Combined systems in areas with many impervious surfaces cause flushes during extreme rain events and this heavily polluted water will enter connected storm drains and eventually the river. This highly concentrated pollution results in severe deterioration of the water quality in rivers and streams.

In most areas not all houses are connected to a sewage system and consequently pollute the environment. Secondly, the sewage of the connected houses does often not even lead to wastewater treatment plants, because there are none or few plants in the area which are often not up to date. Sewage water will infiltrate into the groundwater aquifers and put a risk on groundwater extraction for drinking water or other applications.

1.2. Mobility challenges

Da Nang's traffic is currently functioning well. However, more and more residents are replacing their motorbikes by cars, using about four times more street space, which will lead to traffic congestion in the very near future (4% of car-users in 2016 will increase to 9% by 2025) [4]. The need for parking spaces will increase, the air quality in the city will deteriorate with increasing health problems as a result and the city's positive image will suffer. Da Nang's public transport system is not yet functioning at full capacity to be an attractive alternative for cars or motorbikes.

1.3. Land use challenges

The map for Da Nang's land use shows the situation around 2003. The land between the river delta was still mostly used for agriculture, rice fields to be exact, intertwined with scattered rural residential areas. Current aerial images show that the rice fields east of the 1A national highway have all but disappeared and have been replaced by urban areas and a dense road grid. West of the highway the urbanization appears to have been less drastic although

most of the forests and some of the rice fields have made way for residential areas as well.

The urban area of Da Nang city itself has not increased since it is strictly bound between coastlines and mountains explaining at length the fast urbanization in the river delta area. Of course, there is a lot of variation within the term ‘urban land use’, it does not necessarily implement hard surfaces. Da Nang city is known to be very green and to be the most pleasant metropolitan city in Vietnam.

2. Three resilient landscape strategies and tools for implementation

2.1. Three resilient landscape strategies

The proposed approach to tackle the challenges Da Nang and its Han river are facing, is a combination of three separate strategies, defining the focus for the masterplan 2050. These strategies are called the ‘green corridor strategy’, ‘green connection strategy’ and ‘green program strategy’. All design concepts for the masterplan can be assigned to one of these three strategies. The ‘green corridor strategy’ focuses on providing answers for the climate challenges by reintroducing and detaining greenery in the river delta area as well as in the city centre, in particular alongside the river, and by presenting water related improvements. The ‘green connections strategy’ proposes ideas for an interlaced system of sustainable modes of transportation. The ‘green program strategy’ aims to ensure the quality and strategic clustering or dispersion of Da Nang’s

architecture typologies, range of activities and touristic highlights.

The masterplan combines all strategic elements from the ‘green corridor’, ‘green connections’ and ‘green program’ into one combined strategy. The plan highlights the activities with a link to the river, strengthens the sustainable transportation connections towards and alongside the riverfront and also reinstates the green continuity. The multimodal transportation hubs and green connections will transform Da Nang into a well-functioning, pleasant and appreciated metropolitan city.

Successful adaptation to the climate challenges, eco-friendly city development and the emphasis on green space will make Da Nang the number one exemplary city of Vietnam and will attract foreign tourists since eco-tourism is gaining importance and popularity worldwide.

Green corridor strategy

The fast urbanization of the city requires the determined protection and development of a robust and resilient ecological river network, the ‘green corridor’. This network is the green basic principle for the masterplan. Its central themes include the green network city, the qualitative development of green riverbanks, beaches, coastlines and parks, the preservation of natural values and biodiversity and the protection of the landscape itself, responding to climate-change challenges in urban spaces and rain and waste water management. The key elements of this strategy are:

- Continuous green network: recovering the ecological function of the river delta with a network of green riverbanks, green coastlines, green roads and green parks
- Protected and maximized river delta: reducing the risk of erosion and flooding in the flood prone south river delta by protecting and maximizing the riverbed for water storage
- Permeable street network: reducing the risk of erosion and flooding in the flood prone north urban neighbourhoods by maximizing water infiltration and water storage in the city centre
- Two safety thresholds: protecting the north city centre and manage water retention in the south river delta
- Clean water network: Stopping the flow of sewage water, keeping the river clean and pollution-free by adding a new sewage line on the north urban riverbanks and a natural water treatment system in the south
- Flood surge protection for the coastlines: protecting the coastlines from high waves associated with tropical storms

Green connections strategy

The ‘green connections strategy’ devises a comprehensive, well laid-out public transport system in which a water-taxi network, a bike and pedestrian network and, on the long term, a tramline network complements the existing bus network in Da Nang. These connections are the basis in terms of mobility for the masterplan. The service level of the public transport network will be sufficient during the daytime as well as at night. The overall reachability of urban neighbourhoods, workplaces and other

services by public transport will be enhanced. This will require substantial investments in new traffic routes and better designed interchange stations: the multi-modal hubs. The key elements of this strategy are:

- Continuous recreational walking and cycling network: developing two river routes connecting the south river delta with the north city centre and offering bike rental at strategic locations
- Waterborne public transport system: integrating services for water-trams and water-taxis, linking them with other modes of public transport (buses, bicycles) to optimize movement by public transport, creating qualitative infrastructure for cruise boats and tourist boats
- New (motor)bike bridge and new pedestrian bridge: connecting the waterhub, the biggest multimodal hub with a cruise terminal, port and new urban neighbourhoods on the left riverbank, recovering and enforcing the historical axis of the city centre with a slow connection to the urban area on the right riverbank
- New coastal and city centre tramline: developing a tramline, connecting the north coastline, the city river and the east coastline
- Bridges as multimodal hubs: developing the base of existing and new bridges as multimodal hubs, aiming to provide fast and efficient transfers as well as comfortable and convenient facilities.
- Cooling river: using the cooler river water as a cooling system for the city

Green program strategy

Sufficient construction of private housing and commercial facilities in tune with the population growth results in significant new building volumes and increasing claims on the open space. To protect and preserve Da Nang's green areas for future generations, it's irresponsible to only expand horizontally on the outskirts of the current built environment. A new way of perceiving the city's innovative capacity needs to be introduced. The emphasis of the city's investments will lie in restructuring and supplementing the existing urban areas. The key elements of this strategy are:

- District level mixed use urban centres: developing the district level urban centres with a high density, distinctive architecture and a mixed program
- Different areas for urban development, each with their own character and identity: developing urban areas with functions and building typologies which are related to their context: coastline area, mountain area, river delta area and city river area
- Network of river related public buildings: integrating a network of river related buildings to guarantee the public character of the riverfront and to support a memorable riverfront identity
- Waterhub: developing a waterhub as the multimodal gate to the city river and as a city icon
- Airport park: developing the green area next to the airport as a central park on the scale of the city

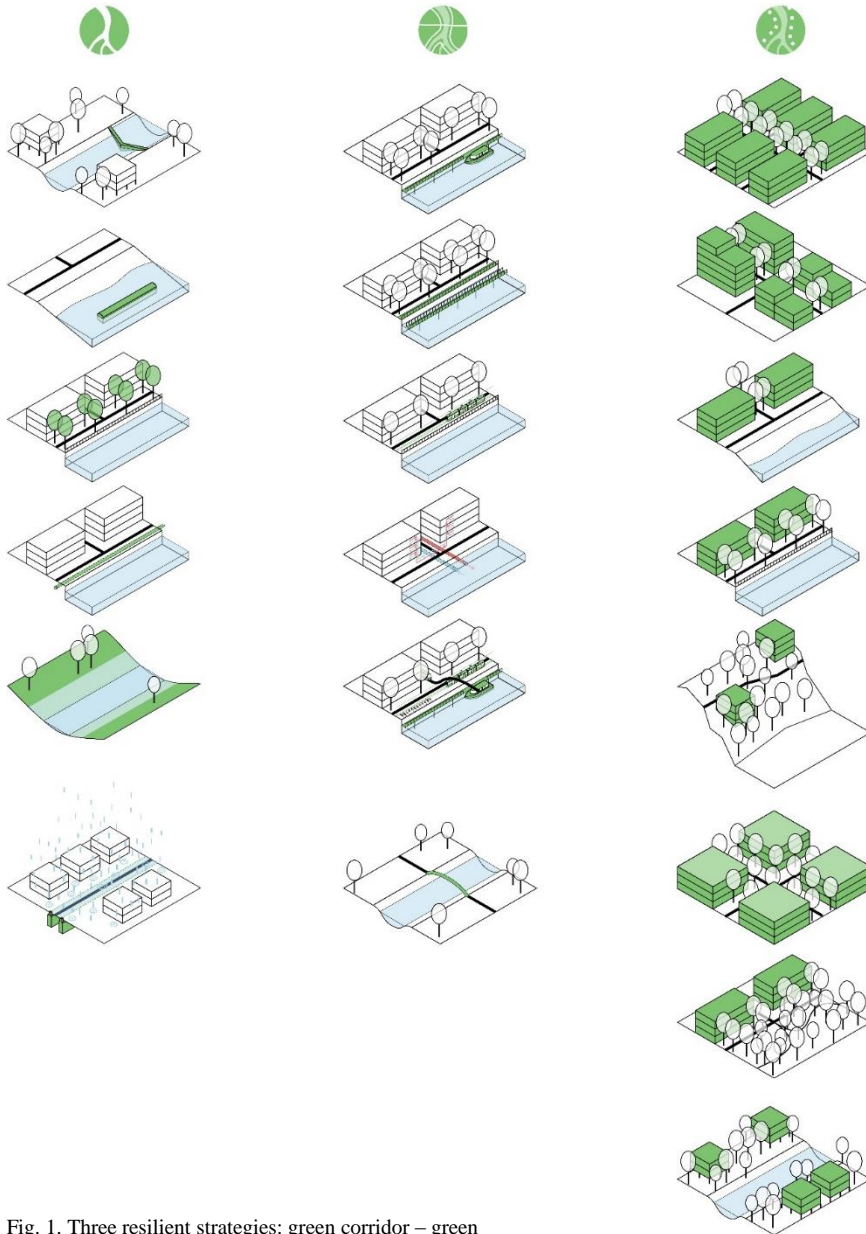


Fig. 1. Three resilient strategies: green corridor – green connections – green program

2.2. Tools for implementation

In addition to the three ambitious resilient landscape strategies, the Han river masterplan 2050 also provided tools for implementation: a logical phasing strategy with a range of short, medium and long term initiatives and the identification of funding resources for operational costs.

A logical phasing strategy

The Han river masterplan 2050 sets out the vision and goals for the riverfront on three scales, with a range of short, medium and long-term initiatives.

- Short-term, 2016 to 2020. Short-term projects establish critical first elements for the overall riverfront transformation. These projects reflect key investments anticipated to produce important short-term results and/or set a strong foundation for the longer-term project elements.
- Mid-term, 2020 to 2030. Mid-Term projects reflect the results of a public and private sector cooperation to achieve large waterfront redevelopment projects like the opera building.
- Long-term, 2030 to 2050. Ambitious, long range efforts, which are important, but often still flexible/adaptable to remain responsive to changing market conditions, community needs and other factors.

The long-term initiatives for 2050 apply to the whole river delta. The medium-term initiatives for 2030 affect the urban river and the short-term initiatives for 2020 are part of the strategic area. The flexibility of the vision and the planned initiatives increases as the scale and the implementation period

increase. At the same time, new insights on the different scale levels can influence and interact with the other scale and implementation levels. This flexibility and interaction is important for community supported plans and projects. Other keystones for the implementation strategy are communication and public involvement.

Potential funding resources

The vitality of the strategic area and in general the whole urban Han riverfront will depend on identifying funding resources for the operational costs. We suggest some primary types of potential funding sources: enterprise revenues; local government funding; republic government funding; public-private and private funding. Outlined here are examples of some of these potential sources. Each source comes with a series of challenges and opportunities. The strategic area is a collection of unique river related projects. Comprehensive discussions with city representatives will be a critical first step in assessing which funding strategies might be appropriate for these and other riverfront developments.

- Enterprise Revenues
 - Concession Fees: the urban river and especially the Waterhub with a cruise terminal and other commercial facilities will include concessions and rent which can be allocated towards Waterhub operational costs. The shop concessions within the Waterhub as well as the restaurant will pay a basic rent and could pay an extra percentage from net cash flows above an agreed-upon threshold. Ferry and / or water taxi operators will pay landing fees and

city-owned underground parking in the proximity of mobility hubs will generate more profit.

- **Special Events Fees:** The urban river already hosts numerous large-scale public celebrations and special private events, for example the annual fireworks event. These draw significant crowds and media attention from throughout the city and the region. And yet, as a matter of policy, the city has not captured the value of hosting these events on its riverfront and surroundings. Instead, event organizers receive permits for events with little, if any, monetary consideration paid to the city. Waterfront parks, public promenades and other municipally owned venues throughout the city, should identify ways to monetize the value of their riverfront venue to support ongoing public programming and operations.
- **Local Government Funding:** Directed by the City Council, City Staff may be able to identify additional sources, reserved for public projects.
- **Republic Funding:** The riverfront of Da Nang and especially the Waterhub can be accessed from boarding points for ferry transport along the East Sea coastline. This could open up opportunities for republic funding support for the Waterhub-project.
- **The Han river Fund, public-private Funding through impact fees:** An important way to obtain impact fees are one-time fees collected from developers with projects within a specified radius from a public infrastructure investment, like the urban riverfront of Da Nang.

Impact fees are typically utilized to fund road, sewer or open space renovations, water related projects etc. There must be a rational nexus between the private development and the need for infrastructural improvements. Furthermore, the developer's fair contribution to the public-private fund must be defined.

2.3. Unclear perspectives towards implementation

Even with all the tools for the implementation prepared in 2016, the implementation of the master plan has yet to be kick-started by the government. For future projects and implementation of climate resiliency strategies, it is important to find out what is causing the holdup. The scale and complexity of this study area are too large to determine one clear answer to why the project seems to have stranded. Building on previous experiences with master plans, the following possible reasons come to mind:

- Da Nang is growing at such a high pace that the city council is overtaken by events. The government may lack experience in coordinating complex planning processes. An experience expert from the project team could assist the government and act as a hinge between design team, government and private stakeholders.
- Immediately after the completion of the masterplan elections led to a new city council. The masterplan may not be a priority or may not be supported by the new city policy.

- The spatial but also financial tools for implementation might have been too general and should have been more detailed and tangible.
- There is a need for a project director as a link between the government and the design team.
- The masterplan had a strong focus on the public space. The relationship between property developments along the river and the added value for developments in the public domain should have been highlighted.
- Awarding a joint first prize made the already complex assignment even more difficult to work out since there is no clear definition how the cooperation between the two winning teams should proceed.

3. Towards a resilient policy and management

Like many South East Asian cities, Da Nang and its river needs a spatial answer for the challenges related to the rapid urbanization due to population growth, climate challenges concerning the Han river such as floods, precipitation, extreme weather, erosion, wastewater etc., mobility challenges with increasing car use, traffic congestion, air pollution etc. and land use challenges with the gradual intake of open space, the increase of hard surfaces etc.

The Han river masterplan of 2016 tried to formulate an answer to these challenges with three general resilient landscape strategies integrated into the design of a masterplan for the Han river.

To implement and realize these resilient strategies the following suggestions were provided: set up a logical phasing with a range of short, medium and long term initiatives and identify funding resources for operational costs.

But even with these suggestions, the masterplan of 2016 has not been activated. It shows that the government needs more than just a masterplan. The implementation of large scale masterplans demands a specific expertise to support the local Vietnamese authorities. A middleman project manager could help steer the project in the right direction and could bring the design team and the government closer together so that resilient strategies and masterplans can gain ground in local policies and can turn the tide in favour of sustainable urban development. In that sense resiliency is also necessary in terms of policy and management.



Fig. 2. Overview masterplan

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Acknowledgments

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Re-use of Contaminated Soil in the Dense Cityscape

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Abstract

As city planning in Europe aims towards densification and sustainability, empty or buildable plots are becoming hard to find.

Ancient and unused industrial plots, old landfills, abandoned tracks, now part of the inner city, are now often seen as a new opportunity to densify the city and the problematic of contaminated ground is becoming a new concern.

We are dealing, at the same time with the necessity to build a more sustainable environment, mixing new housing and buildings with green public spaces, preserving biodiversity, enabling “green commuting”, cycling, walking, playing in a safe environment.

Re-use of contaminated soil tends to reshape the way we plan and design, public and common spaces in these neighbourhoods. Full phytoremediation directly on site is often not an option as the pollution happens to be ancient and often deeper underground.

In France, Law implies, as we plan new buildings, parks or public squares, to analyse ground and classify the way polluted soil is going to be stocked reused or decontaminated: (ISDND / ISDI /ISDI+ / ISDD)

- Dangerous versus non-dangerous
- Inerte (inactive) versus non-inerte (active)

Pollutant such as Heavy metals, Hydrocarbons, PCB, etc.. are analysed and located.

Main guide line are as follow and depends on the classification and density of each pollutant present in the ground :

- If dangerous and above legal limits : removed and treated in a specialized facility
- If not dangerous and above sanitary legal limits: kept on site and confined as to not endanger the people living there and as to not spread pollutants.

Keeping contaminated soil on site generates new ways to rethink how we design open spaces, and the way people are going to use it. These guidelines, when applied to small scale projects can impact the whole concept of the new design.

As we encounter this problematic in some of our current project, we wish to present two case studies

- Place des Carmes (public square), Clermont Ferrand, France (20 000m² / 215 sqft)
- Quartier Ambroise Paré : Construction of a social Housing complex, underground carpark and upgrade of the small residential park, Lyon France. (13 000m² / 139sqft)

Place des Carmes :

- Located contaminated ground : Hydrocarbons, copper,
- Impacts on playground
- Impacts on storm water infiltration

The impact is rather small, and the choice has been to « block » the pollutants under a concrete pavement. Stormwater infiltration will be limited and a fair amount of natural ground will be brought on site.

Quartier Ambroise Paré :

- deeply contaminated ground (dates end of WW2): Hydrocarbons, copper, arsenic, antimony and PCB
- Impacts deep underground : excavated ground from the underground car park (5 300m³)
- Impacts on storm water infiltration
- Impacts on the surface : heavy metals contamination

The choice has been to re-use soil as much as possible :

- under a newly built concrete pathway on high ground allowing a direct level access to existing hallways.
- Under planted earth banks with thickets and grove thus creating a new landscape.

Pollution; pollutants; contaminated soil; phyto remediation; phyto stabilisation; urban project; design; density; Europe; France; Lyon; Industry; Urban planning; Cityscape; Landscape

1. Introduction

For a few decades now, densification of cities has been a relevant and recurrent thematic of European urban planning. As the trends towards suburban urbanisation and urban sprawl lead to low density and consumption of agricultural land, urban planners aim to tackle this issue by promoting a more compact city and implement mechanism to densify the city centre itself as well as its vicinity. A few figures of population density in middle size cities in the 3 past decades in France illustrates this trend :

	1982 inhbts/km ²	2014 inhbts/km ²	%
	<i>32 years span</i>		
LYON			
Urban area	2 133	2 538	+ 19%
Lyon	8 629	10 583	+ 22.6%
TOULOUSE			
Urban area	1 083	1 630	+50%
Toulouse	2 941	3 941	+34%
NANTES			
Urban area	908	3 689	+ 30%
Nantes	1 183	4 571	+ 23%
Urban area London	5 285		
Urban area Tôkyô	6 278		
Urban area Singapore	7 697		
Hong Kong	6 553		
Paris intra muros	20 647	21 066	+2%

Fig 1 : Population Density evolution in France - source INSEE

The dense city centre tends to gain population and the surrounding cities of the urban area seem to follow this specific trend.

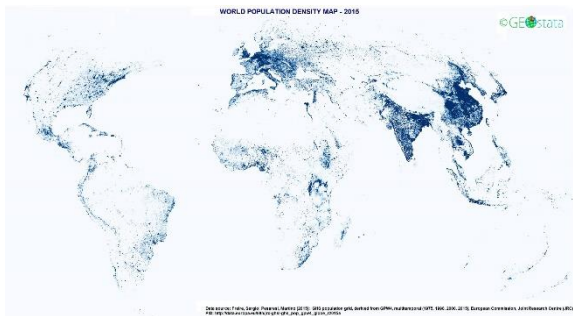


Fig 2 : World Population [1]

2. Contaminated Soil and Density in European cities.

Promoting densification versus sprawling cities is also a tool to protect agricultural land as well as to promote better and more efficient public transportation and reduce car use. It is part of a global scheme towards a sustainability.

At the same time, as we are dealing with a compact city, we also need to create a more sustainable environment for its inhabitants, mixing new housing with ancient building refurbishment, creating new public spaces, green networks preserving biodiversity in the city itself, enabling green commuting, cycling, walking, playing and living in a safe environment.



But, we must confront the problematic of the lack of vacant plots,

making this densification of the urban fabric more difficult.

Reuse of abandoned industrial plots has been a common response to this lack of urban space to develop since the early 80's and its steady closing and relocation of industries and smaller scale business from the city core to the suburban areas. When developing the city on such contaminated soils we must tackle the problematic of planning, planting and building on polluted ground.

These urban projects are well documented and there are well established procedures, but as this kind of re utilisation of vacant plots are more and more common, the way of planning and conceptualizing have been influenced by those procedures.

The two following well known projects showcase ways of dealing with contaminated soils and infrastructure such as

- Ecological restoration of water banks.
- Phyto remediation.
- Restoring natural process.
- Sealing contaminated soil and excavated materials.
- Cut and fill balance and displacement of polluted soil.
- ...

These operations, show us the influence of a contaminated context on planning and conceptualisation of an landscape project.

2.1. Westergasfabriek

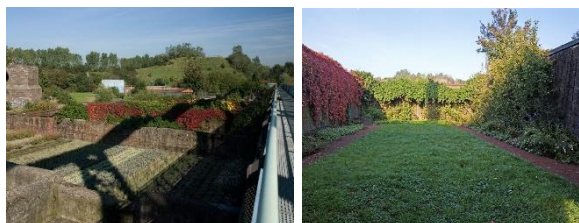


Fig 3 : Westergasfabrik Park – 2004 -Gustafson, Porter and Bowman, Mecanoo Arch. Netherlands. [2]

The park is located on a partially dismantled industrial facility. The site was heavily contaminated, and, as not to spread “contaminants”, the contaminated soil could not be taken off site :

- A cut and fill balance had to be calculated.
- New soil has been brought on site and polluted soil displaced.
- An Undulating ground has been created as to re stock the surplus soil.
- A wood land has been newly planted with new salix babyionica.
- The remaining basement of the old gasholder has been filled with the worst pollution and caped and has become a waterlily pond.

2.2. Landschaft park



Duisbourg Nord

Fig 4 : Landschaft park Duisbourg Nord – 2002 – Latz + partners Germany [3]

Situated in the Ruhr district, the park takes place amongst a wider network of several projects with the aim of transforming an old industrial district.

There, patterns and fragment of industrial vestiges found on site are reinterpreted as to form a new landscape.

Trees have been planted and a square build in the midst of the old structures, the open

waste channel has been transformed in a clear water canal.

Most contaminated places have been demolished and evacuated. Enclosed garden have been build, their high walls now enclose old pollutants in sealed containers or excavated materials.

In a dense cityscape these techniques are hardly possible to implement as empty space lack tremendously. Phyto remediation of soil by a long-term cultivation, while being a appropriate technique in a park, is here not a viable option.

Phyto stabilisation on the other hand, might be an effective procedure to keep pollutants underground and reduce toxicity in the aerial parts of the plants. For instance, it has been noted that Festuca Rubra can be quite effective in a copper accumulated context, as well as Acer Pseudoplatanus (Zn) and Robinia Pseudoacacia (Cd + Pb) in other contaminated soils.

Other methods available tend to reshape the way we plan and design open spaces as we are dealing with re-use of soil and treat contaminated land.

In France, part of the ALUR Law (2014) takes into account contaminated soils. Its aims are as follow

- To prevent future pollution
- To treat existing contaminated sites
- To keep trace and memorize soil and contaminated sites.

On every new urban development, or new project, whether it concerns a public space or a new building, ground assessment must be organized.

Soil analysis lead to classify contaminated soil into 4 classes ranging from mostly harmless to the worst case scenario that needs to be evacuated and treated in a specialised facility.

These 4 classes are from less dangerous to worse : ISDI / ISDI+ (inert - inactive)/ ISDND (non-dangerous) / ISDD (dangerous).

Pollutants such as heavy metals, hydrocarbons, PCB are analysed, and located on site.

Main guidelines are as follow and depend on the classification above, as well as density and quantity of each pollutant present underground:

- If dangerous and above legal limits: soil must be removed and treated in a specialized facility
- If non Dangerous, non-active but above legal sanitary limits : soil can be kept on site, marked and protected, as not to endanger people living near and as not to spread pollutants.

As seen in the Gasfabriek Park project, contaminated soil can be displaced and / or kept on site. New, clean soil must then be brought on site to replace the existing displaced soil. As for the contaminated soil if kept on site, it must be blocked under any hard materials such as concrete, as well as, if planted, a certain thickness of new top soil.

These guidelines imply to work with shapes, to deform the site, to create an “undulating terrain” dyke walls, banks and shoulder that shape the landscape and the cityscape no longer seen as a levelled and simple site.

Keeping contaminated soil on site as well as to try a certain form of phyto stabilisation generates new and different ways to think and design open public spaces such as parks, places and common grounds. These guidelines when applied to a smaller scale project in a dense cityscape can impact a whole concept or design.

3. Case studies

As we encounter in our daily practice such problematic we would like to share two case studies.

3.1. *Place des Carmes Déchaux Clermont Ferrand, France*

Clermont-Ferrand is a middle size city in central France bordered by an ancient volcanic mountain chain, with a population of 142 000 inhabitants. It is the headquarters of global tyre company, Michelin.

The Place des Carmes is an urban 20 000 m² / 215 sq feet square situated north of the train station, in front of “Campus Michelin”, the Research and development Michelin Facility.

It is noticeable in the urban fabric since the early 20th century and has never been part of an industrial facility.

In the 80’s the square has been divided in two parts to allow the construction of a elevated road bridge used by car and the tramway line.



Fig 5 : Google earth image of the square

Nowadays the square presents a fragmented space that the remodelling project aim to reinvent and reconnect. The two slip roads will be demolished and three new monumental staircases will be build,

allowing pedestrians to climb on a newly accessible bridge and reach from there the tramway station. Old trees, *Platanus x Hispanica* and *Pinus Sylvestris* will be protected, and a fair number of new species will be planted.

Pollutants found on site in 2017 originates from car traffic pollution as well as general urban pollution.

The impact is here rather small, but other environmental and archaeological constraints must be taken into account:

- Presence on antic vestiges and relics as well as medieval relics.
- Floodable zone of the river Tiretaine.

Zn - Zinc			
PH	8.2 < PH < 9.2		

Fig 6 : Summary of pollutants found on site [4]

As the project location is an urban site, long term phytoremediation can't be implemented and choice has been made to keep the contaminated soil on site and to block hydrocarbons as well as heavy metals. Storm water infiltration is going to be heavily controlled and most of the storm water will be discharged to the municipal sewer.

Almost 50 trees will be planted, including new species such as *Alnus Cordata*, *Amelanchier Lamarckii*, *Carpinus Betulus*, and Pines. Tree pits will be created and filled with new top soil, brought on site.

Here, in this special case, the problematic implied by soil contamination was easily solved.

3.2. Ambroise Paré Laënnec – Lyon France

This 60 years old residential building complex is located in the eastern part of Lyon "8th arrondissement". This area began its development in the very beginning of the 20th century when the Grange Blanche Hospital (now Hôpital Edouard Herriot) was completed (1910-1933). Nowadays the IARC (International Agency for Research on Cancer) and one of the main science and medicine university can also be found in the vicinity.

In the 30's and 40's, small scale industries began their development on the ancient agricultural lands, and small suburban houses surrounding the newly established hospital, as well as some higher

	Lim. Cat A+ (ISDI+)	Lim Cat B1 (ISDND)	Lim Cat C (ISDD)
	<i>Kept on site</i>	<i>Kept on site</i>	<i>evacuation</i>
HYDROCARBONS			
Fraction C10-C40			
ANIONS			
sulfate			
chloride			
HEAVY METALS			
Sb - Antimony			
As - Arsenic			
Cr - Chromium			
Cu - copper			
Pb - lead			

constructions began to be build on each side of the main roads.

In the 50's, and as part of the post WW2 massive reconstruction plan, bigger scale social housing as well as rental units were built in the area, as industries began to be relocated in the city suburbs.

Those rental units and social housing complexes were build around large green common spaces, which now tend to be redeveloped and densified as part of the city growth.

As regulation and newly implemented laws lead to ground assessment, these ancient and often forgotten industrialized plot are rediscovered and contaminated soil resurface.



Fig 7 : Drone photography of the site 2016 © empreinte virtuelle

The Ambroise Paré / Laënnec housing complex was built From 1950 until 1964, partly on ancient vegetables patches and partly on a forgotten WW2 landfill. It's on this specific location that a 3 parts project was decided to be developed in 2015.

The whole plot restructuration was to allow:

- The construction of a 37 units social housing building.

- The creation of a two levels underground car park (100 vehicles) that can host cars of the new building inhabitants as well as the older buildings.
- The development of 1.3 Ha common spaces on the new-found surface freed of the old aerial car parks.

As per French law guidelines, ground assessment was done in 2 phases (2016 an additional testing in 2017) and the ancient landfill linked to the small factories network was rediscovered.

Most found pollutants are mostly common in such context, but number and density of heavy metals was such that the site was deemed unfit to allow ground excavation without treatment.

	Lim. Cat A+ (ISDI+)	Lim Cat B1 (ISDND)	Lim Cat C (ISDD)
	<i>Kept on site</i>	<i>Kept on site</i>	<i>evacuation</i>
HYDROCARBONS			
Fraction C10-C40			
ANIONS			
sulfate			
chloride			
HEAVY METALS			
Sb - Antimony			
As - Arsenic			
Cr - Chromium			
Hg - mercury			
Pb - lead			
PH	8.2 < PH < 9.2		

Fig 8 : Summary of pollutants found on site [5]

High levels of arsenic and antimony have been found in the 2017 ground assessment,

as soil was tested between ground level to 7.00 m deep.

No ground water was found as the water high level seem to be far below the contaminated soil.

The specific danger resides then in pollutants vaporization and dissemination, thus impacting health and safety of the people living in the polluted plot.

As construction work is about to begin, precise guidelines have been established such as :

- **Removal and treatment** in a special facility of polluted soil with high density of arsenic and antimony.
- **Kept on site** non-dangerous contaminated soil (stocked and protected while construction is underway) and located as follow :
 - Under concrete path and sidewalk (this specific contaminated soil being not fit to resist a road charge)
 - Under 50cm of clean top soil plus geotextile fabric, marker tape being placed above the kept on site contaminated soil.
 - No fruit trees should be planted, and vegetables parch should be cultivated off ground.
 - Trees should be planted in specific 12m³ tree pits, protected by geotextile fabric.
 - New pipes and sewer, as well as water supply network should be placed in a clean brought on site ground.
 - Strom water infiltration is possible as long as contaminated soil in replaced in specific zones where infiltration is located.
 - As there is a strong soil acidity, concrete infrastructure must be protected, and / or special concrete formula must be used.



Fig 9 : Kept on site contaminated soil : under landscaped shoulders © Plan b architectes

This guidelines led to a totally renewed and reshaped design of the housing complex common spaces :

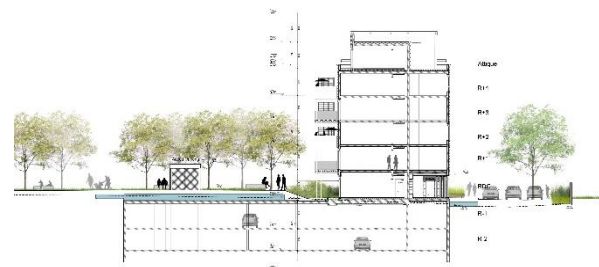


Fig 10: Kept on site contaminated soil : under sidewalk and green spaces © Plan b architectes

- To allow kept on site contaminated soil led to a global raise of ground level from 30cm to 150cm at the highest.
- As to stock more contaminated soil, three different landscaped shoulders were created.
- As to keep pollutants underground, and to allow some long term Phyto stabilization, as well as to reduce the urban summer heat, more than 80 trees, hedgerows and wooded hedges are to be planted.
- Contaminated soil is also going to be kept and blocked under concrete pavement and confined between walls as new levelled access to the existing buildings are to be created, thus replacing the old stairs and implementing universal design.
- An undulating landscape will help noise reduction and sound reverberation in the common spaces.

- These gradation in different ground levels will allow some of the building units and

These constraints were taken as a real chance to rethink the whole plots



Fig 12 : a new park. © Plan b architects – empreinte virtuelle
 their private gardens to gain some privacy and protection.

organization and its landscape.

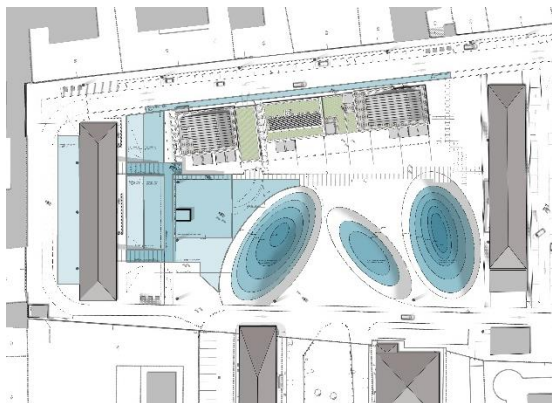


Fig 11 : Kept on site contaminated soil: under sidewalk and green spaces © Plan b architectes

4. Conclusion

Implementing these guidelines as well as allowing some long term Phyto stabilization, led to a chance to improve a pre-existing design and include general conceptualization process ideas dealing with universal design and a sustainable urbanism.

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New Waterfront for the Ecological City: Redesign of Namhang-dong Pier, Busan Korea

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Abstract

Busan Port is Korea's first trade port which opened in 1876. Namhang-dong pier has a facility where fishing vessels can berth, and equipment and catches related to landing, sale, and transportation of fishes can be processed and stored. However, facilities for processing and storage and repair facilities located in the Namhang-dong pier were closed due to the bankruptcy of the Hanjin Shipping Corporation and the downturn in the shipping business. Thus, the city became a deserted city, and there were many neglected buildings and idle spaces. And although it is a coastal area, its waterfront cannot be utilized because of its role as a port. And the green area ratio of the Namhang-dong area is low (no parks and street trees). The idle space in the industrial facilities was 2.2% of the total area of Namhang-dong. And we analyzed about Coastal breakwater, section, and possible to waterfront ecological design. The coastal and breakwater areas were surveyed to determine the areas where biodiversity is likely to increase, the space that can be accessed by humans, and the spaces inhabited by living creatures. And currently, the rate of greening in Namhang-dong is 1%. We propose an ecosystem diffusion strategy through first diffusion of biodiversity in sea and breakwaters, second diffusion to coast (waterfront), and third diffusion to idle space in Namhang-dong. And through the direct experience of people, we will revitalize the Namhang-dong pier to strengthen its resilience. With much interest and volunteer programs, it will increase its resilience. Due to the existing green area of 6,930 m², the green area of 14,443 m² through the diffusion of idle space, and the waterfront green area of 10,521 m², Namhang-dong will secure 5% of the green area of 31,894 m² of the total area of 662,634 m². And because of the design of the sea and breakwaters to increase biodiversity, the increase in ecological rate is infinite. If all these ecological re-designs are completed, there will be a numerical 5% real ecological space, and invisible ecological values will be too large to be quantified. And the most important component in reviving a dying city is attracting users. The goal is to provide rich ecological space and resting space and bring economic value through ecological activities that can be practiced. Because of its geographical accessibility, Namhang-dong has a resilience to revive quickly if you create a bright city through ecological redesign. Through this design, people will be able to manage the biodiversity without forgetting the history of Busan Port and Namhang-dong, and as a result, it will create a great economic benefit.

Keywords: ecological resilience, port, pier, waterfront, eco-system, Biodiversity, idleness space;

1. Introduction

1.1 Study background

Busan Port is Korea's first trade port which opened in 1876. Busan Port is classified as North Port and South Port. Namhang-dong pier has a facility where fishing vessels can berth, and equipment and catches related to landing, sale, and transportation of fishes can be processed and stored. Connecting the north pier and south pier in Busan Port is the Namhang-dong pier, and it is also important in terms of location. However, facilities for processing and storage, repair facilities in the pier of Namhang-dong closed due to the bankruptcy of Hanjin Shipping Corporation in February 2017 and the downturn in the shipping business. [Thus, the city became a stopped city, and there were many neglected buildings and idleness spaces. And although it is a coastal area, it can not utilize the waterfront due to its role as a port, but now it can utilize a waterfront that is not used for the downturn of the shipping business. And the green area ratio of the Namhangdong area is low (no parks and street trees).] So it is urgently necessary to transform the city into a green city before it completely dies out.



Busan port, 1935

closing manufacturers

repair & inspect

1.2 Purpose of research

The physical strength of the Namhang-dong pier starts at a site that has been shut down as a dock and has not been used. From the sea and the breakwater to the coast (waterfront) and the idle space in Namhang-dong, ecological redesign leads to the diffusion of

ecology. In order to induce contact between nature and human beings, we provide ecology by the coast from the north to the south of Namhang-dong. In addition, since economic value can be provided through nature, the economic development of Namhang-dong is gradually achieved through ecological design methods.



Fig. 1. Analysis Idleness space of Namhang-dong

2. Present analysis Introduction

2.1 Present condition of idleness space

The idle space in the industrial facilities was 2.2% of the total area of Nambang-dong (total area of Nambang-dong 662634 m², idle space 14443 m²). In order to present the concept of idle industrial facilities, it is first necessary to examine the concept of idle

space. (Urban regeneration method utilizing idle industrial facilities –Focused on culturally regenerated spaces, (Cho, 2011). It refers to an existing space that is unused, space that is utilized but unsuitable, and wasted space that created by the loss of function due to social change (Baek, 2003). As the industrial structure changed, the facilities that can process and store the buildings and the fishing facilities for landing, sale, and transport ceased to function and only the forms remained. In order for these spaces in the port city to energize the city while improving the quality of life of people, nature must breathe together \. Among the contents that the space should be equipped to operate vigorously with the sustainable vitality (The necessary strategies and planning factors for making cultural space), it is necessary to strengthen the cultural identity of the city center (Securing the place-specificity and enhancing the symbolism in the city) and to preserve and utilize the historical and cultural elements in the port (Use of historical symbolism of preserved resources, reuse of old buildings, preservation of historical cityscape and street landscape, preservation of traditional buildings, cultural properties (Son 2005).At present, the shipping facility is closed by more than 30%, so the alleys are not cleaned or managed, and there are brownfields left after the buildings have been demolished. And there were many short-term accommodation facilities that were not open. And people did not live in aging low-rise housing. So, we selected unused space that is not utilized, polluted land due to coastal garbage, uneven gravel sand, and large spaces gathering scrap iron and garbage.



Idle space of Namhang-dong

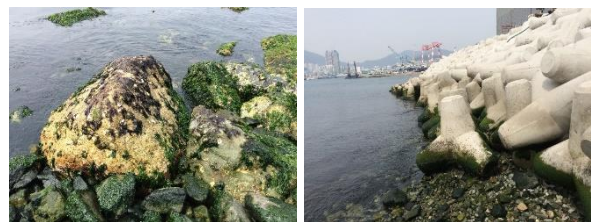
2.2 Characteristic of Namhang-dong pier

We analyzed Coastal breakwater, coastal species, and possibility of waterfront ecological design. Marine species were found in the coastal area, most of which were seaweed



Coastal Species

However, as we entered the breakwater zone, some shellfish were found.



Breakwall zone

The coastal and breakwater areas were surveyed to determine the areas where biodiversity is likely to increase, the space that can be accessed by humans, and the spaces inhabited by living creatures.

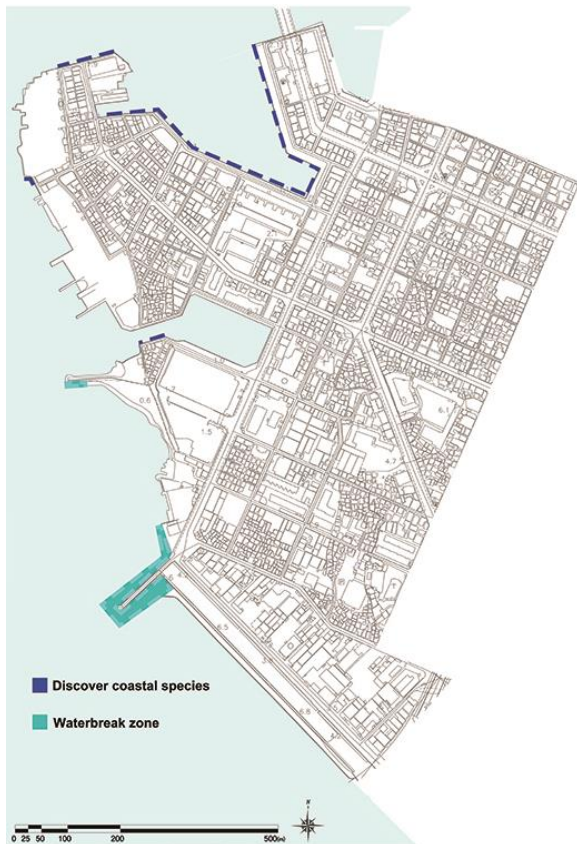


Fig. 2. Coastal Species Discovery and Breakwater Areas

2.3 Green area ratio of Namhang-dong

Currently, the rate of greening in Namhang-dong is 1% (the total area of Namhang-dong 662634 m², green area 6930 m²). Namhang-dong is mostly composed of ship repair facilities, short-term accommodation facilities and old low-rise houses. So it is quite unpleasant when you walk down the street.



Fig. 3. GIS analysis of Namhang-dong

3. Method

3.1. Ecological Diffusion Strategy

We propose an ecosystem diffusion strategy through first, diffusion of biodiversity in sea and breakwaters, second, diffusion to coast (waterfront), and third, diffusion to idle space in Namhang-dong.

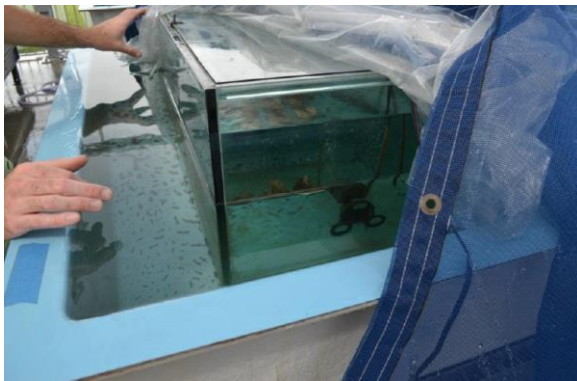
3.1.1 Sea and breakwater - supplement of ecological elements (ecosystem functioning as a habitat for various fauna and flora)



Case of Coral Raise, Ebru Özer

A. Transplanting into the sea after coral form raise

When field-grown coral specimens reach appropriate size and age, they are transplanted into the ocean. Coral plays an important role as natural barriers to help protect coastal cities from the effects of storm. Corals also account for about 25% of the world's marine life. (Nova Southeastern University Oceanographic Center: Phase Landscape – Hollywood, FL - Methodology for Landscape Performance Benefits, Ebru Özer, 2014).



Coral Reef Tank Research Area, Ebru Özer

B. Creature inhabitation in breakwater

The composition and surface roughness of building materials at microscale (<1 cm) have a significant impact on the structure *and* function of colony communities (Coombes et al., 2011; Green et al., 2012). Small breaks (<10 cm) of holes and rock pools in small- and medium-sized (1-10 m) breakwaters provide important havens for many species (Bracewell et al. 2012). The artificial surface of most breakwaters lacks the micro-habitat that can be found on the coast of natural rock (Firth et al., 2013a, b). Therefore, many species using this microhabitat will decrease (Chapman, 2003). Furthermore, if the

material used to make the structure is different from the natural habitat, the sedimentation and survival of the species can be varied and reduced (Davis et al., 2002).

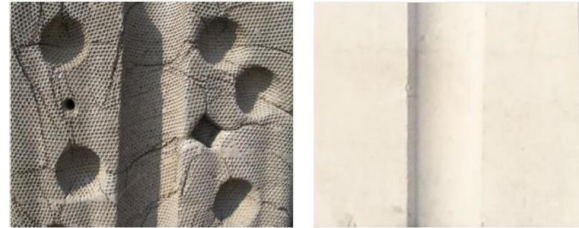
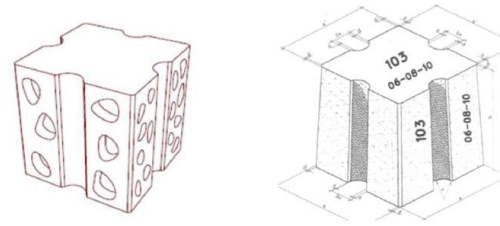
When resident species are more suited to living on gentle slopes, they may not survive on a vertical surface, especially where the waves are severe. Therefore, the steep intertidal zone can reduce the quality of the habitat in addition to the available area, thus the structure of the relevant community is different (Glasby, 2000; Vaselli et al., 2008). So far, little research has been done on the importance of biological habitats in artificial and natural environments. Slabs with low tide height and greater surface complexity have been found to support higher biodiversity (Borsje et al., 2011). This approach relies on the general logic that the habitat becomes richer as the complexity of the habitat increases. Changes in the artificial environment can be implemented for conservation or species diversity. For example, adding a pit to a breakwater increases the limpet *patella candei* (shellfish) as the complexity of the microbial habitat increases (Martins et al., 2010). In the case of The Creation of Artificial Pits on Plymouth, England, Investigated the species richness of No pit and pit (14mm, 22mm) by piercing 14mm and 22mm in 100 * 100cm width on breakwater. The many pit of waterbreak was higher in species richness and there was no difference in width between 14 mm and 22 mm (Between a rock and a hard place: Environmental and engineering considerations when designing coastal defence structures, L.B. Firth et al. 2013).

In the case of Manipulation of the rock sizes in gabion baskets: Wales and the Netherlands, Progressed experience through (1) small rocks (6-10 cm); (2) large rocks (> 18 cm); and (3) rock mixtures of different sizes (between 6 and 18 cm). We hypothesized that gabions containing multi-size mixtures would have a higher abundance than gabions containing only small stones or large stones. As a result, the species richness of the rock mixture was high. (Between a rock and a hard place: Environmental and engineering considerations when designing coastal defence structures, L.B. Firth et al.



2013)
 ECONcrete®Antifers (EA) undergoing deployment by a technical dive team.(Blue is the new green – Ecological enhancement of concrete based)

We investigated the effect of concrete composition and complexity on the biological performance of external structures named Antifers. Increased surface complexity and ecologically reinforced concrete, ECONcrete®Antifers-EA, were compared to standard Portland cement-based devices (StandardAntifers-SA) (Blue is the new green – Ecological enhancement of concrete basedcoastal and marine infrastructure, Sella Ido et al. 2015).

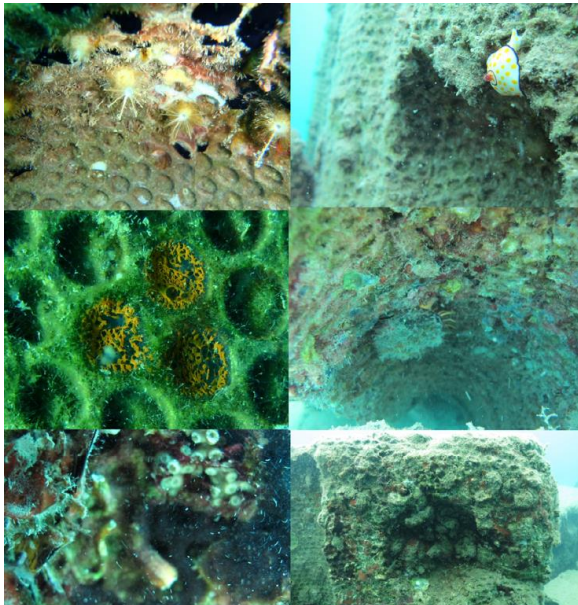


(Left) ECONcrete®Antifer: (EA) with complex concrete surface including holes and crevices, designed to provide shelter and add diverse biological niches into theunit. (Right) Standard Antifer (SA): smooth surface, lacking complexity.



A 30 × 30 cm² quadrat used to monitor the fauna and flora on the ECONcrete®Antifers – left, and on the Standard Antifers – right.

In the EA breakwater, various species(Barnacles, Bivalves, Bryozoans, Coralline algae, Gastropods, Oysters, Sabellidae, Serpullidae, Sponges, Tunicates Colonial. Tunicates Solitary) were inhabited and in the SA breakwater, Turf algae accounted for 80%.(Blue is the new green – Ecological enhancement of concrete based coastal and marine infrastructure, Sella Ido et al. 2015).



Typical live cover of the EConcrete® Antifers (EA), exhibiting diverse benthic assemblage composed of oysters, sponges, tunicates, Sabellidae, Serpullidae, bryozoans, coralline algae and more.

3.1.2 Ecological Diffusion Strate Waterfront ecological design

Busan is a temperate climate and plant trees called ‘southern species’. They are planted in the order of the halibut plants and the plants resistant to salting, spreading from the area facing the shore. Salty plants in the southern area plant *Elymus dahuricus*, *Cynodon dactylon*, *Setaria viridis* var. *pachystachys*, *Carex boottiana*, *Cyperus rotundus* L., *Boehmeria pannosa* Nakai & Satake, *Aster hispidus*, *Tetragonia tetragonoides*, *Sagina maxima*, *Dianthus japonicus*, *Melandryum oldhamianum*, *Corydalis heterocarpa*, *Raphanus sativus*, *Arabis stelleri* var. *japonica*, *Sedum oryzifolium* Makino, *Rosa wichuraiana*, *Eurya emarginata* (Thunb.) Makino, *Oenothera laciniata* Hill, *Angelica*

japonica, *Peucedanum japonicum*, *Lysimachia mauritiana*, *Hedyotis biflora* var. *parvifolia*, *Aster spathulifolius*, *Farfugium japonicum*, *Wedelia prostrata*, *Crepidiastrum lanceolatum*.

Arbor plants resistant to saltiness in the southern area plant *Camellia japonica*, *Pinus thunbergii* Parl, *Pinus parviflora*, *Prunus sargentii* Rehder, *Styrax japonica*, *Koelreuteria paniculata*, *Salix babylonica*, *Acacia catechu*, *Chionanthus retusa*, *Tamarix chinensis*, *Celtis sinensis* Persoon. Shrub plants are *Rhododendron yedoense*, *Euonymus alatus*, *Ficus carica*, *Abelia mosanensis*, *Rosa rugosa*, *Vitex rotundifolia*, *Poncirus trifoliata*, *Ficus erecta*, *Callicarpa dichotoma*. Herbaceous flowers are *Aster koraiensis* Nakai, *Aster spathulifolius*, *Typha orientalis*, *Zoysia sinica* Hance, *Phragmites communis*, *Campsis grandiflora*, *Yucca*.

3.1.3 Design of Idle Space in Namhong-dong

The unused space that is not utilized, are turned into a southern species planting and resting space, and the atmosphere of the downtown is changed brightly. In order to solve the situation, we had to go through the polluted land which caused walking discomfort, and garbage through which we had to go through and uneven gravel sand in order to go to the coastal area. We made it into a small coastal park after washing the soil. And a large area of coastal scrap irons and garbage is transformed into a space where coral farms, skin scuba and snorkeling can be operated.



Case Study of Busan Dadaepo Beach

3.2 Ecology-Human Connection

Through the direct experience of people, we will revitalize the pier of Namhang-dong to strengthen the resilience of Namhang-dong pier. With much interest and volunteer programs, it will increase its resilience. It can be reborn as a new coastal city through experience of coral aquaculture and biological experience (skin scuba and snorkeling) in breakwater. In the case of Okinawa, a project was carried out to raise the gradually disappearing coral and send it back to the sea. This makes it possible for people to participate in the restoration of coral and to enjoy the scuba diving experience.



Coral raise and tourism in Okinawa of Japan

4. Result

4.1 Masterplan

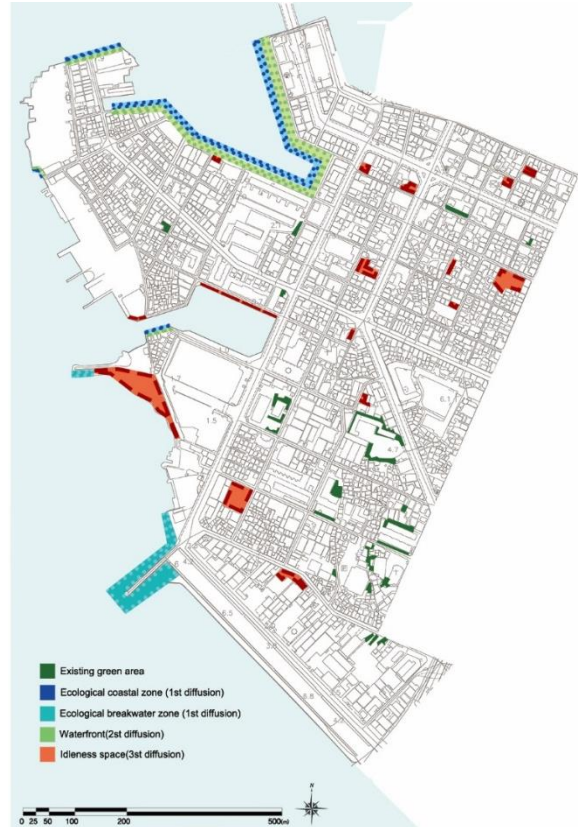
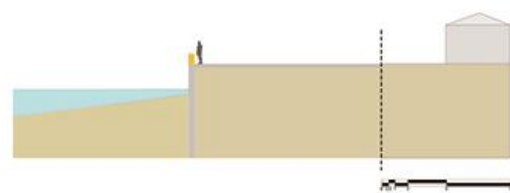
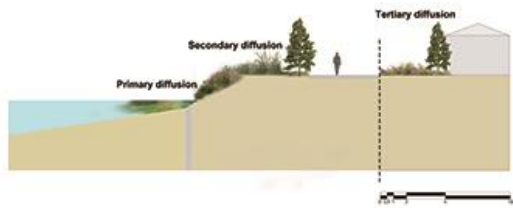


Fig. 4. masterplan

4.2 Section



Present condition



Diffusion

4.3 Change in the green area ratio

Due to the existing green area of 6,930 m², the green area of 14,443 m² through the diffusion of idle space, and the waterfront green area of 10,521 m², Namhang-dong will secure 5% of the green area of 31,894 m² of the total area of 662,634 m². And because of the design of sea and breakwaters to increase biodiversity, the increase in ecological rate is infinite.

5. Conclusion

Now Namhang-dong pier has stopped, but it will lead to the diffusion of ecology through ecological redesign, starting from sea and breakwater to coastal (waterfront) and idle space to revitalize Busan Port, which has a long history. Although only seaweeds exist in the present coastal area, EConcrete®Antifers (EA) breakwater promotes biodiversity and ties coastal waters between the sea and land to link ecosystems through the use of marine plants. If all these ecological re-designs are completed, there will be a numerical 5% real ecological space, and invisible ecological values will be too large to be quantified. And the most important component in reviving a dying city is attracting users. The goal is to provide rich ecological space and resting space, and bring economic value through ecological activities

that can be practiced. Because of its geographical accessibility, Namhang-dong has a resilience to revive quickly if you create a bright city through ecological redesign. Through this design, people will be able to manage the biodiversity without forgetting the history of Busan Port and Namhang-dong, and as a result, it will create a great economic benefit.

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Projected land-use change impacts on ecosystem services in a highly urbanized landscape

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Abstract

Massive and rapid urbanization caused considerable land use changes, biodiversity loss, and habitat fragmentation. To understand the potential impacts to urban ecosystem services, give the suggestions on how to solve the conflict between environmental protection and the economic development, and explore several opportunities on policy-making for the future, we developed a spatially explicit land use change projection for a rapidly urbanized urban region in Seoul 2030. For 7 districts developed since the 1970s in Seoul city, we quantified the interaction of future development on biodiversity maintenance. The Land Use Land Cover (LULC) maps of 1972 and 2015 were employed to predict the LULC scenario for 2030 using Multi-layer Perceptron (MLP-ANN) and Markov Chain Analysis (MCA) method. Then we quantified habitat quality (HQ) as a proxy for biodiversity in 1972, 2015, and projected 2030 using Integrated Valuation of Ecosystem Services and Trade-offs (InVEST) model. The results show the area with high HQ-value and low HQ-value decreased by 35.15% and 27.42%. In Contrast, the area of medium HQ-value increased by 20.93%, while the area of non-habitat increased about 6 times from 1972 to 2015, dramatically. The MLP-MCA-based prediction for 2030 showed that fragmentation of forest habitats would be increased slightly which causes the decrease of the area with high HQ-value. We hope that the results will contribute to an understanding of the potential of future landscape changes based on the ESs concept in green-infrastructure and land-use planning, and conclude with providing some challenges for future research.

Keywords: land-use projection; urban biodiversity, ecosystem services, Seoul 2030

1. Introduction

Massive and rapid urbanization caused considerable land use changes, biodiversity loss, and habitat fragmentation [1]. This situation makes urban planners and policymakers needing to move beyond a

mere management of urban landscape to translate and uptake the concepts of ecosystems functions, resilience, and sustainability into the governance policies.

Ecosystem services (ESs) is defined as the manners in which ecosystems benefit humans. Since Costanza et al (1997)

evaluated the ESs valuation at a global level in a paper published in *Nature* [2], the term of ESs gained broader attention. From 2001 to 2005, the United Nations finished its Millennium Ecosystem Assessment (MA), a four-year, 1300-scientist study for policymakers [3]. This assessment defined the functions of ESs as four aspects (provisioning, regulating, cultural, and supporting) which were broadly accepted and applied by public and professionals. Between 2007 and 2010, United Nations Environment Program undertook a program called the Economics of Ecosystems and Biodiversity (TEEB), which brought ESs to a broader audience through the mass media [3]. Later, Intergovernmental Science-policy Platform on Biodiversity and Ecosystem Services (IPBES) was created in 2012 further enhanced the ability of the evaluation, management, policy application, and international cooperation on ESs.

ESs are still prone to frequent rapid degradation and depletion by multiple natural and anthropogenic disturbances [4, 5]. The Land use and land cover (LULC) changes have been defined as the most important anthropogenic disturbance to the environment at the local level that can greatly alter the provision of ESs [6]. The LULC projection is a useful tool to understand the potential impacts to urban ESs, which give the suggestions on how to solve the conflict between environmental protection and the economic development and explore several opportunities on policy-making for the future.

This study aims to detect the response of ESs to a LULC projection, using

biodiversity as a case study. We developed a spatially explicit land use change projection for a rapidly urbanized urban region in Seoul. For 7 districts developed since the 1970s, we quantified the interaction of future development on biodiversity maintenance. We try to answer these two questions: 1) how did the habitat quality change during the rapidly urbanized period of 1972 to 2015? 2) what will the trend be in habitat quality according to land-use projection in 2030?

2. Methods

2.1. Research Site

South Korea is one of the most urbanized countries in the world, with an urbanization rate of almost 90%. One of the major challenges experienced by Korea was the reduction in biodiversity due to the expansion of population and the loss and fragmentation of natural habitat caused by the rapid industrialization. In Seoul, the

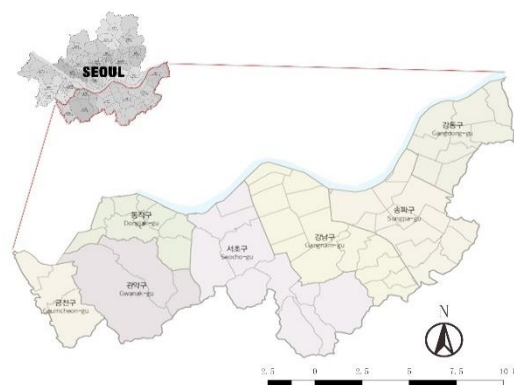


Fig. 1. Research site

capital of South Korea, forest areas cover 24.5% of the city area, and parks cover

2.0%. This study investigated a newly expanding and developing urban area since the 1970s in the southern part of Seoul. A region of approximate 20430 ha in size, including Gangdong-gu District, Songpa-gu District, Gangnam-gu District, Seocho-gu District, Gwanak-gu District, Geumcheon-gu District, and Dongjak-gu District (*Fig. 1*).

2.2. Data collecting

A time series of LULC maps were derived from historical aerial photos with 5 meters resolution. The map of 1972 was digitalized from historical maps and the map of 2015 was provided by Seoul Metropolitan Government (*Appendix 1*); we then standardized and transformed the significant LULC types in the different maps into a common classification using ArcGIS 10.2.2. Finally, 12 re-classified LULC types were created.

2.3. Research methods

This study developed a spatially explicit land use change projection for a rapidly urbanized urban region in Seoul. We quantified the interaction of future development on biodiversity maintenance. The LULC maps of 1972 and 2015 were employed to predict the LULC for 2030 using Multi-layer Perceptron (MLP-ANN) and Markov Chain Analysis (MCA) method, firstly. Then, habitat quality (HQ) was quantified as a proxy for biodiversity using InVEST model.

2.3.1. LULC projection

The LULC change analysis, simulation, and future LULC change prediction were carried out using Land Change Modeler (LCM) for ecological sustainability which is an integrated software environment available in IDRISI. Clark laboratory and International Conservation cooperated for many years and designed the IDRISI. LCM mainly includes MLP-ANN, MCA, Cellular Automaton, and Soft and Hard Prediction Model.

The modeling of potential change was used LULC maps of 1972 and 2015 to simulate the year 2030 (see Appendix 1). Firstly, a transition map was generated for all LULC classes to produce the empirical likelihood of change statistic [7, 8]. Then, six major transitions were considered that was supposed to be possible factors driving LULC change in the study area. The variables used to derive this included nature factors and spatial distance factors, regarding (1) slope, (2) terrain height (DEM), and (3) soil classification as natural factors; (4) the distance from green space edge, (5) the distance from roads, (6) the distance from water bodies (river and wetlands), (7) the distance from the green belt, (8) the distance from urban infrastructure, and (8) the distance from urban core of Seoul city as spatial distance factors.

2.3.2. Assessing habitat quality (HQ) and hotspots through InVEST tool

We apply InVEST model produced by Clark Labs to evaluate HQ as a proxy for biodiversity [5, 9]. The modeling process of

Table 1. Threats table

Threats	Max_Dist	Weight	Decay
agri	4 ^{ab}	0.8 ^b	linear
resi	5 ^c	1 ^c	linear
indu	5.6 ^a	0.8 ^a	linear
van	4	0.4	linear
ruls	4 ^a	0.68 ^a	linear
tran	2.0	0.7	linear

HQ module is based on the hypothesis that areas with higher HQ support higher richness of native species, and that decreases in HQ lead to a decline in species persistence [10]. This study has assumed that the changes in ESs are caused mainly by changes in land usage [11]. The input parameters including the suitability of land use type for providing habitat for biodiversity, the different anthropogenic threats likely impairing HQ [10, 11, 12, 13], and the sensitivity of each land use type to each threat was referenced from previous studies (Table 1) (see InVEST user's guide for further details on this method) [5].

3. Results and Discussion

3.1. How did the habitat quality change during the rapidly urbanized period of 1972 to 2015?

The HQ model result shows the pixel values range from 0.1 (lower quality) to 1 (higher quality) for urban habitat (Appendix 2A). The map result represents the previous and future conditions based on LULC 1972, 2015, and 2030 data. The good quality habitat was mostly in mountain landscape, followed by secondary forest/remnant forest and plantations in public parks. The hotspots

of biodiversity are concentrated in Gwanak-gu and Seocho-gu District both in 1972 and 2015. Most of the hotspots of habitat quality decreased in Gangnam-gu, Songpa-gu and Gangdong-gu District where multiple land-use types are present (Appendix 2B). The reason for this landscape change is related to many various development projects with little consideration on the natural environment in Seoul [14].

We scored the HQ value into four groups: between 0.85 and 1.0 (high), between 0.55 and 0.85 (medium), between 0.01 and 0.55 (low), and 0 (non-habitat) (Fig. 2). During the rapidly urbanized process (1972 to 2015), the area of high HQ-value and low HQ-value decreased by 35.15% and 27.42%. In contrast, the area of medium HQ-value increased by 20.93%, while the area of non-habitat increased about 6 times dramatically from 1972 to 2015.

3.2. What will the trend be in habitat quality according to land-use projection in

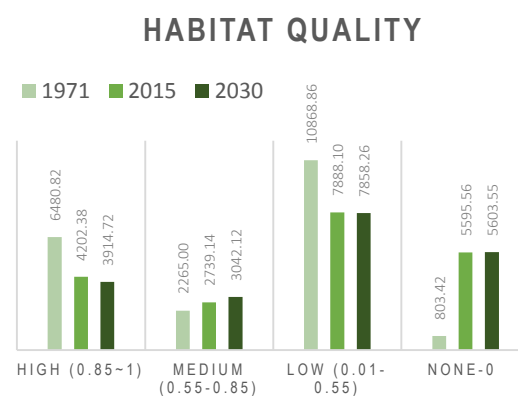


Fig. 2. The area of habitat quality (HQ) from 1972 to 2030

2030?

Habitat for the HQ we modeled showed overall declines under land-use change projection. Till 2030, biodiversity of hotspots shows a decrease in mountain-foot area. The fragmentation of forest habitats mainly causes the decline of the area with high HQ-value (*Fig. 2*). The area of medium and low HQ-value increase a bit, correspondingly.

3.3. The implication for future projection in ecosystem services of Seoul

The conservation of biodiversity is the main biodiversity strategy in Korea. National research organizations specializing in biodiversity and its conservation have been continuously stabled to enhance the research capacity and conservation of biological resources [15].

The 2030 Seoul Plan is the Seoul Metropolitan Government's priority plan for the direction and change to be pursued by the city until 2030 [16]. One of Seoul 2030 plan's goals is to preserve the ecological environments and scenery that are unique to the city, particularly, protecting and restoring the four inner mountains, located within the boundaries of the old capital, and the four outer mountains, which are outside the boundaries of the old capital. The MLP-MCA-based prediction for 2030 showed that fragmentation of forest habitats would be increased slightly. Therefore, the conservation of forest area and careful design of green spaces should be paid attention to in the future policy-making to biodiversity conservation. In addition, effective projects of green infrastructure

should be built to link fragmented habitat continuously on the ground and build a habitat network, such as well-created green rooftops that can support animals and plants extensive and play an important role in conserving urban diversity.

4. Conclusion

This study explored the response of habitat quality to land use change projection in a highly urbanized area, using Seoul as a case study. Our findings indicate that the huge decline of biodiversity happened in a rapidly urbanized period (1972-2015), and this negative situation will be continued according to the MLP-MCA-based prediction for the year of 2030. These findings support a reference to implement the plan of Seoul 2030. The conservation of urban forest remnants and construction of newly formed green spaces should be viewed as essential components in future ecological planning and integrated into biodiversity conservation schemes. We hope that this study will contribute to an understanding of the potential of future landscape changes based on the ESs concept in policy-making, and conclude with providing some challenges for future research.

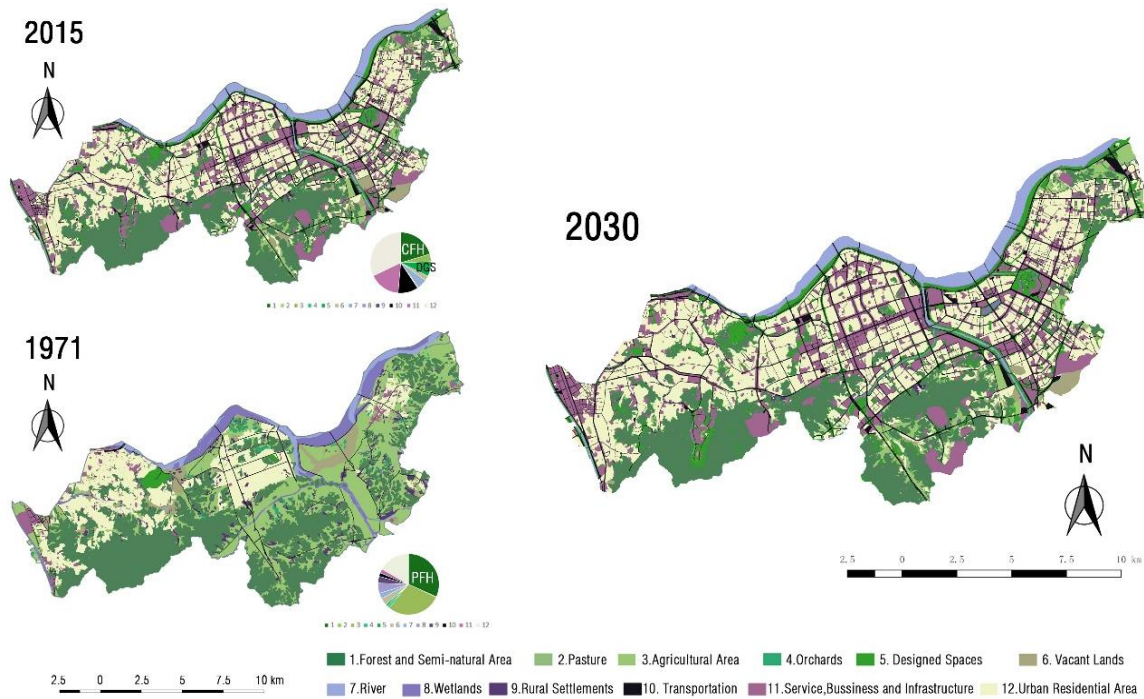
Acknowledgments

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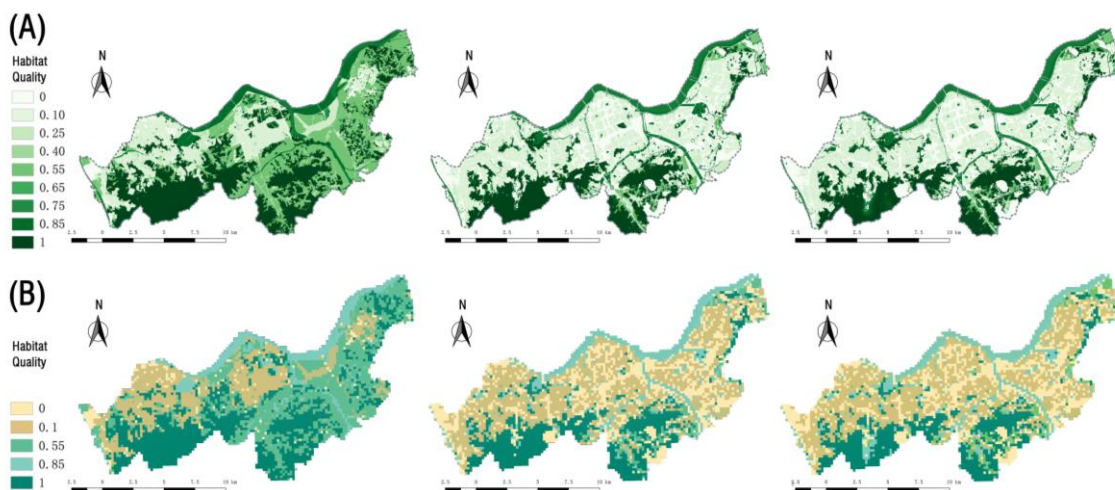
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Appendix



Appendix 1. Re-classified land use and land cover maps of 1972 and 2015; Projected map of 2030.



Appendix 2. Mapping (A) habitat quality and (B) hotspots of biodiversity of 1972, 2015, and 2030.

The San Leandro Creek Urban Greenway in Oakland, CA

Resilient Infrastructure for Retrofitting the Future Biophilic City

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Abstract

This paper presents the efforts of an ongoing community-based “biophilic” infrastructure project that demonstrates future resilience by reclaiming a fragmented and compromised urban creek corridor within East Oakland (San Francisco Bay Area), CA.

The San Leandro Creek Greenway project took shape through the shared vision, engagement and leadership of an applied urban greening studio program at Merritt College working directly with neighborhood residents in the explicit effort to restore community livability by bringing nature back into the fabric of the built environment. This section of Oakland, under-resourced and disadvantaged, is a culturally rich mixture of Latino and African American residents.

Due to historic neglect and the hubris of high-modernism, it is also a community ensnared in concrete, asphalt and all manner of pollution that not only is crippling to habitat biodiversity but leaves this bay-side community extremely vulnerable to sea-level rise and storm-surge inundation. Addressing these cumulative conditions is a sustainability and climate resiliency effort but most importantly for the residents, it is a health and environmental justice issue.

When it comes to green infrastructure investment and initiatives, neighborhoods like these are below the city’s radar. This project highlights though how landscape architects and students successfully collaborated with community leaders to strategize a “bottom-up” design-build approach to transform the neighborhood culverted-watershed into a greenway that can weave together people and place as part of a living environment.

The authors convey how this unique intensive local planning approach not only garnered implementation funding to establish needed non-motorized transit and recreation but also provides residents with new contact to the existent wildlife corridor, spaces for urban agriculture, and infrastructure for floodplain protection and climate adaptation. In a larger sense, this paper illustrates how neighborhood-based urban greening, as a landscape strategy oriented

around the often hidden natural assets of place, can lead the inspirational citywide strategic visioning for a city that is retrofitted for transformative resilience. This is the future “biophilic city” that is rooted in equitable everyday livability.

Key words: community engagement; urban challenges; greenway; retrofitting; creek rehabilitation

1. Introduction

“Trees don't grow to the sky” – the old saying goes. By now, more and more people realize that there is no such thing as limitless growth in a limited system. This is especially true for the world's cities and metropolises. Currently, more than half of our global population is concentrated in cities or in urban areas, and this number is exponentially rising. Today's societies must find a way to make cities, our largest human artifacts, livable and sustainable.

2. Nature and the future biophilic city

Sustainability and urban “greening” approaches, including specific focuses on climate adaptation and resiliency, have been increasingly emerging as critical city development strategies over the last decade. However, these strategies do not necessarily imply how such development relates to nature, people's connection to nature and natural processes. In fact, many sustainable development and infrastructure projects may be applied without any direct engagement or integration with local site “nature” or the ecological health of a site. This marginalization of the conditions of “first nature” in the realm of sustainability planning may be starting to change.

Cities such as Singapore as a celebrated example, are now beginning to showcase urban redevelopment that reflects a deeper ecological understanding and “biophilic” sensitivity with an explicit intent to make

greening more than just aesthetic additions - a move to imagine a 21st C “city in a garden” as a transformation from the 20th C “Garden City” ideals.^[1] Many environmental urban planners, led by the seminal work of Timothy Beatley, are emphasizing the overlap between such biophilic approaches and climate adaptation, sustainability and resiliency planning.^[2] Others are emphasizing the need to be able to interact with nature and natural processes as a fundamental part of our human existence.^[3]; 4]

However, the critical question remains whether new urban eco-greening approaches are putting connection to nature at the core of city planning in just a figurative sense (read new eco-downtown as the latest complement of “smart growth”) or in a literal sense of transforming cities and citywide planning as a whole? Do such developments increase the City's climate adaptation or resiliency or overall sustainability? Are such developments equitable and accessible to integrating people to nature or do they mostly stand as commercialized spectacle? Optimistically, large center-piece urban development projects start the re-imagination of “future biophilic cities” in a strategic way that is compatible with growth. Even if this is true, such eco-greening as urban redevelopment needs to be balanced, perhaps even led, by approaches that provide opportunities for natural process to be woven into the everyday fabric and infrastructure of our urban environment for a deep citywide transformation that is sustainable, resilient and livable.

Consider how thoroughly our current built environments are quite the opposite of the biophilic approach to nature succeeding in suppressing the visible natural processes while our cities remain more unsustainable and vulnerable to climate change even as we claim progress with green architectural gems. Our high-modern infrastructure is built on the logics of domination, suppression and overcoming nature and natural processes – are characterized by urban patterns of fragmentation and social isolation. Despite such logic, our urban landscapes still are place-based and must work together with nature in a dynamic balance. Our cities of grey infrastructure are unsustainable, vulnerable to climate change events like sea level rise, urban heat island effect, storm surges and even cascading social upheavals.

Often, we do not sense the precarious status of this balance until there is an event that overwhelms our systems as we have seen with storm-surge flooding, urban-wild-land interface fires, mudslides and so forth. The current infrastructure, instead of enabling adaptation to stress and shocks, is actually very fragile and dependent on large capital intensive super structures and mobilization of resources on a global-scale to maintain itself. Meanwhile, the urban ecologies of concrete and asphalt landscapes have been unceremoniously denuded of diverse native habitats and place features to be replaced by invasive colonizing monocultures.

Can we retrofit our existent urban infrastructure to integrate biophilic ideas to become more balanced with natural processes and more resilient – an

infrastructure that is about transformative adaptation as opposed to ad hoc reforms? What would such infrastructure look like? What features, and characteristics would it have? How would it affect the ordinary life of urban residents? How can such infrastructure help support local diversity, equity, and organic cultural emergences? To achieve biophilic city planning that reflects the natural processes, makes such processes visible and accessible in different scales; integrates the nature of place with the built environment in a sustainable manner, creates points of shared intimacies of people with the rhythms of place requires the cooperation of landscape architects, city planners, civil engineers, architects, ecologists, biologists, sociologists, but most importantly, involvement of the people living in a place. Such approaches means nothing less than putting standard planning, even in its focus on green development, on its head.

3. Focusing on watersheds and topography – the intersection of people and place

When it comes to natural landscape forms, nothing shapes the topography – the topos – more than water. Water also sustains life of all forms and is the conduit for ecological richness and interaction. Human ecologies are no different. Since the ancient ages, water is the place where we come together and celebrate our conviviality.

After a century of hydraulic engineers' flood control management, most urban creeks and rivers have been channelized, while wetlands and marshes have been filled in and regraded for development. In the

current form of the built environment, site water is often relegated to hidden infrastructure – conduits, culverts and pipes. Springs are obliterated, rivers dammed, flood-plain graded while the new constructed landscapes are dotted with closed-loop water fountains that help attract consumers to glitzy malls and pavilions. This outcome denies residents access to connect with actual site water forms and ecosystems that these features support. [6]



Fig. 1. The San Leandro Creek flows behind fences and dead-end streets that become a target for illegal dumping.



Fig. 2. The creek as flood control culvert courses under the grey infrastructure of freeways and railroad tracks.

The cost of altering the existent hydro-scape is an increased risk of flooding, habitat destruction, and the removal of a key natural asset that many do not even know we are missing. The city with truncated marshland and concretized rivers is far more vulnerable to climate events like hurricanes as we saw vividly with Katrina in New Orleans. The lessons are clear. The topography, exemplified by water and how we interact

with it, cannot be the after-thought after all the buildings and freeways and parking lots are laid – it cannot be what is wedged into to the left-over spaces. These spaces must come first, be valued and protected and supported – be built around. They are the fundamental assets of the place and can be connected with the hidden assets of our communities as well.

With this approach, our aim as biophilic landscape planners is to envision and seed topographical-oriented infrastructure that builds inter-connected conduits weaving together people and place in the city. These living conduits exist already – our urban watersheds. For example, as highlighted in this paper, we focus on designing infrastructure interventions as “greenways” that connect the communities in which people live to the city as a whole. While the term greenway has its roots in the rather staid if not genteel naturalized landscape expression exemplified by Olmsteadian parkways, in our current treatment, they have to be more than just a walking path, a creekside trail and a palette of trees – they are where nature, culture and everyday life can be woven together. [5] They are the emergent structure of the resilient and biophilic city.

This greenway emergence must directly involve the community and the living aspects of a place if it is to resist the unintended consequence of re-colonizing space and the tentacles of a probing capital-growth machine that thrives on the extractive logic of commodifying nature and displacing that which it cannot digest. As a principle, a biophilic and resilient city must involve at all levels protecting the health of its diverse populations and habitats. It is a sad reality that too often the creative rawness of our most poor and disadvantaged communities

are seen as a threat to the social order of the city – to only be policed and managed. Really, such in-situ creativity and the people as creative agents are like the ecological “indicator” and keystone species upon which the health of the macro-community is reflected and predicated. With all of this in mind, our team of landscape architects, planners, teachers and students started working to help establish a watershed-based



Fig. 3. The San Leandro Creek flows across East Oakland as the only remaining entirely day-lighted watershed in the city.

greenway project in Deep East Oakland along the San Leandro Creek – a corner that the city government has essentially bypassed. The residents though began their own neighborhood greening campaign starting in 2007. One of the first projects identified was creating access to the fenced-off creek at the end of 105th Avenue.

4. The San Leandro Creek as a case study

“Greening without Gentrification” reads the flyer. Our team joined by students from Merritt community college meets with a group of residents on this bright fall morning for a series of community conversations and an informal “charrette” to gain a better understanding of what the San Leandro

Creek means to those who live next to it and what their visions entail. We show creek maps, photos of the creek and with note boards, talk about how the creek and the neighborhood could work together. Conversations ensue retelling how this creek has been fenced off, how it attracts trash dumping and other negative activities. But there are more positive stories: of remembered times fishing down at the creek,



exploring and riding bikes as kids, of picking wild watercress and other useful Creekside vegetation. The hum of the nearby freeway straddling the creek interrupts the conversation as the streets rattle with the passing of each diesel truck overhead. On this day we are working with a new group of largely Latino neighbors of Sobrante Park and Columbia Gardens inviting them to be part of shaping the design of the greenway. Merritt College has been taking students down to this creek for the last eight-years to help start the visioning and planning process of how this forgotten creek can become a



Fig. 4; 5. Opening new routes: East Oakland “scraper bike” crew riding along creek towards a shoreline park (right) less than one-mile from where they live though most never visit as it is cut-off by freeways and railroad tracks.

jewel reinvigorating a neighborhood seeking healthy planning solutions to counter the alienation of the everyday struggle in this corner of East Oakland – “one way in and one way out.”

Our classes have been working with small neighborhood groups and community gathering with a direct intention that what emerges from this creek project must reflect, involve, and benefit the residents who live here and not further exacerbate conditions that might make their neighborhood more vulnerable to unwanted cultural or ecological dissolution.



Fig. 6. A resident strolls along a creek maintenance road imagining possibilities.

We talk about existing assets: there are several schools nearby, a church and a new plant nursery. We talk about the existing London Plane (*Platanus x acerifolia*), the few Redwoods (*Sequoia sp.*), Acacias and the Prickly-Pears (*Opuntia sp.*). We talk about how and where the kids bike, the formal and informal paths people use to cut across the neighborhood, and the community enthusiasm for clean-ups and greening projects. We also talk about the deficits, such as the lack of safe, attractive and useable parks. On this day, there is a great reluctance

when the idea of potentially establishing access to a new park on the creek greenway emerges. “This will attract the drug-dealers... it will create an area for criminals to run.”



Fig. 7; 8. Community design charrette for “envisioning the creek”

Residents point out that the existent small Columbia Gardens Park has been thoroughly stripped of its swings and just sits as a desolate patch of unkempt grass and a broken sign. Ironically, the general idea of a creek path is heartily accepted – as long as it is not directly immediate to their backyard – a strange twist to the well-known planning NIMBYism typically reserved for richer

folks fighting against unwanted land-uses. Surprisingly, the idea of improving the current park as a gateway to the creek was supported and soon various ideas were spurred of what this could contain.



Fig. 9. Initial Columbia Park design ideas taken from charrette (designs by D. Bekesi)

As we talked, we were all frustrated by the fact we were locked out of the very creek area we were discussing, only able to gesture to it behind a Flood Control fence. Suddenly, one of the neighborhood residents who lived next to the service entrance to the creek remembered that a County worker had entrusted him with a spare key and decided to try it. It worked and with the group of skeptical residents we excitedly walked back to a tree-lined world where the neighborhood cul-de-sac disappeared, and we stared into the pulsing life of this creek confluence area where it conjoined with another culverted tributary. The place that only moments earlier was resoundingly dismissed as any kind of park looked different in person. The fall leaves littered the ground in a beautiful red and orange carpet, egrets skipped low over the water, and the shimmering rise of the creek water in this inter-tidal zone reflected a long band of impressive murals framed by the gentle sway of the trees. There was silence

and hushed talking. There was a new energy awakened by the nature of the creek. Suddenly, it all made sense about what the intentions of the greenway were. Here was a creek that these long-time residents have never actually been able to get to and only had negative views. This was a hidden asset and they were now ready to help shape it.

Over the next few months, our team took the accumulated community input compiled over the eight-years and packaged a grant funding application to initiate a one-mile design-build phase to what this greenway linking the neighborhood to the Bay could become – a watershed corridor of “organic” place-making, community reflection and inspiration and not the default standardized “off the shelf” style of development that radiates value-engineering and business-as-usual or more focused on bringing in “outsiders” without providing for the “insiders” first. To construct, the project calls for prioritizing resident job-training, education and workforce development in the design refinement and building of the project as well as tree plant establishment for three-to-five -years post construction and on-going resident stewardship. The project also calls to establish places for job opportunities and places for neighborhood businesses.

5. Conclusion

In October 2017, the State of California awarded \$4.1M from greenhouse gas reduction funds to start building this project. The greenway project stood out in its unique level of participatory design and the deep ground work that modeled what co-benefit

urban greening, climate mitigation, and adaptation strategies could look like. On a more intimate scale it is about improving health, increasing resilience, and fostering connections to re-awaken the senses to natural processes, to think about where the water comes from, to think about the steelhead trout spawning in the creek, to feel the totality of earth, wind, water and fire.

As an urban design feature, the greenway it enables people to adventure out to the Bay marshlands, to feel the coolness on a hot day, or the shelter of the tree canopy as a respite from city noises. This project will succeed when neighbors create a connected zone between their gardens, backyard fences and the creek, when kids ride and walk to school, parents go on group exercise walks, the neighborhood boxers come down and do a training regimen, families hold picnics, older couples stroll hand-in-hand, cyclists and joggers pass through with a smile (Appendix 1-4).

At a larger level, the life and soul of the San Leandro Creek's rehabilitation is addressing the current issue of our age: the already-felt climate change and sea level rise impacts and shows how such watershed corridors can operate as a buffer protecting ground areas from critical flooding. This project thus sets the stage for the type of needed "biophilic" investment that can retrofit the city structure for climate resilience and sustainability while improving the health of local residents. While city planners can easily talk about the need for such investments, actually manifesting such projects where they are needed most have not only not been done successfully, they have been not prioritized – losing out favor to big commercial-oriented development projects.

Reconnecting our landscape to the nature of place through under-valued watershed corridors has clear benefits on multiple scales however the push has to come from those people, planners and landscape designers operating closest to the water.

We started this green infrastructure/urban greening project on the San Leandro Creek to re-stitch a broken and fragmented landscape and hopefully to plant a seed for a larger restructuring of the city.

There are eight other of these significant creek corridors in Oakland that connect to the San Francisco Bay. To achieve a transformative adaptation, further watercourse rehabilitation promises to be a good strategic goal and should be carried out along this principle pioneered by the conversion of the San Leandro Creek.

Like water breaking through rock or concrete, this infrastructure will find its path and in doing so, set the stage for a more resilient and biophilic city not just for the future but for the quality of life we are for building now.

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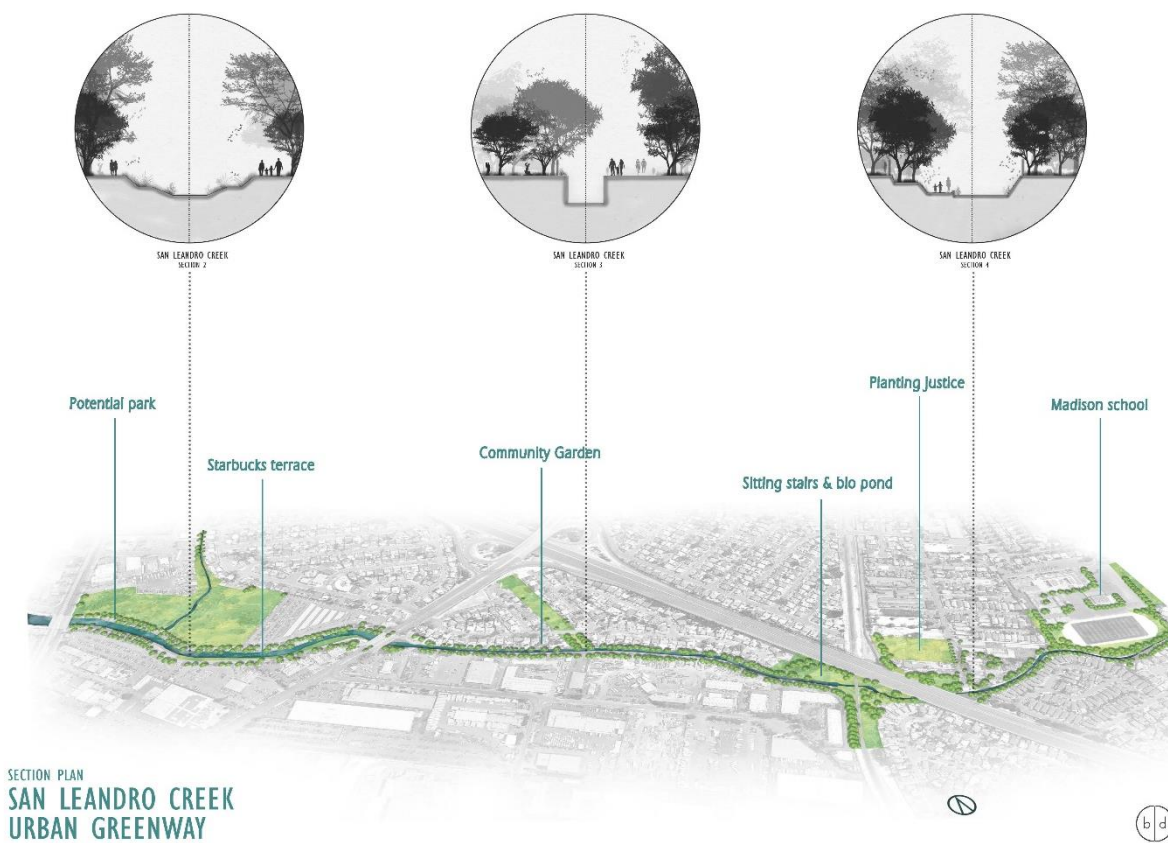
This paper is dedicated to the neighbors of Deep East Oakland and the many classes of Merritt College and the students who have contributed to this project over the last eight-years.

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Appendix



Appendix 1. Overall greenway design connecting (from left to right) a large potential urban-ag park; existing commercial; community gardens; Columbia Gardens Park; creek confluence nature area; to neighborhood nursery and school. (D. Bekesi)



Appendix 2. Example of creekside seating area and trail (D. Bekesi).



Appendix 3. Example of rainbow trout graffiti on the concrete wall (D. Bekesi).



Appendix 4. Example of the trail with information boards (D. Bekesi).

Study on Landscape Development Strategy of Sustainable

Urban Water Cycle

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Abstract

Since climate change has made floods and droughts more drastic, our city often faces the condition where flooding and water shortage are easy to take place. Urbanization has fundamentally changed the characteristics of water, which are gravity flow and cycle process, and has overlooked the comprehensive consideration of the impacts of water management on ecological improvement, comfortable environment, scenic beauty, and disaster prevention and control. Therefore, integration of water management and landscape have become important issues.

Observing the water emitted by the city environment, rainwater and grey water, which were considered wastewater, can be regarded a type of resource. Sustainable water cycle strategy is to consider the space, water, and natural resources for the integration of the urban environment. Developing a sustainable landscape environment through the integration of water management measures with creativity and the urban areas are combined with the development of ecologically balanced water environment in order to ameliorate urban heat island effects and the crisis of water shortage.

This study mainly used the methods of literature research and content analysis to collect theories to serve as the basis of its argument and combined analyses of international cases. The aim was to reduce the reliance on tap water input, transform the construction of impermeable infrastructures, increase infiltration and provide evaporation, optimize urban water cycle, improve the quality of the water flowing back to the environment.

Through the research and development of the strategies for sustainable urban water cycle, it was hoped that the study could promote urban water resources to have multiple uses for people and for the environment, and that it would serve as the reference for practicing sustainable engineering and developing ecological cities.

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Keywords: Water cycle, water management, sustainable landscape

1. Preface

Due to the impact of climate change, the uneven distribution of topographic features, rainfall timing and rainfall areas in Taiwan island have led to the increasing frequency of disasters such as: torrential flows, landslides, urban floods, and shortage of water supply during dry seasons. Moreover, City planners using the traditional urban development model has always neglected the function of water cycle, changes the characteristics of rainfall runoff, and infiltration that has reduced the natural detention capacity and as a result, it has caused the deterioration of water control in urban areas.

2. Issue of current urban water cycle under climate change

The climate warming rate in Taiwan is twice as fast as the global average, and the main hazard arising from climate change is hydro-meteorological disaster, due to such warming affects the delicate balance between water cycle, rainfall, evaporation and all processes in it, which in turn causes the change of the intensity and type of rainfall and the spatial distribution. The phenomenon of excessive dryness and torrential rains possibly caused by increased evaporation along with the additional environmental factors of landscape change due to urban development, have all contributed to the deterioration of urban water resources (Figure 1) which leads to the following issues:

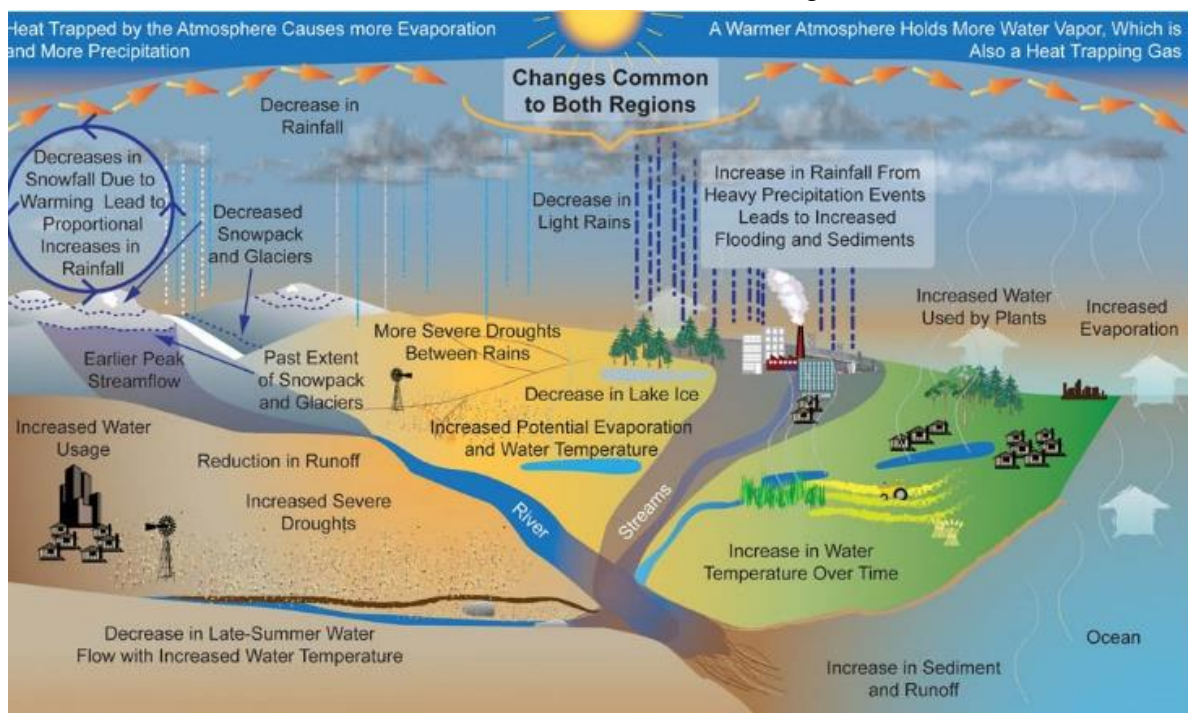


Fig. 1. The changed phenomenon of water cycle caused by climate change Source: <https://www.epa.gov/climate-impacts/climate-impacts-water-resources>

2.1 Water supply affected by uneven rainfall

The warming phenomenon in Taiwan mainly appears in the increasingly uneven rainfall during the dry and rainy season periods. The increased intensity and frequency of extreme rainfall during the rainy season has elevated the risk of flood, while the incapability of keeping water by reservoir system due to restriction of safety management and the lack of rainfall during the dry season have affected the detention of surface water and the groundwater recharge. In return, it has downgrade the supply of water resources.

2.2 Increased probability of high temperature leads to worse problem of water use

Temperatures in urban areas of Taiwan are still significantly higher than those in non-urban areas. Among them, the heat island effect is playing an important role in fuelling the flames. When the temperature rises, people and animals and plants need more water to maintain the health and growth of themselves. When the demand of water increases, gradually, the use of water dispatch becomes more and more intense. As a result, it will face the crisis of water resources shortage.

2.3 Impact on infrastructure carrying capacity

The extreme rainfall caused by climate change often leads to serious urban flooding. The floods are always for beyond the designed drainage system.

For example Typhoon Soudelor, August 2015 brought in a heavy rain of 253mm in 3 hours, that severely damaged the urban flood-water facilities (Figures 2, 3), while the engineering means to improve the frequency of flood protection in urban drainage system design may not be able to accommodate the extreme rainfall under climate change in terms of economic efficiency and time consuming. [1]



Fig. 2. The soared flood of Jingmei River caused by Typhoon Sudeil. Source: <http://www.appledaily.com.tw/realtimeneews/article/new/20150808/665238/>



Fig. 3. The flooding of Fuzhou City caused by Typhoon Sudeil. Source: <http://www.appledaily.com.tw/realtimeneews/article/new/20150809/665974/>

2.4 End treatment concept leads to rainwater is treated as waste water

From the perspective of the construction of urban water resources facilities, the intricate network of pipelines constructed that carries water to urban premises, in which the used water will be transferred to a sewage treatment plant and then discharged to the ocean via a series of underground sewage pipelines. In the meantime, the relatively clean rainwater under the current concept of centralized end treatment often leads to the lack of water infiltration and interception to earth soil. In addition, due to the promotion of the collection and transportation of pollutants, rainwater is treated as waste water to hydrate the lands under natural water cycle and as a result, it destroy the capacity of ecosystem to recover or compensate. We must re-think the functions and benefits of water cycle in order to let it balance and restore the ecological environment!

3. Case study

3.1 Case of Sidwell Friends School

Sidwell Friends Middle School was completed in September 2006 and was awarded a LEED Platinum rating in March 2007,(Figures4,5) The innovative stormwater management systems included both an on-site constructed wetland treats wastewater and green roof and outside bio-retention that reduces stormwater runoff and improves the quality of infiltrated runoff. After first flowing through a treatment tank to remove solids, the wastewater is treated using biological processes. These

constructed wetlands treat wastewater to the same standards as the municipal system but due to health codes, the water can be reused only in commodes. Models show that the building uses 93% less District water by treating our sewage in the wetland and reusing the water, as well as through water-efficient landscaping.

The planting design was inspired by this ecological context. Peripheral areas were converted from lawns to "micro-restoration areas" intended to showcase native ecosystems such as oak-beech woodlands and wet meadows. More than 80 kinds of plants in wetland garden. So Aquatic plants, water, sun, soil, microorganisms, sand, and air filter and clean the water.



1. Existing Middle School
2. green roof;Trickle filter with interpretive display;
3. Wetlands for
4. wastewater treatment;
5. Rain garden;
6. Pond;
7. Outdoor classroom;
8. Butterfly meadow;
9. Woodland screen at neighborhood edge;
10. Playground.

Fig. 4. The configuration map of Sidwell Friends School, Washington, USA Source: <http://pruned.blogspot.tw/2009/06/wetland-machine-of-sidwell.html>

Also using plant species that are drought resistant and able to thrive naturally in the area eliminates the need to irrigate, saving water and energy. Planting native species and non-invasive adaptive plant varieties preserves local biodiversity.

The goals of the master plan were to integrate educational opportunities into the campus landscape. The aesthetic proposition was to feature a traditional academic quadrangle while turning its focus outward to the natural world and its systems. Integrated water management solutions into the landscape, inextricably linking the building to its site. The wetland becomes a “working landscape”; in their dirty, smelly, real-world engagement with the landscape, using biological processes to clean water while providing students with a vivid example of how such systems work in nature. This “working landscape, wherein natural processes are co-opted into a cybernetic amalgam of landscape, architecture, geology, biology and institutional pedagogy.

3.2 Case of Dockside Green Community, Victoria, Canada

Located in Victoria, British Columbia, Canada (Vancouver Island) and covered with seven hectares, the Dockside Green community is the world's first platinum-certified community (Figure 6). In addition, it was rated as one of the ten sustainable and green building demonstration programs by the American Institute of Architects (AIA). The first phase of the project was completed in July 2008 with an overall construction project including residential buildings, commercial buildings, sewage treatment plant, and thermal energy plant.

Dockside Green's rainwater management is designed to mimic the natural hydrological cycle, in which the rainwater is filtered through roof greening and grass ditches, and it adopts visible open water and small waterfall designs to replace the grey rainwater pipe design. Through the processes of rainwater gardens and native plants,

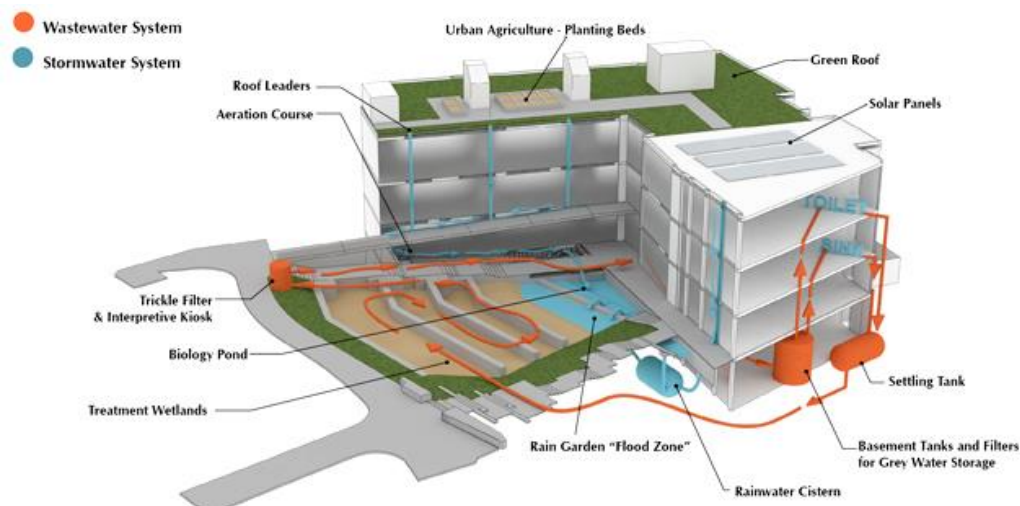


Fig. 5. Schematic diagram of the reclaimed water system for at Sidwell Friends School in Washington, USA Source: <http://pruned.blogspot.tw/2009/06/wetland-machine-of-sidwell.html> this study

been designed as a public recreational space. It can



Fig. 6. General layout of the Dockside Green Community in Victoria, Canada. Source: <http://www.pwlpартnership.com/our-portfolio/planning-urban-design/Dockside-green-development-master-plan>

rainwater is stored in underground water storage tanks or flows into central artificial rivers to facilitate it to be integrated into the water recycling system. All collected rainwater can be reused for irrigation and toilet flushing, and its rainwater management measure adopts infiltration and treatment design of ecological greening. This not only reduces impervious paving surfacing, slashes storm runoff, restores the ecological functions of the site, creates a diversity waters features landscape, and enriches green planting. It will provide the community a vibrant landscape serve and eases the urban heat island effect as well.

The artificial rivers in the center of the community is the core belt for development, which serves as a barrier between the public and private spaces, providing places for children to play and for environmental education, it will also serve as habitat for local wildlives, ducks, crayfish, Ardea herodias and otters, etc. This model has increased the value of the “water front area” residential units. More important, as the sewage treatment plant is located at the center of the site and the outdoor terrace has

jointly serve as an environmental education demonstration site for on-site treatment and resource recycling.



Fig. 7. Central Artificial River and Residential Source: http://www.solaripedia.com/13/247/2607/dockside_green_water_feature.html

4. Suggestions for the sustainable water cycle and landscape development strategy in the city

When a city has changed its water cycle for city development, it should re-face the

falling raindrops and change the thinking about the urban system only on the implement of discharging rain and sewage. The paper put forward suggestions as follows:

4.1 Continuing the natural water cycle model to return to the function of the ecosystem

Strategies of the urban environment in response to the warming phenomena is to maintain more water in the environment and allow the city to integrate into the natural circulation of water: the processes of flow, infiltration, filtration, sedimentation, and purification, the opening of closed rain drainage pipelines and impervious pavements in order to strengthen rainwater storage and infiltration facilities for reducing surface runoff and drainage pipeline load. At the same time, the concept of centralized sewage treatment in the past should be changed, and local water use and source treatment methods should simulate the natural water cycle model in water transport, recovery, and utilization of the city in order to reduce runoff and increase Permeability so that to increase the evaporation amount of the metropolitan environment, reduce surface temperature and increase the comfort of the city.

4.2 Developing a sustainable landscape environment through the integration of rainwater and Wastewater management measures with creativity

The current urban rainwater sewerage project should consider the cooperation of

urban landscape and greening as well as integrate the ecological landscape facilities of the purifying function into the rainwater and Wastewater purification design, so that the organic substances and nutrients of phosphorus and nutrients in the city's sewage can be circulated on the spot to nourish urban planting greening in order to create a green eco-city landscape. It is suggested that the landscape engineering method shall be based on ecology and natural life and select appropriate construction materials and measures to reduce the ration of cementation and hard paving, so as to gradually transform into a sustainable urban landscape environment system that integrates with the ecology, and thereby facilitate the urban construction technology engineering method to return to the original value of nature. Among them, the water cycle is also an important process of ecological diversity and climate regulation, which will enable the restoration and reconstruction of the environment landscape and improve the water management mode from the remote input and output.

4.3 Creating regional water texture and imagery

Through the construction and pavement of land preparation and road facilities, the landscape is often altered in the course of such transformation, and the original hydrological context is erased as well, leading to multi-faceted environmental issues and the change of landscape. However, "water" is an important design element for activating the urban environment. Although the water space of

point distribution can achieve local environmental improvement, if the water network can be implemented through water management measures, the ecological environment not only can become more rich and stable, the water governance can also be integrated into urban planning strategies so that to create a landscape ecosystem and form an urban open space system. In this way, not only can the urban environmental comfort be improved, but the transformation of urban construction can also be promoted, and the rich ecological benefits of the natural environment can thereby be returned to the city.

5. Conclusion

Sustainable water cycle strategy is to consider the open space, water, ecosystem and natural resources for urban environment. Through the integration of landscapes, architecture, soil geology, environmental protection, ecology, and education, it regulates and simplifies the management of the dirty and smelly metabolic wastes in urban water systems into urban water cycles

and reverses the traditional practice through on-site processing methods as a perpetual and recyclable resource for the environmental landscape. Our management of the water environment should be based on regional circulation to reduce the pattern of reliance on external input, and to integrate landscapes and natural elements through continuous regeneration cycles in order to maintain the ecosystem and enhance the environmental quality.

6. Acknowledgments

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Flood Resilience through Learning from Experiences – A Case Study of a Frequently Flooded Village

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Abstract

Despite resilience increasingly comes to be an important goal for many cities, both the definition and implementation of this concept remain vague. Although recent flood resilience literature general emphasis that city as a complex social-ecological system should adapt to flood, current flood risk management still highly relies on hard measures and people's risk perception remains low for an extended period. To improve people's capacity of flood adaptation, this paper constructs an argument that, in flood-prone cities, urban and landscape design should accommodate with flood and make space available for citizens to experience and learn from it. This research is based on a case study of the Xinnongcun village, which is a frequently flooded village and located in the west of Wuhan city China. To explore what kind of knowledge can residents learned from past flood experience, I propose data collection through semi-structured interviews with local households and observation in site. Findings illustrate that people with more experiences of flood will hold more tacit knowledge of adaptation. In addition, with continuously observing flood level changing, fear of flood event will be diminished, which also reduce the losses during emergencies. Learning from the village, this paper suggests that urban and landscape need to be designed with resilience thinking, including designing for multifunctional space and promoting people's interaction with floods, through which the flood adaptive capacity of citizens can be improved.

Keywords: Learning; flood resilience; tacit knowledge; transformation

1. Introduction

Globally, climate changes have caused impacts on natural and human systems [1]. Floods are the most frequent hazards among all natural disasters, resulting in widespread devastation, economic damages, and loss of human lives [2]. Due to urbanization, population density in flood-prone coastal zones and megacities is expected to continue growing [3]. This future megatrend emphasises the need for better flood-risk mitigation approaches. However, it is believed that traditional flood control infrastructures are unreliable to protect cities, especially after the case of Hurricane Katrina [4]. Thus, a new approach to design and plan for flood-resilient cities is increasingly important.

As resilience increasingly becomes a buzzword, extensive studies propose that resilience could be achieved through a professional design and urban planning practice. Some researchers consider green infrastructure as an effective approach to achieve flood resilience. For example, Lennon, et al. [5] outlined green infrastructures as a means for achieving urban resilience to flooding by providing a design response focused on the receptors of flooding and the pathways by which floodwaters reach these receptors. Ahern developed a 'safe-to-fail' framework [6-7] and stated that use of green infrastructures can be a strategy to improve urban resilience capacity. Other scholars focus on flood resilience through architecture design. For example, the United Kingdom published a flood resilient-construction guideline which laid out design strategies for new building

construction [8]. The New York Department of City Planning released a guidance [9] for flood-resilient architecture. In general, the current discussion of flood resilience design mostly focuses on expert knowledge. Local knowledge, regarded as the source of social-ecological resilience [10] was ignored in design practice, however. Furthermore, there are very limited works on how to operate flood resilience at a street or neighbourhood scale.

Learning is an important pathway to provide adaptive capacity that enhances and builds resilience [11]. In this regard, this research argues that learning from flood experiences is essential for improving flood resilience. Based on Argote and Miron-Spektor [12] organizational learning study, this paper refers to learning from floods (LFF) as the accumulation of flood adaptation knowledge that occurs during or after an organisation experiences flood events.

In the rest of this paper, a brief review of resilience with learning will be presented. Second, the background of the Xinnongcun village, where the fieldwork has been done, will be introduced. Third, this paper discusses the results of the fieldwork transforming a village from suffering from floods to tolerating floods. After that, the advice for urban street design for flood resilience will be suggested, followed by a discussion of learning from experiences and a general conclusion.

2. Resilience and learning

The recent discussion of resilience always goes back to Holling's research [13] in 1973 which challenged the classic equilibrium

paradigm in ecological research. Because ecosystems and social systems were considered to be interrelated, resilience later was brought into a larger context and discussed with social-ecological systems [14-17]. Social-ecological resilience emphasizes the ability to adapt to disturbances and to transform once the current state can no longer exist. It addresses disturbances as opportunities to learn from experiences [18]. Based on Holling's ecological resilience study, flood resilience was defined as *'the capacity of the city to tolerate flooding and to reorganize should physical damage and socioeconomic disruption occur, so as to prevent deaths and injuries and maintain current socioeconomic identity'*. [19]

To enhance resilience, recent research found it is important to identify the 'source of resilience' [20]. In this regard, learning and knowledge are increasing linked with resilience as knowledge represents an important determinant of adaptive capacity [21-22]. Adaptive capacity is the main factor in a system that influences resilience [18]. To improve the adaptive capacity of the system, it is important to improve the learning cycle through which humans directly experience and receive ecological feedback from their actions [23]. Gunderson stated that successful management for resilience should contain a learning-based approach that allows for the accumulation and periodic testing of knowledge [24]. Nykvist and von Heland proved that accumulated experience held by the community play as an important source for general and specified resilience [25].

3. Background of Xinnongcun Village

3.1. Uncertain flood risks

Xinnongcun is a small agricultural village located in the middle of Dujiatai Flood Diversion Area (FDA) (Fig. 1). FDA refer to rural areas or polders which could be used to store and transfer floodwaters in emergencies so as to lower the river water

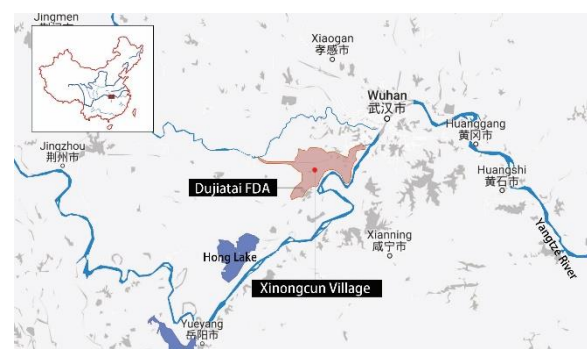


Fig. 1. Location of the Xinnongcun village.

stage and protect nearby cities. The Dujiatai FDA is situated in the west of Wuhan and was constructed in 1955. There are about 180,000 people and 29 townships inside the Dujiatai FDA. The FDA aims to divert floods from the Han River to the Yangtze River so as to control the water level in Wuhan and protect the city. Up to now, the Dujiatai FDA has been used 21 times and most of the time, the flood diversion causes severe economic losses and injuries. For example, in 1984, the Dujiatai flood diversion resulted in 56,700 hectares of farmland ruined and 8,000 people relocated inside the area. In 2011, the flood diversion destroyed about 5,000 hectares of farmland and resulted in 1,700 people with no annual income [26]. Villages inside the Dujiatai FDA suffer from the uncertainties of flood diversion.

3.2. Research method

Two fieldtrips to Xinnongcun were taken in June 2017 and February 2018. This research adopted the focus group interview as the data collection method. Ten group interviews were organized in the front yard of 10 houses. Residents who lived in the village for more than 30 years were encouraged to participate. Both homeowners and neighbourhoods joined in the discussion. Each interview lasted 30–60 minutes with questions focusing on participants' perception of the flood, living experience in the drought season, and living experience during the flood. Field observation also was conducted to record their living environments.

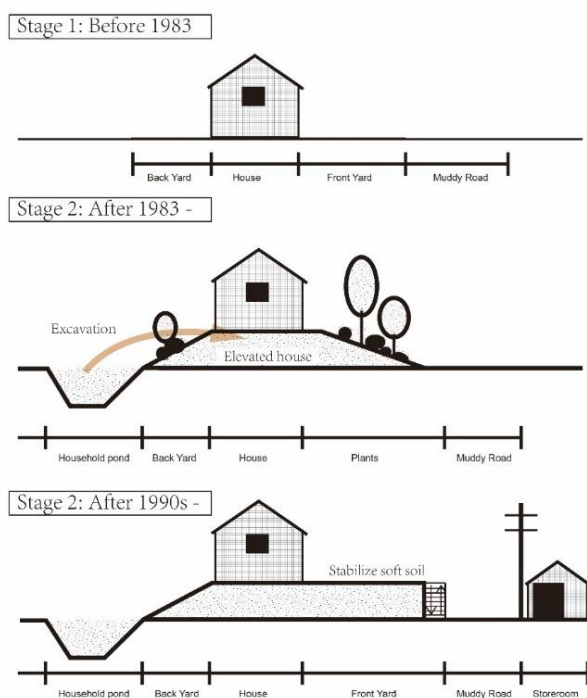


Fig. 2. Three stages of the village street transformation.

4. Findings

Until 2017, the village consisted of 100 households with about 400 people. Most people that lived there migrated from the west Xiliuhe town in the 1970s to escape hunger. Before moving into this area, people had no experience of floods. This research found, however, that after having experienced flooding more than 10 times during last 50 years, locals' perception of flooding, the street form and lifestyle have changed to adapt to the uncertain flooding.

4.1. Perception of flooding

People living in Xinnongcun village now hold a high awareness of flood. The villagers call flood 'Wushui', which means 'inundation'. Local villagers evaluate the risk of the flood according to whether the flood inundates their agriculture land and houses. They believe flooding between June and July to be the most serious as this is close to the harvest season but flooding after September (after the harvest) is relatively acceptable as it will not cause too many losses. The interviewees also said that the fear of flood has been reduced because of many experiences with flooding. They understand that floods are inevitable, and they must live with it.

4.2. Street transformation

Besides changes in the awareness of flooding, to mitigate hazards, the street form has been transformed to be more floodable. This paper summarizes the three stages for street transformation (Fig. 2). In the past, when people initially migrated to this area without any experience of floods, houses



Fig. 3. Streetscape of the Xinnongcun village.

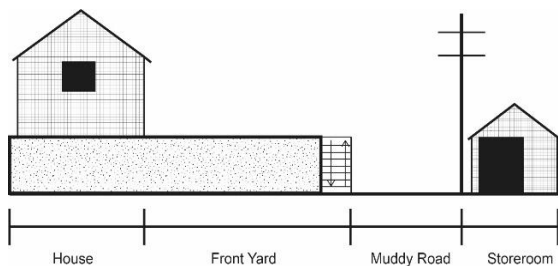


Fig. 4. The section of the street. There are four main elements: 1) The house for people living; 2) Front yard for communication and agriculture products processing; 3) Muddy road for transferring to other places; 4) Storeroom to store the tools and the boat.



Fig. 5. Extra shelf for storage during the flood.



Fig. 6. The self-organized house structure which provides extra space for safe storage during the flood.

could have a thatched roof, front yard, and backyard. For most households at that time, there was no preparedness for floods. As a result, houses directly exposed to floods suffered huge losses. In 1983, the severe flood produced waves and collapsed almost all the buildings in the village.

In the second stage, a typical house is characterized by an elevation base, backside pond, and front trees. The flood in 1983 was a turning point for the village transferring to this second stage. After the flood ruined houses in the village, local people reconstructed buildings at the same site. Considering the past flood level, however, houses were elevated with soil excavated from the backside of each house. The excavation area later became a family pond that some used to raise poultry and grow lotus. At the front, trees were planted on a soft soil base to avoid erosion. Most interviewees believed the reconstruction effectively helped them avoid being inundated. Until the last field trip in February 2017, some poor households in the north of the village remained at this stage while other better-off households (most households in the south) shifted to stage 3 with a structurally stronger house and foundation.

The third stage is the current street form, which is also the most interesting one. As shown in Fig. 3 and 4, there are four key elements. The first element is the living quarters which are situated 2–3 meters above the main road. The difference between the second and third stage is that, for some houses that remain subject to inundation, the owners further improved the building structure to make it more floodable with two tips. Firstly, to reduce loss, the

were built at ground level. A typical house

households self-organized two extra spaces for safe storage during the flood (Fig. 5 and 6). Homeowners used to keep water-sensitive products such as fish feed, fish drugs, and clothes inside. Secondly, in the past, the wall of the house was made of clay soil, which is very fragile to flood. After clay walls were destroyed by flooding, homeowners rebuilt houses with stronger concrete (Fig. 7).

The second element of the street is the front yard, the most active part of people's daily life (Fig. 8). The width of the yard ranges from 3 to 5 meters. The yard offers different functions supplement to the houses. First is breeding. Most front yards used the clay soil excavated from their agriculture land as a foundation. These clay yards not only provide space for livestock but also is



Fig. 7. Reconstruction house with concrete rather than clay.

used to raise little insects and seeds which could be served as food for chickens and



Fig. 8. The connected front yards in Xinnongcun village.

other poultry. Second, it acts as a communication place. Walking in to the village, the researcher found that people like to sit in the front of their yard smoking, talking, or just watching. Local residents say that the front yard is popular for family talks, neighbourhood meetings, and children playing. Third, the front yard serves as a traffic network. This function appears when floods submerge the lower muddy road. Although front yards in the village are mostly connected, in the drought season this place is quite private, and people used to travel on the lower muddy road on motorcycles. When the muddy road is inundated, however, the connected front yards are transformed into a public space that everyone can walk and cross (Fig. 9).

The lower level of the street includes elements of the muddy road and a storeroom (Fig. 2). The muddy road is the main road of

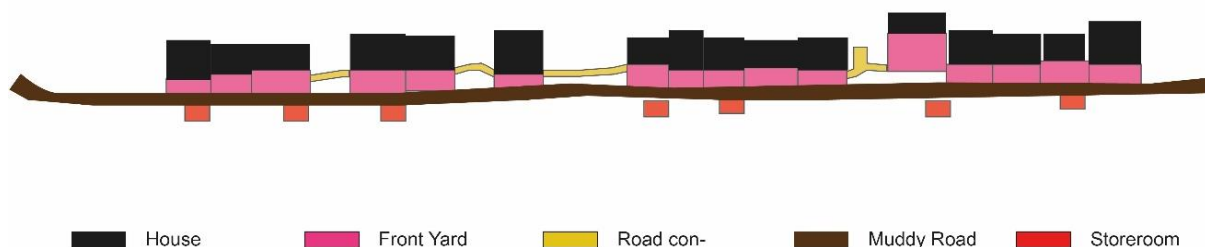


Fig. 9. Spatial pattern of the Xinnongcun village. The front yards of each house was connected together to act as traffic network during flooding.

the village that connects to the nearby town. As there is no public transportation service in the village, each family used to have a motorcycle. The school also is far from the village, and a school bus picks up students every day. Moreover, the muddy road is also a very important ‘economic network’ because local farmers need to use this road to sell and transfer their fish and crops. Finally, the last element of the street is the storeroom. People use this room to keep their fish feed, motorbike, boats, and other tools. The storeroom not only exists near the muddy road, some families locate it in their backyard.

4.3. Living style transformation

The transformation of the street form also associates with changes in residents’ lifestyles. Before 2000, local people relied on agriculture and mainly grew crops, corn, soybeans, and cotton. Because of the uncertain flood diversion and water logging in the farmland, however, local people felt the pain of living on unreliable farmland cultivation. Although their agriculture land was not inundated every year, once a flood occurred, all the farm products would be destroyed. Therefore, after the flood diversion in 2005 which inundated the village’s entire agriculture area and resulted in no harvest, local people started thinking about alternative ways to use their land and make money. About 80% of the local households reached a consensus to ‘renovate’ their agriculture land into fish ponds. Compared with growing crops, fish farming is more ‘flexible’ as collecting fish is much easier and faster than traditional agriculture land cultivation during flooding. One interviewee said,

‘如果是养鱼的话，在洪水来之前我们至少还会抢收到一些。如果是种庄稼的话，那就淹了什么都没有了。’

‘Anyway, we will collect some fish before the flood level rising and submerge the fish ponds. However, if we grow in agriculture land, everything will be washed away and we will have no harvest during that year.’

5. Learning from the case

Communities never control conditions that affect them, but they hold the ability to change many of the conditions that can increase their resilience [21]. Learning from this case, the community’s ability to tolerate floods can be increased by understanding the flood regime and modifying the living environment. In cities, increasing flood risks, coupled with climate change, already has given some urban design concepts opportunities to take flood-risk management into account, such as a water sensitive urban design, low-impact urban design, sponge city, etc. This paper summarizes two principles learned from this case. Firstly, the urban street needs to be designed as multifunctional. Secondly, the urban street needs to keep connectivity during floods.

5.1. Multifunctional

The urban street is a place where people live and work. It is complex, and its functions are highly mixed. Multifunctional use is efficient and economically can be fulfilled by combining functions, stacking,

or time-shifting [6]. Stacking refers to operating different functions in the same space independently or in a complementary manner. Time-shifting refers to using the same spatial location but at different times. In Xinnongcun village, front yards were self-organized by local villagers to adapt to both drought and flooding. People in the village applied both stacking and time-shifting strategies to use the place and concern about floods as a part of its street life.

The practice of multifunctional design in urban areas always is associated with green infrastructures, which often are a hybrid of artificial ecosystems and built infrastructures. Many authors [27-29] emphasise the importance of considering nature in the design process; this can bring benefits of the ecosystem service into human practice. As urban streets keep functioning during flooding, modern cities can include ecosystem service within the street design. For example, Portland's 'Green Street' programme integrates storm water infiltration, pedestrian, automobile transportation, and parking in the street design.

5.2. Connectivity

Ensuring streets connected with the city is essential during floods. Learning from the village, there are two key points that could support the street connectivity – aboveground pedestrian walkways and alternative transportation. Aboveground pedestrian walkways refer to the village's upper-level private front yards which become pedestrian paths during flooding. To practice this principle in urban street design, it possibly could be a temporary pedestrian

walkway, such as the temporal bridge constructed in the Nanyuan residential area in Wuhan city that supports residents' daily movement during flooding.

Alternative transportation also aims to keep mobility. It is dangerous to drive a car during flooding as drivers may get injured when cars hit pools, stall, and get stuck. In this case, people used to drive motorbikes during drought season but transfer to traveling by boat during flooding. Although developing alternative transportation for flooding is difficult to achieve in compact cities because of density, safety problems, and many other issues, this is valuable to help the city to tolerate and transfer to live with floods. For example, in Chennai, India, a local taxi operator Ola tried to provide boat services for residents. Although this service was offered only to rescue people in the waterlogged areas and take them to safer places, it potentially could be developed to be a daily service during a flood.

6. Flood resilience through Learning from experiences

So far, the case reveals that a flood-resilient street needs to be multifunctional and keep connectivity during flooding. Both principles are built on the fundamentals of learning from flood experiences. Learning from experiences helps people to understand the flood regime, such as the inundation area, flood level, flood speed, and duration of floods. This later contributes to the selection of functions such as stacking of front yards, the height of house elevation, and a potential area for aboveground pedestrian construction. Although the development of a mathematic model allows the calculation of

relevant data, simulations cannot capture the complexity of the real situation. Furthermore, people's reaction during flooding also cannot be simulated.

Learning is essential in responding to uncertainty [15]. Flood resilience requires either the 'ability to tolerate flood' or the 'ability to reorganize' when physical damage and socioeconomic disruption occur [19]. In this case, although floods still result in disturbance to the village, the ability to tolerate floods has been improved greatly compared with the 1970s when people had just moved into the area. The three stages of street transformation reveal how learning from past experiences has improved the village's capacity to tolerate floods (such as the self-organized street form, interior design, and lifestyle changes). The knowledge the people learned from experiences and applied to improve the capacity for tolerance is tacit knowledge [30]. In this study village, tacit knowledge was developed from long-term living with floods. This is opposite the cases in modern cities where people always lack experience with floods. Flood control not only reduces flooding but also prevents people from learning from experiences. Thus, to enable communities to learn from flood experiences requires a paradigm shift from flood control to flood adaptation [19, 31]. Without learning from experiences, it is unlikely that communities can test their capacity to tolerate floods and develop the knowledge for flood resilience improvement.

7. Conclusion

In this paper, I discuss a case study of a street formation in a frequently flooded

village. The four elements (storeroom, muddy road, front yard, and house) work together to sustain the normal life under the uncertain flood risks. The village reflects a different way of street formation – learning from the floods and then developing a response and practice. The street pattern of the village is more likely to be shaped by floods rather than professional human design. Learning from this case, this paper develops two principles which may contribute to designing flood-resilient urban streets – multifunctional use and maintenance of connectivity. Multifunctional use refers to integrating the function of accommodating floods into the urban street design. Maintaining connectivity aims to keep the flood area connected with other parts of the city to reduce the impact of the flood. This study argues that to improve flood resilience, communities need to learn from experiences and develop tacit knowledge.

Moreover, based on the case study, I found that to adapt to flooding, only designing a floodable streetscape is not enough. People's lifestyles and awareness also need to change and adapt to the flood process. For example, the village shifted from a farmland-based economy to a fish pond-based economy. Almost all the people who live in the village can swim and drive boats. More research needs to be conducted to determine how people in the cities can work and live during floods.

The outcomes of this paper represent the basis for the next stage of my research, which aims to understand how people can learn from past experience of flooding. In the next stage, more fieldwork will be planned, and the final goal is to provide flood

resilience guidance for urban planning and design.

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Implications for urban biodiversity conservation and planning: Is urban green infrastructure a gateway for improving bird biodiversity?

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Abstract

Urban Green infrastructure (GI) refers to the network of different types of green spaces that enables delivery multiple ecosystem services, not only in regulating stormwater but also in providing the diverse urban habitats. The development of green infrastructure has been advocated as an effective way of alleviating the threaten loss in biodiversity by providing the physical basis for ecological networks and maintaining the integrity of habitat systems. Birds play an important role in urban biodiversity conservation, while the urban environmental variation of habitats has an impact on the avian diversity and abundance in many ways. However, it has not been clear how to maintain the biodiversity of urban birds and what kind of GI structures and characteristics that are relatively important for improving avian diversity and abundance. We selected 17 representative GI spaces in Chengdu, including urban parks, rainwater gardens, green corridors etc., using avian diversity and abundance as proxies for evaluating the functionality of three types of GI structure (corridor, node and net). Besides, we analysed the relationship between GI characteristics, adjacent landscape, human disturbance and urban avian species abundance using Canonical Correlation Analysis (CCA). Our results showed that avian species abundance varied greatly in different GI structure types. GI of nets and corridors were higher in bird abundance, while GI of nodes were highest in avian diversity. Avian abundance was most significantly associated with vegetation cover at the adjacent landscape level, and was not significantly correlated with human disturbance according to our research. Different avian species showed greatly different preference in GI characteristics and human disturbance. Species, e.g. *Pycnonotus sinensis* and *Aegithalos concinnus* were inclined to the urbanized environment, while species like *Turdus merula* were sensitive to human disturbance. Based on our research, we proposed the following suggestions on GI designing and planning for landscape architects: (1) GI spaces should consider the connectivity of GI network, taking advantage of GI nodes and corridors that provide crucial stopover sites for birds to move among urban greenspaces; (2) GI spaces should have the largest possible area and contain a complex vegetative cover to improve the resilience of GI system and reduce the risk of bird loss; (3) The way that GI network designed and planned influences the magnitude of

their impacts on urban ecosystem biodiversity. Priority habitat conservation areas should be fully considered in GI network when designing and planning the urban GI spaces.

Keywords: Green infrastructure; urban biodiversity; resilience; avian species, habitats

1. Introduction

There are many views on the definition of Green Infrastructure (GI). Benedict and McMahon's define GI as "an interconnected network of natural areas and other open spaces that conserves natural ecosystem values and functions, sustains clean air and water, and provides a wide array of benefits to people and wildlife", which has been widely adopted [1]. GI provides multiple ecosystem service not only for improving human well-being by supplying of water, regulating stormwater, mitigating the diffuse pollutions, and providing the recreation opportunities for psychological and cognitive benefits, but also for protecting the wildlife habitats by providing the physical basis for ecological networks and maintaining the integrity of habitat systems [3-4]. There is an increasingly common focus that establishing green infrastructure is a gateway for improving urban biodiversity to build more sustainable and resilient environment [5].

Urban birds play an important role in biodiversity conservation of urban ecosystems, while the urban environmental variation of habitats has an impact on the avian diversity and abundance in many ways. The environmental characterization of greenspace and adjacent landscape varied the diversity and richness of avifauna, and the human disturbance affecting on avifauna habitats and distributions [6]. Carbò-Ramírez and Zuria have shown the greenspace and adjacent landscape (i.e. the percentage of buildings) are important variables that influenced bird species richness [7]. However, with increasing anthropogenic

disturbances the natural habitats by man-made systems in urban context, the trend of urbanization had an inevitable influence on urban avian biodiversity. Miller and Hobbs proved the increasing frequent presence of human reduce the number of breeding bird territories and nests [8]. The more importantly, the changes in the structure of urban green space network led to cutting the bird migration and transiting route [8].

Urban biodiversity conservation and maintaining wildlife habitats has become a significantly increasing concern on landscape planners, researchers and city managers. It has not been clear that how to maintain the biodiversity for urban birds and what kind of structures and characteristics of GI that is relatively important for determining avian diversity and abundance. In our study, we used avian abundance and diversity as the proxies for evaluating the functionality of three different GI structure types (corridor, node and net), and the relationship between the GI characteristics, human disturbance and urban avian species abundance in Chengdu. The aims of this study were 1) to explore the relationship between avian abundance and diversity and the GI structure, characteristics; 2) to determine what are important variables of GI landscape variables and human disturbance influenced on individual species; 3) to provide scientific-based suggestions and design guidance of GI planning for landscape architectures and planners to improve the urban bird biodiversity.

2. Methods

2.1. Study area and Sampling

Chengdu is the capital of Sichuan province where located in in the southwest of China. It is a metropolitan city with more than million 16,000, 000 permanent populations, covering an approximate area of 14600 km². In last decade, it was the one of highest rapid development of the urbanization cities in the world that has achieved the urbanization rate of 70.6% in the year of 2017. Chengdu has a diversity of the urban ecosystem. It has a high diversity of wildlife recorded more than 466 avian species 600 the terrestrial wildlife species and 3990 flora species. According to the landscape structure of GI in Chengdu, we selected 17 GI sites which represents three types of GI landscape structure: (1) 6 corridor (e.g. greenway, green/blue corridors); (2) 5 node (e.g rain gardens, bioswales) ; (3) 6 net (e.g residential greenspaces, parks) (Fig.1).

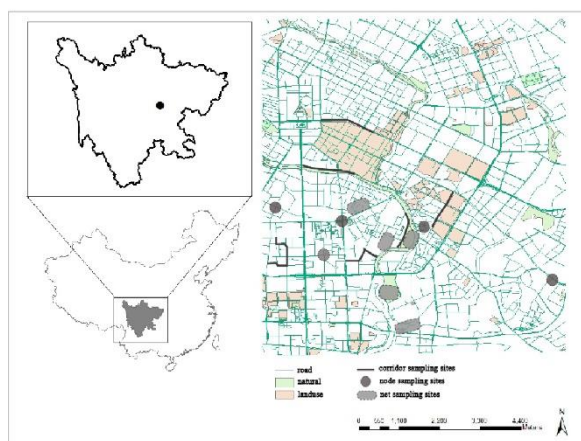


Fig 1. The location of 17 sample sites in Chengdu

2.2 Bird surveys, Human disturbed surveys and Survey site characterization

Bird surveys conducted in all sampling sites from July 2013 to February 2014 once a month, and it counted twice a month in the summer (July,2013 and August, 2013) and winter month (December, 2013 and January, 2014). For GI space of node and net, we recorded bird number and species in 500 meters' radius point counting for five minutes. For strip corridor, six transect line were laid out in 500 meters, and bird counted along the strip corridor sampling site within this 500 meters' area in ten minutes.

Human disturbed surveys conducted after the bird survey in all sampling site. The number of pedestrians and the number of vehicles was recorded the in the intersection of the sampling sites (20-m radius circular plot) within 60 seconds. Every time we conducted three times for comparative purposes. Noise levels were measured in the same intersection of the sampling sites (within the circle of 20 meters' radius). We used a sound level meter to record the noise levels by A-weighted decibels (dBA) every 10s for 1min, repeating three times for comparative purposes. The Noise levels required to conduct in the morning time from 8am to 10am in good weather condition.

We measured landscape characterization for each GI spaces at two spatial scales, site level and the adjacent landscape level. At the site level, we measured landscape characterization by 1) Area(A); 2) Perimeter(P); 3) tree species abundance (B); 4) total tree species richness(S); 5) the average tree diameter(DBH). The landscape structure of each site considered at adjacent landscape level (sites with 100-m width

buffers). We calculated 1) the percentage of tree cover area(Gt); 2) the percentage of shrub cover(Gs); 3) the percentage of herbaceous plant(Gr) in a 100-m width buffer at each sampling site.

2.3 Data analysis

We calculated the species abundance at each GI space surveyed, and sum the number of all bird species in each month. To assess the diversity of bird, we used the Shannon-Weiner index, Simpson index and Pielou index. After ANOVA and Tukey post hoc tests, we applied Linear multiple regression to analyze the relationship between bird abundance and the explanatory variables of landscape characteristics and human disturbance [10]. Then, we examined relationships between both bird communities and landscape characteristics, human disturbance by Canonical correspondence analysis (CCA) [11]. Each CCA included between individual species and 17 greenspaces. Species data included the total number of bird individuals (all surveys together) for each species observed at each GI space.

3. Results

3.1. Urban Bird surveys

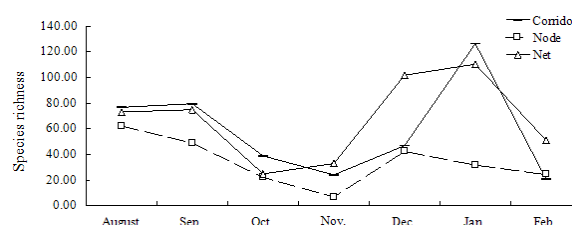
We recorded 46 individual species, and the 10 species were registered common species contributing to 91.2% of the total bird abundance (Table 1). Individual species records were categorized into four trophic groups. The species of insectivores accounted for 50% of the all registered common species, granivores accounted for 30% the all registered common species, nectarivore and omnivores accounted for 10% that of all, respectively (Table 1).

Table 1 Resident bird species recorded in three GI landscape structure categories (corridor, node, net) in southeastern of Chengdu City. Trophic group: (G) granivore ; (I) insectivore ; (O) omnivore; (F) frugivore .

Family	Species	Trophic group
Columbidae	<i>Streptopelia chinensis</i>	granivore
Laniidae	<i>Lanius schach</i>	insectivore
Turdidae	<i>Turdus merula</i>	insectivore
Sturnidae	<i>Acridotheres cristatellus</i>	insectivore
Aegithalidae	<i>Aegithalos concinnus</i>	insectivore
Pycnonotidae	<i>Pycnonotus sinensis</i>	omnivore
Timaliidae	<i>Garrulax sannio</i>	insectivore
Muscicapidae	<i>Paradoxornis webbianus</i>	granivore
Passeridae	<i>Passer montanus</i>	granivore
Frinfillidae	<i>Eophona migratoria</i>	frugivore

The average avian abundance varied over the months in three GI structures (Fig. 2). Corridor, node and net showed different trend in avian abundance. The average of avian abundance in the corridors and net was the highest in January, N= 126.3 and N=113.7 respectively. The trend of avian abundance in the node shows opposite trend, and it reached highest in August (N= 62). In general, avian abundance was higher in corridors and nets, and lower in nodes(Fig.2).

Fig.2 The average avian abundance in different GI spaces structure



The total avian species abundance of nets and corridors were higher than node by 1482 and 1342, respectively, while the Shannon-Weiner index of nodes was highest 0.74 (Table 2). We found there was a significant difference of Shannon-Weiner index in different landscape structures ($P < 0.05$). The GI landscape structures of Simpson index and Pielou index didn't show significant differences.

Table 2. The avian species diversity index in different GI spaces structures

GI spaces structure	Species abundance	Shannon-Weiner index	Simpson index	Pielou index
corridor	2408	0.65 (0.03)*	1.37 (0.07)	0.57 (0.03)
node	1067	0.74 (0.02)*	1.41 (0.09)	0.61 (0.05)
net	2549	0.68 (0.03)*	1.45 (0.13)	0.59 (0.04)

Values followed by *are significantly different at 0.05 level, $P < 0.05$. Values followed by **are significantly different at 0.01 level, $P < 0.01$.

3.2. Influence of landscape variables on avifauna

We found a significant and positive relationship between the species abundance and the percentage of tree cover at the adjacent landscape level ($P < 0.05$) (Table 3). While, the landscape characteristics at the site level, there is no significant relationship between species richness and GI landscape characteristics ($P > 0.05$). As well as human disturbance, there is no significant relationship between species abundance and visitors flow, vehicle flow rate and noise ($P > 0.05$).

Table 3 Final models and R^2 values obtained from linear multiple regression analyses between bird

species richness and the GI landscape characteristics and human disturbance explanatory variables (X). HP=visitors flow rate; VF=vehicle flow rate; dBA=noise; A=Area(ha); P=perimeter (m); B=tree species abundance; S=total tree species richness; DBH= tree diameter; Gt=tree cover(%) Gs=shrub cover(%); Gr = herbaceous plant (%)

Dependent variable	Model	R^2	P
Human disturbance	183.75-12.209HP-13.018dBA	0.28	0.08
Greenspace characteristics	339.892+0.006A+0.394B	0.301	0.23
Adjacent landscape	-2.696+8.874Gt	0.441	<0.001

The first three axes explained 23.9% of the variance in bird species, and first three axes explained 100% of the variation in the species-human relationship (Table 4). In general, species like *Pycnonotus sinensis* (*P.sin*) and *Aegithalos concinnus* (*A.con*) were inclined to urbanization; while species like *Turdus merula* (*T.mer*), *Garrulax sannio* (*G.san*) and *Eophona migratoria* (*E.mig*) tended to living in the urban areas with more far away from human disturbance (Fig. 3).

Table 4. Results of CCA analyses for human disturbance variables. The percentage variance in the species data and species-human relationship explained by the canonical axes are cumulative.

	Canonical axes			
	1	2	3	4
Eigenvalues	0.099	0.057	0.013	0.173
Species-Human Factors correlations	0.647	0.721	0.417	0.000
%species data	14.0	22.0	23.9	48.2
%species-Human Factors relation	58.6	92.4	100.0	0.0

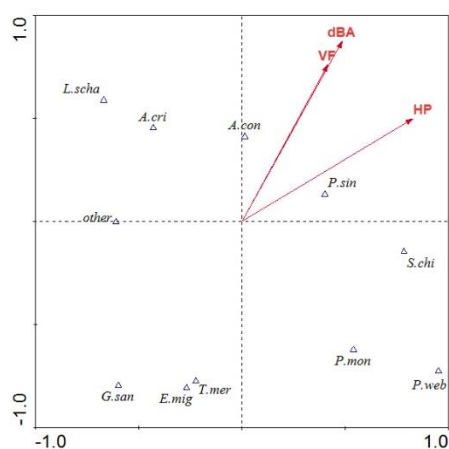


Fig. 3. Environmental gradients of human disturbance variables and locations of bird species in the ordination space constructed with CCA. The length and direction of the arrows indicate the relative degree and direction of association. Species codes are in Table 1. HP=visitors flow rate; VF=vehicle flow rate; dBA=noise.

As for the site level, we did not obtain a significant relationship between species and GI characteristics ($P > 0.005$). The first axes explained 27.0% of the variance in bird species, and the first two axes explained 80.6% of the variation in the species- human factors relation habitat relationship (Table 5). In general, species like *Pycnonotus sinensis* (*P.sin*), and *Passer montanus* (*P.mon*) were richer in larger greenspaces with bigger and more trees (Fig. 4). Some species were richer in open areas like *Eophona migratoria* (*E.mig*), *Lanius schach* (*L.sch*) and *Acridotheres cristatellus* (*A.cri*). At the adjacent landscape level, we obtained a significant and positive model between the species richness and the percentage of tree cover ($P < 0.05$). The first three axes explained 29.0% of the variance in bird species, and first third axes 100% of the variance species-environment relation (Table 6). *Eophona migratoria* (*E.mig*) were

favored by more shrub area, while species like *Lanius schach* (*L.sch*) and *Garrulax sannio* (*G.san*) were more abundant in larger greenspaces that had more trees (Fig. 5).

Table 5. Results of CCA analyses for GI landscape characteristics variables. The percentage variance in the species data and species-environment relationship explained by the canonical axes are cumulative at the site level.

	Canonical axes			
	1	2	3	4
Eigenvalues	0.191	0.103	0.050	0.018
Species-environment correlations	0.886	0.882	0.775	0.486
%species data	27.0	41.5	48.5	51.0
%variance species-environment relation	52.4	80.6	94.2	99.2

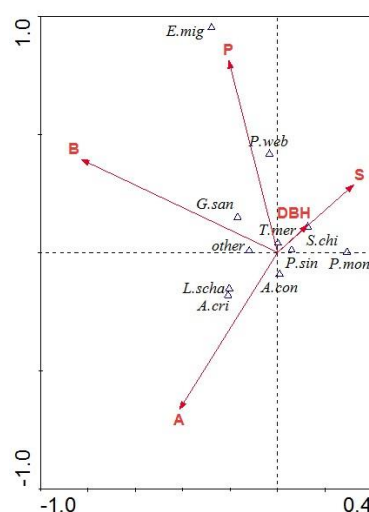


Fig. 4. GI landscape characteristics gradients of site level variables and locations of resident bird species in the ordination space constructed with CCA. The length and direction of the arrows indicate the relative degree and direction of association. Species codes are in Table 1. A=Area(ha); P=perimeter (m); B=tree species richness; S=total tree species richness; DBH= tree diameter.

Table 6 Results of CCA analyses for GI landscape characteristics variables. The percentage variance in the species data and species - environment relationship explained by the canonical axes are cumulative.

	Canonical axes			
	1	2	3	4
Eigenvalues	0.162	0.033	0.010	0.185
Species- environment correlations	0.840	0.574	0.428	0.000
% species data	22.9	27.6	29.0	55.0
% variance species- environment relation	78.9	95.0	100.0	0.0

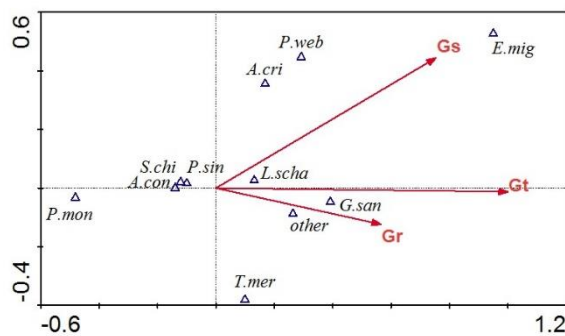


Fig. 5. GI landscape characteristics gradients of adjacent landscape-level variables and locations of bird species in the ordination space constructed with CCA. The length and direction of the arrows indicate the relative degree and direction of association. Species codes are in Table 1. Gt=tree cover (%); Gs=shrub cover(%); Gr = herbaceous plant (%).

4. Discussion and conclusions

Our results provided evidence that different GI landscape structures of southern Chengdu City affected the avian species abundance and diversity. Nets had the largest avian abundance among these three GI spaces, which had a complex habitat structure and been away from human disturb. Corridors of GI had higher species

abundance playing an important role for avian movements. The same result was found in Clevenger *et al* [12] research that the corridors of green/blue spaces acted as the crucial stepping stones sites connecting the buildings and urban landscape. Miller *et al* [8] also found the linear green strip corridors had a higher probability of attracting some specific species, i.e edge species. Another reason was that these green and blue belts also had been used as an alternative habitat for foraging and nesting [6]. It was worth noting that though the nodes had the lowest avian species abundance, those GI spaces were valuable to hold avian species diversity. In our result, we found the Shannon-Weiner index of nodes was highest. Nodes combine the advantages of good connection and complex habitat structures. In general, nodes were the vital connectivity between landscapes that some species could temporarily take advantage of these stopover sites to fly from man-made area to other green habitats. And the nodes had higher habitat heterogeneity and more complex vegetation structures (e.g, trees, lawns and shrubs, etc.) providing different habitats structure for both granivores and insectivores [13].

Bird species abundance recorded in southern of Chengdu City showed there was no significant relationship between species abundance and visitors flow, vehicle flow rate and noise. Gómez-Aíza and Zuria research also found that the intermediate levels of human disturbance might reach the peak of bird species richness, rather than at zero or very low urbanization [14]. Some urban resident adapted to the urbanized environment, while some species are

vulnerable to human disturbance. We also found that *Pycnonotus sinensis* and *Aegithalos concinnus* tolerant to noise and human visit, while species like *Turdus merula*, *Garrulax sannio* and *Eophona migratoria* was sensitive to human disturbance. One of the obvious phenomenon for the urban bird was that the adaptability to urbanization varied from different species. Some residents (e.g., doves and sparrows) are inclined to urbanization, they even take advantage of food resource by human feeding or waste [14]. However, we found the most species have less resilience to urbanization which tends to less urbanized areas with a greater percentage of vegetative cover, e.g. urban park and natural wildland. These species still had a variety of negative impacts on noise levels and traffic of vehicles and visitors, and the higher level of noise nearing their habitats leads to the lower bird abundance (Table 3). Different GI space played important role in maintaining bird species richness. To ensure the plenty of GI space with high-quality bird habitats and biological integrity, it was important to support a diverse bird community.

Many research demonstrated that GI landscape characteristics, e.g. the patch size, habitat heterogeneity, vegetation complexity, these variations of GI space directly affect the bird species richness, which influences the quality of habitat for urban biodiversity. In my research, compared with site level, the adjacent landscape-level of GI landscape characteristics had a more significant influence on bird species richness. Carbò-Ramírez and Zuria^[7] had the similar result in

the Mexican city. At the adjacent landscape-level, considering the factor of vegetation complexity, the different percentage of vegetation has direct influence to habitat quality. Also, it was, to some extent, decided the species distribution due to the different habitat preference of avian. Granivores and other bird species which nest on the ground area inclined to natural shrublands or grasslands. Some birds (e.g., *Lanius schach* and *Garrulax sannio*) preferred the habitats with a greater percentage of vegetative cover. At the site level landscape-level, we found the area and tree species richness were the most important explanatory variables. Heezik et al. [15] study also found the size of the park to be the most important indicator of species richness, and the similar result found the in New Zealand. Tree species richness not only reflected the canopy density, more importantly, but also it affected the avian food resource and nesting site which could substantially affect the nature of bird assemblages [16-18]. Therefore, maintaining a certain scale GI space and increasing the diversity of trees could help increase the diversity of birds at the site scale. As for the adjacent landscape-level, it was needed to consider keeping a diversity of vegetation cover to satisfy the different habitat requirements for different species.

As a landscape architect and urban planner, we should fully consider how to allocate and design GI space to maintain urban biodiversity and increase flexibility in urban context [19-20]. Our research encouraged systems thinking of GI spaces to fulfil the ecological function of node and corridor, improve the integrity of GI space

network, and thus contribute to improving the overall resilience of the city [21-23]. Though we considered the GI structure, characteristics and human disturbance affecting on avian abundance, the study has the limitations of studying features of GI space, e.g. water cover which could be explored in the further research. Based on our research, we proposed the following suggestions on GI designing and planning for landscape architects: (1) GI space should consider the connectivity of GI network, taking advantage of GI nodes and corridors that provides crucial stopover sites for birds to movement among urban greenspaces; (2) GI spaces should have the largest possible area and contain a complex vegetative cover to improve the resilience of GI system and to reduce the risk of bird loss; (3) The way that GI network designed and planned influences the magnitude of their impacts on urban ecosystem biodiversity. GI network should fully consider priority habitat conservation areas when landscape architects designing and planning the urban GI space.

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Resilient Village: Conceptual Planning for Post-disaster Reconstruction of Wenquan Village in China

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Abstract

The concept of “Resilience” provides a new way of thinking for disaster management and post-disaster reconstruction. Chinese ancient villages are facing threats of various natural and man-made disasters due to their fragile ecological environments. How to improve the resilience of the villages to cope with the disaster and rebuild resilient villages after the disaster has been an important issue for landscape planning. Wenquan Village is a traditional minority village with a long history. However, most of traditional residences were destroyed by a sudden fire on February 20, 2016, which led to hundreds of residents were homeless. It is urgent and necessary to carry out the post-disaster reconstruction planning. We choose the “Resilient Village” as the concept of post disaster reconstruction to build a self-growth and self-sustaining village system from four aspects: planning and layout, ecological environment, architecture design and institutional management. Firstly, planning and layout: Arrange the combination of linear layouts along with contour lines and group layouts to keep enough fire distance. Secondly, ecological environment: Integrate rivers, public space and green space to construct fire isolated belts to form a green infrastructure of disaster prevention and mitigation. Thirdly, architecture design: Design five types of indoor layout according to the wishes of the villagers, and properly arrange the relationship between living space, eating space and sleeping space to satisfy the needs of people. Fourthly, institutional management: Establish village information center and create village information network to realize information sharing when disaster happens. Moreover, strengthen publicity and education of fire prevention and organize fire disaster trainings to enhance villagers’ self-help capacity. In response to natural and social disasters such as fire, the village can self-adjust and self-adapt to achieve normal operation of the living environment, public safety and social order with above four points, which forms a three-dimensional ecology - production - living resilient village system and provides a reference for the building of disaster prevention village.

Keywords: Resilient village, Disaster management, Disaster prevention and mitigation

1. Introduction

Rural communities are generally considered to be more vulnerable to the adversity than their urban counterparts. The frequent occurrences of natural and man-made disasters have brought great challenges to environment security in some villages. Especially in some Chinese remote mountainous areas, being constrained by many factors such as severe geographical environment, underdeveloped economic level, weak infrastructure construction and insufficient public services, they lack the capacity to effectively resist the internal and external disturbances and tend to suffer from devastating consequences when disasters strike. Rural vulnerability to disasters has gradually become a bottleneck that restricts rural survival and sustainable development.

The traditional concept of disaster prevention and mitigation can no longer meet the requirements of future rural development. Village is a complex social ecosystem that integrates agricultural production, ecological protection and residential living. The concept of resilience provides a new idea to rural disasters response from the perspectives of holism and dynamics^[1]. Resilient villages not only focus on reducing the impact of disasters, but also emphasize their adaptability and recoverability to disasters^[2]. Landscape design and planning play a critical role in a rural ecosystem to adapt external shocks and minimize interference with organized structures and functions.

The concept of resilience has become a global concern in the face of environment disturbances and emergency management. There has been an increased attention to the issues of building city resilience towards various disasters, however, little research

pays attention to rural areas. At present, the concept of resilient city is mainly applied in natural hazards and climate change mitigation^[3-5], urban and regional economic resilience^[6-8], urban infrastructure resilience^[9-11], urban terror attack resilience^[12]. The research content mainly focuses on the urban resilience evolution mechanism^[13, 14], urban resilience assessment^[15, 16] and urban resilience planning practice^[17-19]. Current research concentrate on economic recession in terms of globalization process, industrialization of agricultural systems, extreme weather and sociodemographic changes^[20-22]. In China, there was an upsurge in research of disaster and hazard risk management in rural areas after the 2008 Sichuan earthquake. Various attempts have been made to support post-disaster reconstruction from the perspective of resilience with economic and social reconstruction and environmental protection^[23, 24]. The construction of a resilient village has become a new research trend for future rural disaster management and post-disaster reconstruction planning.

The paper explores post-disaster reconstruction planning strategies from the perspective of rural resilience, utilizing empirical research conducted in a Chinese traditional minority village after a severe fire. With a brief review of studies on resilience, we reported the research methods, including the description of the study area, and builds a “Stability—Adaptability—Recoverability” theoretical framework of resilient village based on literature review and related planning practice. Then, we put forward specific resilient strategies from physical environment (planning and layout, ecological environment and architecture design) and social system (institutional management). Finally, we conclude that the rural resilience relies on the interaction of physical environment and social system.

Implication of this study on improving the existing rural resilience efforts is also discussed.

2. Resilient village

2.1. The concept of resilience

The word "resilience" originated from the Latin word "Resilio" and its meaning was "revert to its original state". In 1973, the concept of resilience was first introduced in ecological system by Canadian ecologist Crawford Stanley Holling^[25]. Then, its conceptual development experienced three stages from engineering resilience, ecological resilience to socio—ecological resilience^[26]. Resilience theory provides an effective theoretical framework for linking physical and socioeconomic environments. In the field of landscape planning, as a new research paradigm for sustainable development, resilience theory has been widely applied in various human settlements environments to deal with different disasters and risks^[27-29].

2.2. The implication and theoretical framework of resilient village

Researchers who have studied the response of resilient systems to disasters summarized eight essential resilience features: redundant, diverse, efficient, autonomous, strong, interdependent, adaptable and collaborative^[30, 31]. The paper constructs the "Stability—Adaptability—Recoverability" theoretical framework of resilient village based on literature review and related planning practices.

(1) **Stability:** A system should consist of diverse and complex components to maintain dynamic stability, which ensures the system is equipped with the

self-sustaining capacity to respond the emergency events and severe threats.

(2) **Adaptability:** A system should realize immediate feedback according to the variation of environment, then have the flexibility of self-adjustment and self-regulation to absorb the outside disturbances.

(3) **Recoverability:** A system should be made up with multifunctional and multi-level components. They are independent yet interrelated, which provides multiple choices and various strategies when disasters occurred.

3. Methods

3.1. Study area

Wenquan village is a traditional minority village in remote mountainous area in Guizhou Province, Southwest of China, with total area of 54 hectares and total population of 2356. The village is composed of four parts. The northern part is located on the hill, which is the core area of the village because many historic dwellings are mainly distributed here. The western part is a transitional area which connects the Wenquan village with hot spring resort. The southern and eastern part are main areas for residents' living. As an ancient Miao village, Wenquan village is famous for the traditional folk dwellings and hot springs, which is a popular local tourist attraction. Wooden stilted building is the traditional Miao building constructed on the steep land in high density distribution (Figure1, Figure 2).

February 20th in 2016, A severe fire broke out in Wenquan Village, which hit the northern part of the village with a total population of 120, burning down 97 ancient houses and 4 hectares of residential area (Table 1). It is of great practical significance

and urgency to build resilient village to recover from the fire and resist and adapt the future disasters.

Table 1
Statistics of destroyed buildings

Site Area(m ²)	50-8	80-11	110-14	140-17
Number	21	36	23	17

Source: field survey

3.2. Data collection

The paper conducts qualitative research with field survey and unstructured interview. Firstly, Unmanned Aerial Vehicle was used to obtain a high-resolution aerial image for master plan analysis. Secondly, three original and typical residential dwelling plans were concluded by architectural site survey (Figure 3). Thirdly, an unstructured interview with villagers was developed to collect data and suggestions for post-disaster reconstruction.

Based on the results of field survey and unstructured interview, we analyze and summarize the current situation and problems of Wenquan village:

(1) Buildings with high density and disordered arrangement. Most of the houses are equipped with private pigsty and outdoor toilets, which results in the limited spaces between the buildings being filled. There is a lack of enough fire isolation space between the buildings and disorderly architectural arrangement which make the fire easily spread and uncontrollable.

(2) Insufficient fire-fighting facilities. The fire-fighting reservoirs are poorly managed and many of them have already dried up and abandoned. Limited number and uneven distribution make it impossible to provide

fire-fighting support for every part of the village in time when a fire occurs.

(3) Serious shortage of public space.

The green and public space in the village are seriously scarce, which are scattered without systemic layout. Furthermore, villagers have single daily activities and little communication due to inadequate high-quality outdoor recreation space.

(4) Disordered layout of traffic situation. There are many twist and narrow roads that make the traffic in the village inefficient. The capacity of emergency evacuation is deficient in responding the sudden risks and threats because of the chaotic traffic organization.

(5) Bad electricity usage habits. With lower level of education, villagers lack good habits of electricity and fire safety knowledge. The vulnerability in individual consciousness and social network may be prone to be struck by severe disasters.

4. Results

Original site reconstruction of Wenquan village was conducted both in physical environment (planning and layout, ecological environment and architecture design) and social system (institutional management) to strengthen the stability, adaptability and recoverability of rural areas in dealing with risks, disasters and emergencies.

4.1. Planning and layout

4.1.1 Master plan

Reasonable plan layout can narrow the affected scope and control the spread speed of disasters, which is an effective way to achieve disaster prevention and resilience construction. On the basis of original spatial fabric and original site topography, linear

layout and group layout are applied in new construction arrangement as fire prevention zone unit. In single unit design, traditional dense and compact architectural style is preserved to maintain historic identities. While between the units, adequate fire separation and green belts are considered to restrain the spread of the fire disaster from one unit to another, which can reduce fire loss greatly. In addition, public space is collocated in the interior of group layout to facilitate the daily communication of residents and provide them with disaster evacuation area (Figure 4).

4.1.2 Vertical design

Besides the master plan, the proper vertical design is also a key point to mitigate the disaster. The disaster-stricken areas are built around the mountains with complicated topography about 75 meters high. The architectural arrangement formed by the unorderedly natural development of the villagers has resulted in overlapped and clustered houses, allowing the fire spreading upward and downward easily. Although the newly-reconstructed houses retained the local dense architectural features, the houses at different elevations were adjusted to be arranged in different layers and the distances between different layers were enlarged properly, which slows down the fire spreading speed from up to down (Figure 5). This kind of design makes it possible for diverse forms of building entrance to fit the elevation differences. Some buildings are placed on the platform from the front to the interior house, others are placed on the edge of the steep terrain from the back or flank to the interior house (Figure 6). The flexible combination of multiple buildings and various terrain not only preserves the traditional style of Miao's architectures, but

also strengthens the building's resilience and adaptability to fire.

4.2. Ecological environment

4.2.1 Water system planning

(1) Rainwater collection system

Rainwater collection system is built on the hillside to collect rainwater and surface runoff to ensure sufficient water supply when emergencies. The system utilizes green planting beds to collect rainwater and surface runoff and store them in underground water reservoirs. They are evenly arranged in every fire protection unit and used as landscape ponds on ordinary days and fire water supply when fire occurs, which can make up for the situation that tap water lacks enough water pressure and water amount at high altitudes. Firewater intake points are set at the foot of the hill and the elevation of the mountains provides the firefighting water pressure. Higher reservoirs can provide adequate pressure for fire suppression (Figure 7).

(2) River network remediation

River network remediation includes connection and purification. The connectivity pattern of the river network affects the ability of water security assurance and water resources allocation. Specific measures include: ① Rivers and ponds are connected to build an integrate river network to achieve rapid provision of water resources. ② Create bio-oxidation ponds to purify the domestic sewage using microbes. The system will improve the ability to resist natural disasters after connection and purification.

4.2.2 Vegetation planning

The planning of fire-resistance tree species can prevent the spread of fire and form a barrier network to control fire. The

fire-resistance features include that the tree body has less oil, higher water content, waxy or leathery leaves, and strong sprouting ability. The main choice is the evergreen broad-leaved fire tree with dense foliage. In fact, there is no absolutely fire-resistant tree species, but compared with other tree species, they can't be ignited easily and they can recover quickly after a fire. The vegetation coverage of fire-resistance trees should be increased between the group and linear buildings to mitigate the fire spread.

4.3. Architecture design

We redesigned the buildings according to the principles of continuation of style, coordination of old and new, and overall unity. The traditional dwellings of Miao village are generally two floors. The ground floor is used to store production and living materials, keep poultry and livestock, or as a toilet. The second floor is used as a living room, hall, bedroom and kitchen. However, as modern lifestyles fit into people's living, there are several problems emerging in ancient buildings, such as confusion in streamline organization, spatial interference and inefficient use of space.

Based on the above problems and typical traditional architectural form surveyed at the site, five types of architecture plans were designed and optimized according to the area and proportion of the affected houses and the villagers' wishes (Table 2, Figure 8).

Table 2
Five Architectural plans

Type	A	B	C	D	E
Floors	3	2	2	2	2
Building area (m ²)	58	75	80	108	128
Gross building	175	150	160	220	298

area (m ²)					
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Source: field survey

4.4. Institutional management

It has reached a consensus that despite the ordered physical environment play an irreplaceable role in disaster mitigation, affected communities are becoming increasingly dependent on their local institutional management. Residents' sense of community are inherent within the community and are constantly developed, reproduced and increased via the daily interaction among the community members and institutions^[32]. In the rural resilience system, the construction of institutional management is mainly reflected in two aspects: the improvement of individuals fire prevention awareness and the sharing and interconnection of residents' fire prevention information. Optimizing the community disaster relief response system and strengthening residents' self-rescue capability are powerful guarantee for community disaster prevention and reduction. Establish guidelines for villagers to regulate the daily behaviors, especially in the aspect of the use of electricity. Enhance fire prevention education, organize fire prevention training, and cultivate awareness of crisis among residents to improve their disaster response skills. In addition, a villagers' information center is suggested to set up in the central square. When disasters occur, village information networks will be communicated with each other to ensure the sharing of information. It also provides education facilities, such as libraries and electronic information rooms to enrich the cultural life of the villagers, encouraging the villagers with higher cultural attainment to meet new opportunities for village development.

5. Discussion

The construction of resilient village depends on the interaction and mutual promotion of the physical environment and the social system. The reconstruction of livable physical environment is as important as the recovery and development of social fabric and communal networks. In addition to emphasizing the resistance and recovery capabilities to disasters, the concept of resilience should also mean the transformation and better development capabilities of village. On the basis of protection and utilization of the unique local natural environment and historical culture, after completion of the post-disaster reconstruction plan for Wenquan village, health tourism will be introduced in the long-term planning to achieve connection between disaster-stricken areas and hot spring resort to reach synergetic development. Tourism products related to hot spring and ancient dwellings can be developed to stimulate vitality and provide impetus for the transformation and sustainable development of villages.

6. Conclusion

The study illustrates the implication of resilience, builds a theoretical framework of “Stability—Adaptability—Recoverability” for resilience, and explores the specific strategies for the construction of rural resilience in Wenquan village from four aspects of planning and layout, ecological environment, architecture design and institutional management. The construction of rural resilience should consider the interaction mechanism of physical environment and social system. The study expects to provide a reference of resilience construction for other disaster-affected rural area in China.

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Appendix



Fig. 1. Aerial view of the site.



Fig. 2. Traditional Miao building.



Fig. 3. Three original and typical residential dwelling plans.

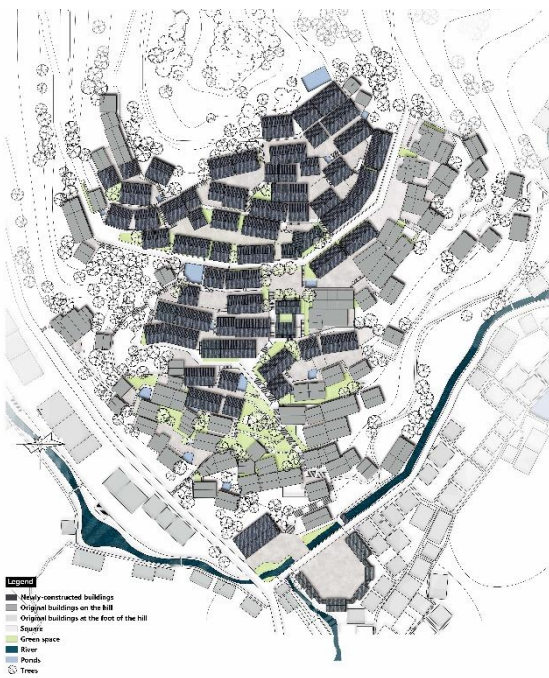


Fig. 4. Master plan of the village.



Fig. 5. Vertical design of the site.

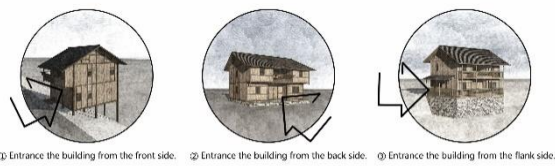


Fig. 6. Different ways to entrance the building.

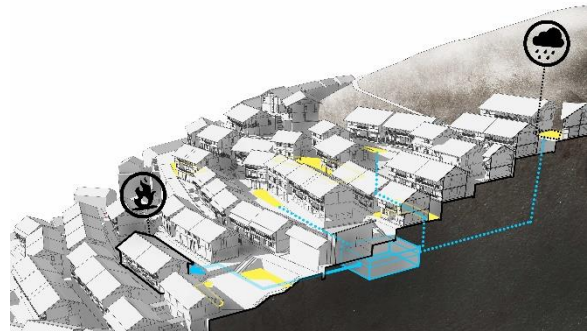


Fig. 7. Rainwater collection system.

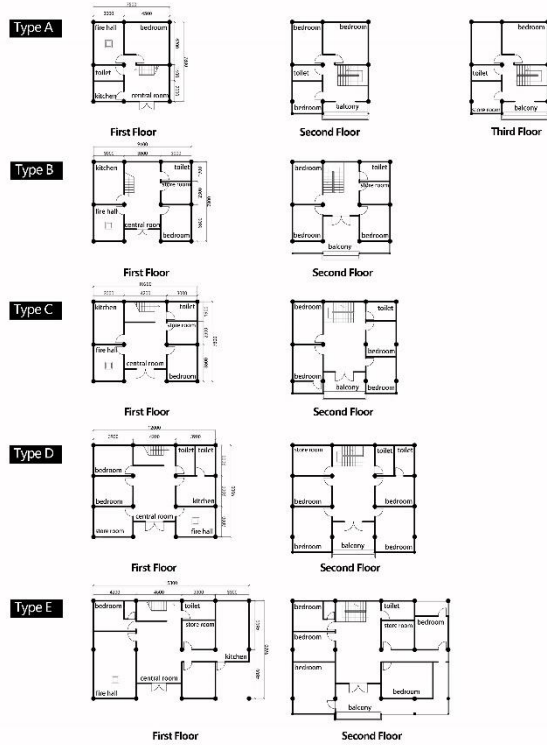


Fig. 8. Five types of architecture plans.

(Ratna, 2015) Study of Infrastructure for Lasem Town Resilience

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Abstract Lasem is a cultural heritage area that has unique and distinctive Chinese architecture and culture and is still well preserved and known as "Petit Chinois", located in Lasem District, Rembang Regency, Central Java, Indonesia. Lasem is 18.2 km to the East of Rembang city center and is part of the city of Rembang. Lasem is a city that became an important part of the main axis of the northern coastline of the island of Java. Astronomically, Lasem is located on the coordinate line 111° 00'- 111° 30' East Longitude and 6° 30'- 7° 6' South Latitude. Lasem has a rich historical heritage in the form of Chinese architecture buildings, which contained the philosophy and cosmology of Javanese society. Lasem declined in its city after the peak of the glory ended in the 19th century, the city has not experienced a significant development in the procurement of municipal infrastructure. Extreme climate change occurs at the Lasem site and its location is close to the coastal area, causing the temperature to become extreme heat and frequent drought in the area. The purpose of this research is to reduce the impact of extreme climate change and to maximize the infrastructure of the area. The method used a descriptive method. The results of this study for environmental improvements carried out by setting green city arrangements using the Lasem's typical vegetation areas, also proposed hydrological improvements at the Lasem site, in an effort to reduce the impacts of climate change, drought, extreme heat and create resilience of future Lasem sites.

Keyword: Lasem site, infrastructure, impact, climate change, resilience

1. Introduction

Lasem is a cultural heritage area that has unique and distinctive Chinese architecture and culture and is still well preserved and known as "Petit Chinois", located in Lasem District, Rembang Regency, Central Java, Indonesia. Lasem is a city that became an important part of the main axis of the northern coastline of the island of Java. Astronomically, Lasem is located on the coordinate line 111° 00'- 111° 30' East Longitude and 6° 30'- 7° 6' South Latitude. Subdistrict Lasem has an area of 4,504 ha and is divided into 20 villages (Nurhajarini, 2015). The Lasem site is traversed by the North Coast Highway, formerly known as

the Grote Postweg or Daendles road that stretches from the West to the East. The boundaries of the following regions: Northside bordering the Java Sea, the east with District of Sluke, south bordered by District Pancur, and next to the west District of Rembang. Lasem geographical conditions affect the history and development of Lasem sites. Lasem Region in the North is a coastal area, the eastern region is mountainous and the center of flat topography. Lasem have a river which in the past has a role as an artery of trade in Lasem. In the river, there is a port that has a function as a point of entry and exit of people and goods. In addition to acting as a trade-lanes, river morphology Lasem also form the city, serves as a transportation hub, so that the development

of settlements along the river such as settlements. At that time, the city center is located in the port area, the center of government/duchy, squares, and markets (Nurhajarini, Purwaningsih, Fibiona, 2015:18-20). But this time, river silting Lasem experience. Anticipated advances in shoreline seaward Lasem occur due to silting at the mouth of the river and the Java Sea (Handinoto, 2015: 52). (Handinoto, 2010) (Lynch, 1960)

In Lasem there are three Chinatowns that have historical value, namely in the area of Chinatown Dasun, Babagan and Karangturi (Aziz, 2014: 115-118). Because of the influence of these three Chinatown, Lasem has a rich historical heritage in the form of Chinese architecture building, which contains the philosophy and cosmology of the Java community. According Handinoto in his book entitled *Lingkungan "Pecinan" Dalam Tata Ruang Kota Di Jawa Pada Masa Kolonial*, Lasem town's heyday was in the late 19th century. However, after the peak of its glory, Lasem not experiencing significant growth (Handinoto, 1999: 459). Extreme weather occurred in Lasem site and its location close to the beach area, causing the temperature became very hot and frequent droughts in the region. A longer dry season than the wet season causes dryness in the area. North-Central Java region has great potential to experience drought (Sunarto, 2010: 621). Then, with the descriptive method, does the proposed criteria for environmental improvements and physical Lasem sites with Kevin Lynch theoretical approach about the city's image-forming element to overcome the above problems.

2. Forming The Resilience Of The City In The Future

Factors affecting the absence of significant developments in the city Lasem due to lack of urban green system and change the function of the town square Lasem. Moreover, the lack of urban green arrangement resulting in frequent occurrence of drought during extreme climate changes is characterized by a long dry season at least due to groundwater reserves (Sunarto dkk, 2010: 621).

The purpose of this study to maximize Lasem local infrastructure by improving the city's image-forming element in shaping the city resilience and mitigate the effects of climate change by pursuing green layout on the site Lasem.

To establish the resilience of the city in the future, it is necessary to improve the image forming elements of the city. According to Kevin Lynch (1960: 46-47), There are five elements forming an image of the city that way, ledges, districts, nodes, and landmarks. On the street in the city Lasem elements, the need for improvement of the green on the main road through town Lasem, namely the northern coast road formerly known as the road Daendles. On the banks of the element in town Lasem, repairs can be done by planting vegetation in shaping the city limits Lasem, improvement district element can be done by going green in the Chinatown district. Repair nodes in the city Lasem done by planting vegetation on the crossroads contained in Lasem. And last, city landmarks, namely Lasem town square, the need for restoration to restore the image of the city. It is caused by irregularities in the form of land use change

into places selling food which eliminates image Lasem town square plaza.

Table1. Proposed criteria in repair image forming elements Lasem city

No	Elements of the city	Repair the city's image element	Criteria
1	Lasem Artery Path	Doing the layout of urban green in city arterial roads Lasem	<ul style="list-style-type: none"> - Using a typical Lasem vegetation to create continuity and identity of the city, such as <i>Azadirachta indica</i>, <i>Ziziphus mauritiana</i>, <i>Borassus flabellifer</i>, <i>Manilkara zapota</i>, <i>Mangifera indica</i>, <i>Limonia acidissima</i>. - Selection of vegetation in accordance with the Regulation of the
2	Lasem city edge	Doing green governance	<ul style="list-style-type: none"> - Using the appropriate type of vegetation in the transition area and the banks of the city Lasem - Planting can be done using several strata to clarify the boundaries
3	Chinatow n District Lasem	Doing green governance	<ul style="list-style-type: none"> - Using this type of vegetation typical of Lasem - Selection of the type of vegetation adapted to

			<p>the philosophy of Feng Shui aspect consideration in the Chinatown district</p> <ul style="list-style-type: none"> - Using this type of vegetation that is not too large because of the limitations of road widths in the Lasem Chinatown district
4	Nodes (road junction in the city Lasem)	Doing green governance and create a landmark	<ul style="list-style-type: none"> - Using this type of vegetation typical of Lasem - Vegetation has a distinctive character in the form of headers, structure, and color of the leaves and flowers - Creating a landmark

			<p>that characterizes nodes, such as a monument, street signs</p>
5	Landmark (Lasem town square)	restoration	<ul style="list-style-type: none"> - Returns the square Lasem approaching its original condition

Conclusion

To maintain the future of Lasem's site in the future, infrastructure optimization needs to be done by way of improvement of the image forming elements Lasem city. Repairs to do green governance in these elements, in addition to improving the city's image Lasem can also contribute in creating environmental improvements and hydrological town which in turn can reduce the impact of climate change is causing extreme heat and drought in Lasem.

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THE STUDY KAMPUNG KASEPUHAN CIPTAGELAR A NOMADEN COMMUNITY

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Abstract

Cultural rooted from an ancestor their the community Kampung Kasepuhan Ciptagelar located in Bogor, West Java Province, Indonesia is still awake, where the indigenous people often migrating the other names is nomaden, this as ordered from an ancestor customary Kampung Kasepuhan Ciptagelar in trust the almighty. The existence of the displacement the one area to a new areas in accordance wangsit from the almighty to the priests exclusive of an ancestor Kampung Kasepuhan Ciptagelar, where today their Kampung kasepuhan ciptagelar have 160 family head and quite large, Often displacement place live in accordance with of environment support in the new place, problem of environment has been increased if Kampung Kasepuhan Ciptagelar will intended located in conservation area.

The purpose of this research identify the factors that existence of the forest in Kampung Kasepuhan Ciptagelar community was meanwhile expected to increase the acquisition of land for the purpose of an indigenous people of will overlap to a forest conservation a Mount Halimun Salak National Park which is located next. For the conservator the existence of zone the nucleus a Mount Halimun Salak National Park will lose biodiversity therefore it needs to be assessed using qualitative descriptive methods to question research “Whether internal and external factors a residential area new ciptagelar indigenous people who always Nomaden?” And “can it be influenced the development of culture and have a negative impact on Mount Halimun Salak National Park ecological service “, Research study is expected to be the base of the management of habitats on biological diversity in the area in which it can be preserved for the future , in preserving landscape character customary Kampung Kasepuhan Ciptagelar, with did not result in the negative impact of for the community and the function of the zones as zone the nucleus of Mount Halimun Salak National Park.

Keywords : Kampung Kasepuhan Ciptagelar, Nomaden, Core Zone, Biological Diversity, Ecological Service, green infrastructure, urban farm.

1. Introduction

Kasepuhan The cultural values that develops and in Indonesia reflected in there are still many findings of their customary or Kampung Kasepuhan/ Culture Village. For example Kampung Kasepuhan Ciptagelar is one kasepuhan inhabited by indigenous people still revere traditions from generation to generation. Kasepuhan Ciptagelar characterized spatial arrangement which balanced in harmony with the nature and create some sort of natural beauty and their environment .

One of them is Kampung Kasepuhan Ciptagelar, located between the coordinates south 06° 47' 10,4" ; East Longitude 106° 29' 52" with altitude 1200 m above the sea level . the area of kasepuhan is 202 hectare. The number of community members ciptagelar kasepuhan a number of 160 families (disbudpar province data in 2010). Residents of kampung customary ciptagelar believed derived from the royal sunda located in pakuan padjajaran bogor districts approximately 648 years ago has done the displacement of one place to another in line with wangsit received and Kasepuhan ciptagelar inhabited by indigenous people still revere tradisinya from generation to generation.

The area that becomes the main area is the protected forest area of Mount Salak in developing manageable forest zones and protected forests by taking into account the conservation of natural habitats . With the application of descriptive cumulative method with reference of regulation and literature. By explaining all the state of existing to answer problems as follows :

1. The influence of displacement their Kasepuhan Ciptagelar affect ecosystem a Mount Halimun Salak National Park region.
2. The local wisdom Kampung Kasepuhan Ciptagelar but can keep the ecosystem stability to Mount Halimun Salak National Park region.
3. Green infrastructure such as what to support the buffer zone of Mount Halimun Salak National Park against the influence of Kampung Ciptagelar Kasepuhan

2. The influence of nomadenism from Kampung Kasepuhan Ciptagelar Community in Mount Halimun Salak National Park Regional

where the indigenous people often migrating the other names is nomaden, this as ordered from an ancestor customary Kampung Kasepuhan Ciptagelar in trust the almighty. The existence of the displacement the one area to a new areas in accordance wangsit from the almighty to the priests exclusive of an ancestor Kampung Kasepuhan Ciptagelar, In fact is pressure to control the population associated with capacity the environment a Mount Halimun Salak National Park are continuing to decrease. In line with tradition displacement done to avoid a decrease in the quality of its environment which then have an impact on disruption of order customs always they protected .

The explanation of Adimihardja,K .(1992), Kasepuhan growing over shed: Environmental management traditionally in the region Mountain Halimun, West Java (*Kasepuhan yang Tumbuh di atas yang*

luruh: Pengelolaan lingkungan secara tradisional di kawasan gunung halimun Jawa Barat), Explaining that the reason displacement Kampung Kasepuhan Ciptagelar never described clearly because only based on wangsit received chairman of customs and related to their belief called “uga”. Can be concluded Materialism approach can be used to assess the nature of the nomaden population as an effort to cope with pressures that can threaten the ecosystem within the Mount Halimun Salak National Park Region. When the pressure population increase and to outside influences start disturbed command wangsit to move come for a reason logical that is they did not maybe satisfy the needs of resources and production pattern limited around a national park guarded its ecosystem to balance ecosystem ecology.

3. The Local Wisdom Kampung Kasepuhan Ciptagelar in keep the ecosystem stability Mount Halimun Salak National Park region

The Kampung Kasepuhan Ciptagelar Community is an indigenous people very preserve nature and respect the environment. Another local knowledge Kasepuhan Ciptagelar relating to see how people perceive the role of available resources which includes the forest , land and water .

The management of a Mount Halimun Salak National Park region based on the system of local knowledge zoning kasepuhan ciptagelar divided some zone specifically as the following :

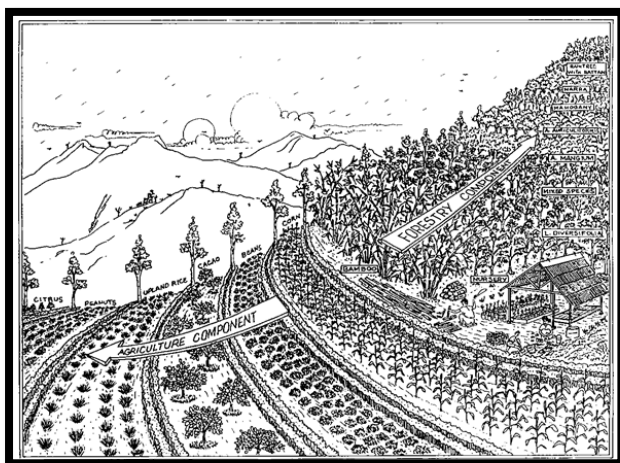
- a. **Strict Natural Zone**(Zona Hutan Titipan) Is a zone which should be protected and conserved.
- b. **Wilderness Zone** (Zona Hutan Tutupan), Is part of a national park that may be visited on a limited extent, with the regulations wholeness and authenticity fixed guaranteed,So construction permanent not allowed to these zones can protect core zone.
- c. **Tourist/Administrative Zone** (Zona Garapan), Is part a zone that can be further developed into zones of the plants producing that become the characteristics of kasepuhan ciptagelar, for example rice which is a symbol of trust to the goddess sri.

And according to Republic Indonesia Constitution Number 5 year 1990 In maintaining natural resource conservation biodiversity and its ecosystem .A national park is conservation areas that have original ecosystem. So that serves keep ekosistem a Mount Halimun Salak National Park region.

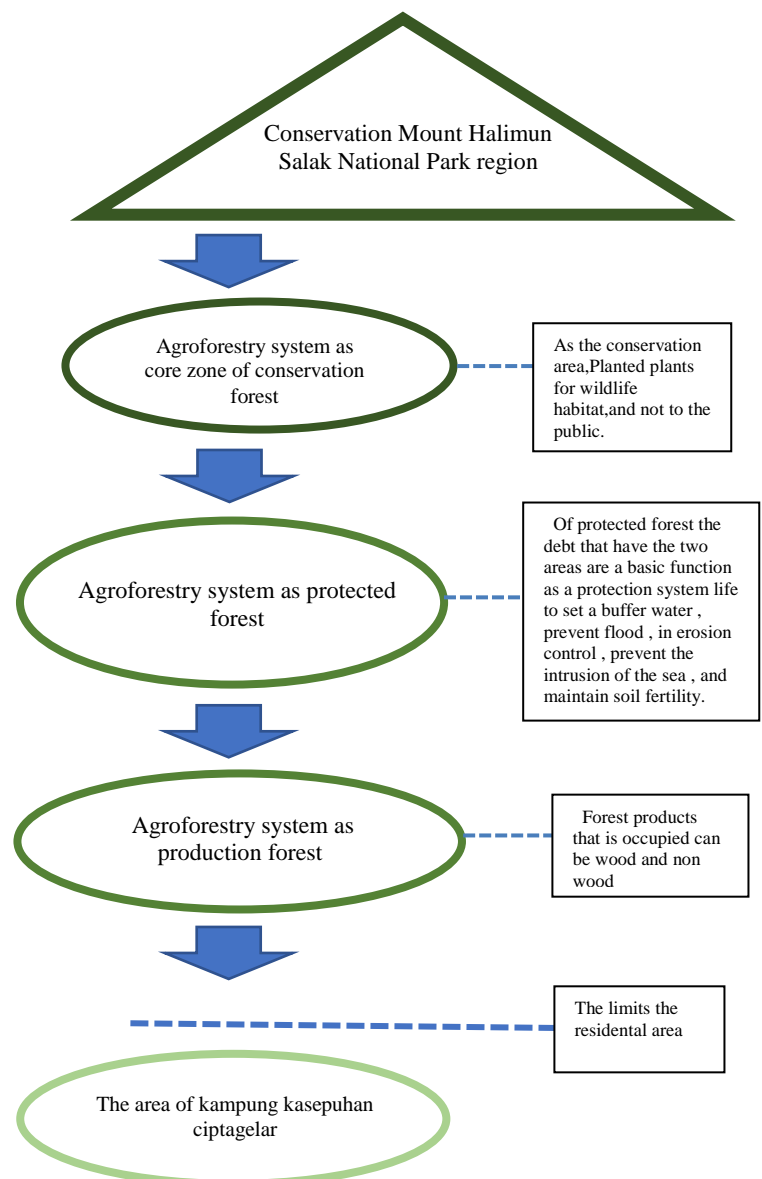
The purpose of study to increase urban farming in the area of a the Mount Halimun Salak National Park region by taking into account restricting factors that could be governance by a resident of kampung kasepuhan ciptagelar, and as one of overcoming the impact of the influence of Kampung Kasepuhan Ciptagelar a Nomaden Community.

Restricting factors as the determination of usage of space in order that the development of its inhabitants do not break the ecosystem a Mount Halimun Salak National Park, with the application of green infrastructure using agroforestry system. According to Huxley (1985) agroforestry is a system land management that combines between excess agriculture and forestry. Space common ground (interface) between trees and crops of is the key in the management of agroforestry. System infrastructure green with agroforestry as the division of the development of zona kampung kasepuhan ciptagelar against a Mount Halimun Salak National Park region in the form of the division of the woodlands from which is considered very protected down to the regions can be processed agricultural.

strategy of agroforestry system as buffer factor in regulating ecological environment of Mount Halimun Salak National Park region, source :



treeyopermacultureedu.wordpress.com



Conclusion

To keep a Mount Halimun Salak National Park ecosystem salak as conservation area and specific zoning designation for the development of space of the development of kampung kasepuhan ciptagelar by means of green infrastructure to optimize the use of the green agroforestry system other than easy to apply just because the forest and agriculture , also as ecological limiting factor in overcome the displacement Kampung Kasepuhan Ciptagelar in Mount Halimun Salak National Park region.

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Community-Based Ecological Network Construction for Wildlife Conservation Surround National Park: A Case Study of Wuyishan

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Abstract

With the purpose of biodiversity conservation, ecological network construction has been acknowledged as an effective way to improve environment quality and response to climate changes. on ecological network of city with the purpose of biodiversity conservation are focused on the habitat assessment and spatial planning, few consider operability of planning policy implementation. Wuyishan is in the southeast of China with high population density and Wuyishan National Park is located near it, facing the pressure from urban sprawl, tourism and tea industry. Although National Park has the boundary, the activity area of wildlife may go beyond the boundary. It is necessary to build an ecological network surround the national park for wildlife conservation. Considering the limit of funding and land ownership, this study focused on the community-based ecological network construction. A four-step framework is proposed. Namely, (1) Habitat suitability assessment of target species; (2) GAP analysis of conservation surround the protected area; (3) Identification of potential small nature reserves; (4) Development of community-based management strategy. *Neofelis nebulosa* is selected as targeted species considering the species representation and sensitivity. The distribution of suitable habitat areas is evaluated with habitat structure theory model by ArcGIS 10.2. From the GAP analysis of wildlife habitat conservation, potential small nature reserves are identified in suitable habitat in north part of Wuyishan City. In the end, from excavation of the traditional ecological protection idea of Fengshui Forest in the village with community participation, community-based management strategy will be developed. The study not only set up a technique framework for ecological network construction for protected areas near the city, but also establish a basic-line condition for future conservation and management.

Keyword: National Park, Urban Protected Area, Ecological Network, Community-based Management, Wuyishan

1. Introduction

Habitat loss and fragmentation have been identified widely as the major threats to biodiversity [1]. Island-like protected areas can no longer prevent the disappearance of species. Some studies indicate that habitat loss and fragmentation adjacent to protected areas can contribute to the local extinction of protected-area fauna [2]~[4]. Especially for urban protected areas, which are in or at the edge of city, are threatened by urban sprawl and intensification of urban development [5]. Ecological network construction surround the urban protected areas has been acknowledged as an effective way to improve habitat quality and response to biodiversity conservation under the background of climate changes [6]~[8].

In China, most researches on ecological network of city with the purpose of biodiversity conservation are focused on the habitat assessment and spatial planning [9]~[15], few consider operability of planning policy implementation[16]. It is ideal to protect all the potential wildlife habitat, considering the limit of funding and land ownership. In our study, we proposed a community-based ecological network construction framework for wildlife conservation surround the national park, in which to establish community-based small nature reserves is the main strategy.

Wuyishan is in the southeast of China with high population density and Wuyishan National Park is located near it, facing the pressure from urban sprawl, tourism and tea industry. Although National Park has the boundary, the activity area of wildlife may go beyond the park. It is necessary to build an ecological network for wildlife

conservation of national park. in Wuyishan. Wuyishan is located in the southern collective forest area, with the protection tradition of Feng-shui forest. Thus, Wuyishan is a typical case for exploring the community-based ecological network construction near the protected area in China.

This study focused on the gap analysis of conservation and community — based ecological network construction. A four-step framework is proposed. Namely, (1) Habitat suitability assessment of target species; (2) GAP analysis of conservation surround the protected area; (3) Identification of potential small nature reserves; (4) Development of community-based management strategy. The study not only establish a basic-line condition for future conservation and management, but also set up a technique framework for community-based ecological network construction for protected areas near the city.

2. Research Area

The research area is located in the northern section of the Wuyi Mountains in Fujian Province and borders Fujian and Jiangxi provinces. It is located at longitude 117°37'22" to 118°19'44" and north latitude 27°27'31" to 28°04'49". It is 70km long from east to west and 72.5km wide from north to south with a total area of approximately 2798km².

Surrounded by mountains in the east, west and north, Wuyishan City is a hilly area, in which the peaks and valleys are stacked and the central and southern parts of which are flat. The terrain is tilted from the northwest to the southeast, with the highest elevation

of 2158 meters above Huanggang Mountain and the lowest at Xingtian Town, with an elevation of 165 meters and a relative elevation of 1993 meters. Wuyishan is located in a subtropical monsoon humid climate zone with four distinct seasons, abundant sunshine, and abundant rainfall.

Wuyishan National Park preserves the largest, most complete, and most typical of the subtropical primary forest ecosystems in the world with the same latitude. It has a primary subtropical vegetation community and a typical vertical vegetation spectrum.

Wuyishan National Park has an extremely rich species. Most of the other latitudes in the world are deserted or have poor biological species, while Wuyishan Nature Reserve is rich in species and unique components, and is the center of species formation and differentiation in southeastern China [17] and a key area for the biodiversity of the continent southeast of China [18].

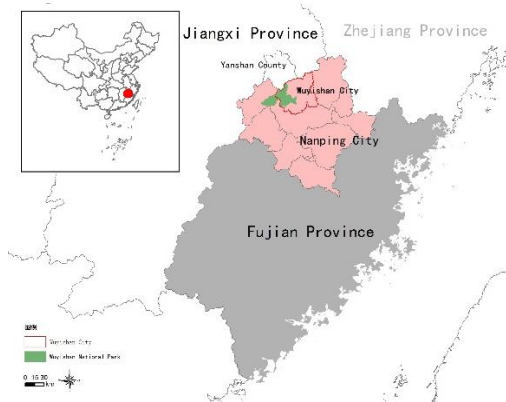


Fig. 1. Location of Wuyishan National Park.

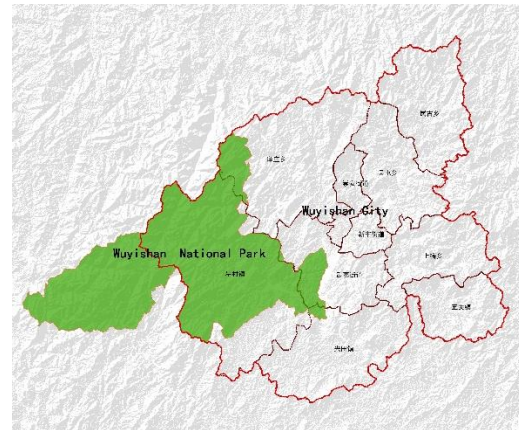


Fig. 2. Research Area.

3. Data and Methods

3.1. Data

Basic data includes land cover data, digital elevation model data, road data and boundary data. The condition of See the table below for details. Road data is refined by latest google map. The other data such as slope data is calculated by ArcGis 10.2.

Table. 1. Location of Wuyishan National Park

No.	Name	Time	Spatial resolution	Source
1	Land cover data	2010	30 m *30m	GlobeLand30 [19]
2	Digital elevation model data	-	30 m *30m	ASTER GDEM [20]
3	Road data	2016	-	Open Street Map [21]

4	Forest data	2016	-	Forest Department of Wuyishan City
5	Boundary data	2016	-	Wuyishan National Park Administration

3.2. Methods

Community-based ecological network construction framework concludes four steps. The main methods of each steps are listed as follows.

(1) Habitat suitability assessment of the target species

According to the current research in Wuyishan District, *Neofelis nebulosa* is the existing large Cat Predators, whose Habitat requirements can basically cover the protection of other species. *Neofelis nebulosa* belongs to the national first class protected animal and mainly inhabits the subtropical and tropical mountainous regions and the evergreen forests in the hills. The altitude of the distribution can range from low elevations up to 3000m in alpine forests. Thus, *Neofelis nebulosa* is chosen as the target specie for wildlife conservation in Wuyishan District.



Fig. 3. *Neofelis nebulosa* [22].

Habitat suitability of the target species is evaluated with habitat structure theory model by ArcGIS 10.2. The habitat structure theory model [23][24] takes physical environmental factors, biological factors and human activity factors into consideration. Habitat suitability assessment criteria is asset according the current research about the *Neofelis nebulosa* [25].

Table. 2. Habitat suitability assessment criteria of *Neofelis nebulosa*

Type	Factor	Suitable	Sub-suitable	Not-suitable
Physical-environmental factor	Elevation	1600 - 2158	1100 - 1600	165-1100
	Slope	0-10	10-50	50-80
Biological factors	Land cover type	Forest	Grassland; Crop land	Water body; Artificial surface
			500-5000	0-500
Human activity factor	Road Distance	Above 5000		

(2) GAP analysis of conservation

The GAP analysis of conservation is to quantitatively evaluate the status of protection and vacancies of *Neofelis nebulosa* in the surround the national park. The suitable natural habitat of the *Neofelis nebulosa* was overlapped with the established nature reserves in Wuyishan City to identify suitable

habitats with high conservation value but were easily disturbed by human activities in Wuyishan city.

(3) Identification of potential small nature reserves

The identification of potential small nature reserves is to identify the village collective forest located in the suitable habitats surround the Wuyishan National Park. Through the overlap analysis of conservation GAP space, forest distribution, boundary of villages of Wuyishan City, the potential small nature reserves can be identified.

(4) Development of Community Based management strategy

Community-based management strategy should be developed from excavation of the traditional ecological protection idea of Fengshui Forest in the village with community participation. The boundary and community-based management should be based on current administration boundary and consultation with local communities.

4. Result

4.1. Habitat suitability assessment

The habitat of *Neofelis nebulosa* is mainly distributed along the main ridge of the Wuyi Mountains. Around the Wuyishan National Park, the habitat suitable for *Neofelis nebulosa* is located in the high-altitude forest area of Yangzhuang Township in the north of Wuyishan City and Jiangxi Wuyishan National Nature Reserve in the north.

The fragmentation of *Neofelis nebulosa* suitable habitat is shown in the Fig.4. It shows that main railroad and national-level

road that pass through Wuyishan City are the main influencing factors, blocking national park from the eastern part of Wuyishan City.

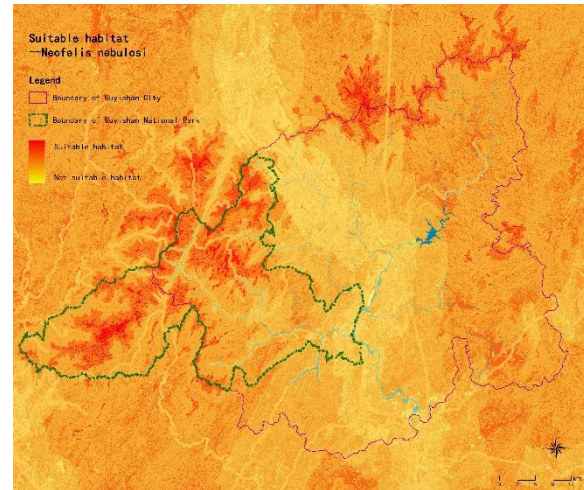


Fig. 4. Habitat suitability assessment of *Neofelis nebulosa*

4.2. GAP analysis of conservation

The number of protected areas established in Wuyishan City is small and the level is low. In addition to Wuyishan National Park, Wuyishan City only established Huanglongyan Provincial Nature Reserve and Donghu National Water Conservation Scenic Area. Huanglongyan Provincial Nature Reserve and Wuyishan National Park are the main cover the most of suitable habitat of *Neofelis nebulosa*. Near one third of suitable habitat is outside the current protected area. As is shown in Fig.5, the conservation GAP is in the west of Huanglongyan Provincial Nature Reserve. The current protected area is not enough to support *Neofelis nebulosa*.

4.3. Identification of potential small nature reserves

According to the habitat suitability assessment and GAP analysis of conservation, we can find the north part of

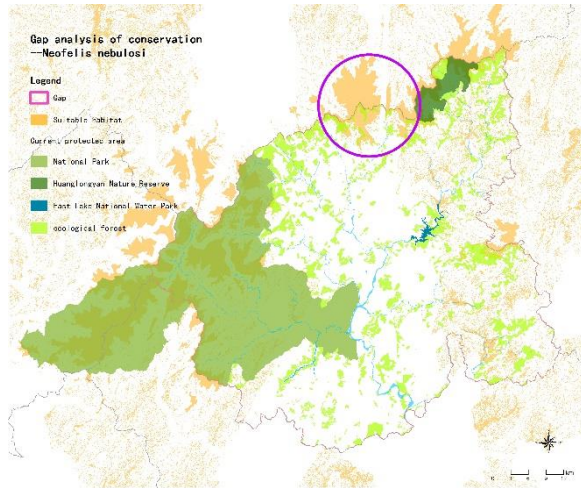


Fig. 5. GAP analysis of conservation of *Neofelis nebulosa*

Wuyishan City is suitable for *Neofelis nebulosa* while not protected by official protected area. The north part is the main corridor of ecological network surround the national park. Through overlap of suitable habitat, forest distribution map, village boundary, it can be identified Da'an Village, Xiji Village, Kenkou Village, Shangcun Village of Yangzhuang Township.

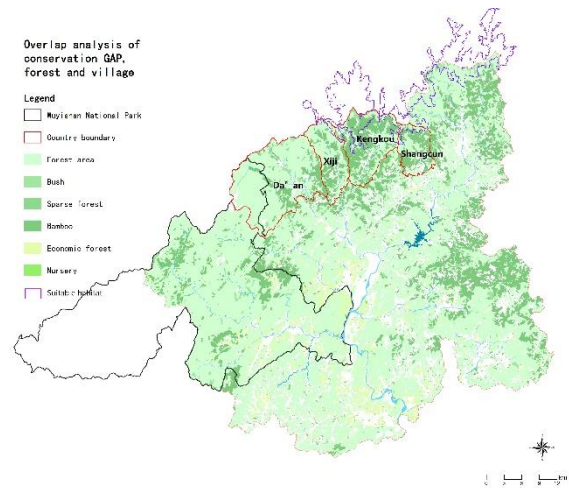


Fig. 6. Potential small nature reserves for *Neofelis nebulosa*

Small nature reserve in China is one of the best practice of community-based management [26]. They are the extension and complement for natural protected areas and have been doing indispensable work on protecting fragmentary wildlife habitats and improve management resilience. We suggest the government promote the forest of four villages to be small nature reserves.

4.4. Development of Community-based management strategy

Potential small nature reserves identified are located in the rural areas between Wuyishan City and national park. In the rural areas of Wuyishan district, the traditional customs of the conservation of Fengshui Forest are common. Fengshui forest conservation means that villagers protect the forest to conserve water resources and ensure agricultural production and living.

Almost every natural village in Wuyishan has fengshui forests such as village entrance

forests, forests along the river, etc. The protection of Fengshui forest has become a custom developed by villagers. Fengshui forest community self-government model is the wisdom of the community to protect forest resources for thousands of years, with village regulations as a guarantee, the villagers participating in mutual supervision. The traditional system of community self-government and the traditional knowledge of resource utilization should be tapped and integrated into the ecological network construction.

Inspired by the community autonomy management model of Fengshui Forest, the study proposes that to study the changes of the traditional system to improve community-based management of small nature reserve. Through the excavation and transmission of local knowledge, it may help to find new green growth points for community development. When the local residents of the community see the link between ecological network protection and livelihood improvement, they may become more respectful for nature and attach importance to ecological protection. The protection awareness of community residents can be mobilized and they can actively participate in the construction and management of ecological network.

5. Discussion

The study sets up a technique framework of 4 steps for ecological network construction for protected areas near the city considering community-based management. Wuyishan is a special case represent the south collective forest area with Fengshui Forest conservation custom. For the urban

protected areas in north or west of China, community-based management may consider the local culture and other factors.

In the assessment of habitat suitability part of our study, we found the suitable habitat is not only located in Wuyishan City, but also across the boundary of Fujian province. It reveals the importance of Cross-provincial protection mechanism for large cat mammals.

Neofelis nebulosa was chosen as the target specie in the study according partly by the limitation of time. Lack of the monitoring point data of wildlife, we applied habitat structure theory model to analysis. The spatial analysis can be deeply refined by add other rare and endangered species and monitoring data update.

Although our study has the limitation mentioned above, it establishes a basic-line condition for future conservation and management. In the future, with the improvement of public awareness of biodiversity conservation, community-based ecological network may be the main supplemental for wildlife conservation near the urban protected areas.

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Transforming Thermal Roads into Wind Bridges, A Case Study of Areas along Tokyo 2020 Marathon Route

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Abstract

With rapid urbanization in recent years, most metropolis are facing an increasing threaten of thermal environment and stagnated wind. Copious artificial structures keep influencing environment and weakening the resilience to climate change of cities, and among these, roads have contributed a lot while they were supposed to act as corridors for wind. Based on the result of recent experiments, the environment effect of green space and wind are closely related.

Present studies on urban wind and temperature condition mainly focus on green corridor systems creation in large scale, materials of road and buildings, relation between wind and city pattern and green belts' ecological effect. This study mainly focuses on exploring the specific space-related factors' function for forming and transferring wind in downtown areas and improve the air condition of local circulation. The factors include density and height of buildings, portion and pattern of passageways, and the arrangement of open space, and by calculated by CFD modelling technology. After modelling and simulating calculation, it forms an index system that could be used for specific site to evaluate the possibility to strengthen the wind with limited resources.

Marathon course is passing through or along many significant green open spaces and rivers in Tokyo which temperatures are relatively low. It also links the core of the city where the high-rises are crowded and air rarely flows, so the potential of transforming into a bridge to connect these two kinds of places and bring wind to larger areas of the city. Firstly, based on mapping and analysing city's temperature data of land surface along the route areas, sort out large areas with lower temperatures to be the origin of wind, mainly are parks and waters. Secondly, modelling the area by CFD analysis system to sort out places where wind stagnated most. Next, build an index system of factors that can influence wind condition and apply it into evaluating the potential of surrounding areas of chosen places by testing the factors to sort out most potential areas of forming and transferring winds. Then, apply the strategies to ameliorate the wind condition according to the previous factors and remodel the surrounded area. Based on the existing urban structure pattern and architecture layout, the microclimate can be improved by modified little factors value. Finally, simulates the effect of the improving proposals in computational fluid dynamical simulation system to testify the result.

This study forms a framework for bringing out the best in existing metropolitan environment to improve the wind and temperature condition, and provides a practical case of improving wind condition in existing urban environment.

Key words: CFD analysis; downtown environment; urban ventilation corridor; small environment; green infrastructure

1. Introduction

Tokyo is a metropolis with high construction density and now facing increasing threaten of thermal environment and stagnated wind. Copious artificial structures keep affecting environment and weakening the resilience to climate change of cities, making the city less and less comfortable for living while global temperature keeps rising. City's public spaces are important for citizens' daily life and environment has significant effect on public activities like gathering and sports. In Tokyo, heat island effect and the wind retard are most severe problem in downtown area, but it is also with high density of population and frequently used as various citizen activities including gathering and sports, these activities have relatively high requirements for air and thermal environment. Since the upcoming Olympics in 2020 will have marathon game around Tokyo downtown area and it is an opportunity to improve city environment and infrastructures, this is a juncture of exploring ways to improve the wind and thermal condition by transforming some vital points within the downtown area.

Many scholars have studied on city wind environment optimizing and forming city natural ventilation path. Since 1980s, researches on thermal comfort in outdoor environment increased because of increasing attention for pedestrians in urban canyons, plazas and squares. In specific calculating and modeling field, most researches concentrate on wind ventilation system of large scale [1], some focuses on single factor like geometry, trees[2], traffic or buildings'

arrangement. Olgyay[3] and Oke[4] focused on the interactions between building and microclimate design.



Fig. 1. Tokyo wind in a windy day(Downtown circled)

(Source: <https://air.nullschool.net>)

This study mainly focuses on how to stimulate a specific small-scaled city area's airflow in field of landscape and architecture, trying to find out ways for improving air ventilation condition by as less change from existing condition as possible.

2. Theory and methods

The function mechanism of forming partial wind bridge can refer to city ventilating theories in the fields of city planning, urban design, and ecology. In 1979, Kress R. put forward assessment standards for climatic function of underlying surfaces in city and classified city ventilating system into three parts, compensatory area, effect area, and ventilation path. The core of this theory is also in correspondence with source-sink-flow theory in environmental ecology. When studying wind condition in small scale, this theory is useful to help analyze the potential corridors and choose target areas to transform for improving wind environment.

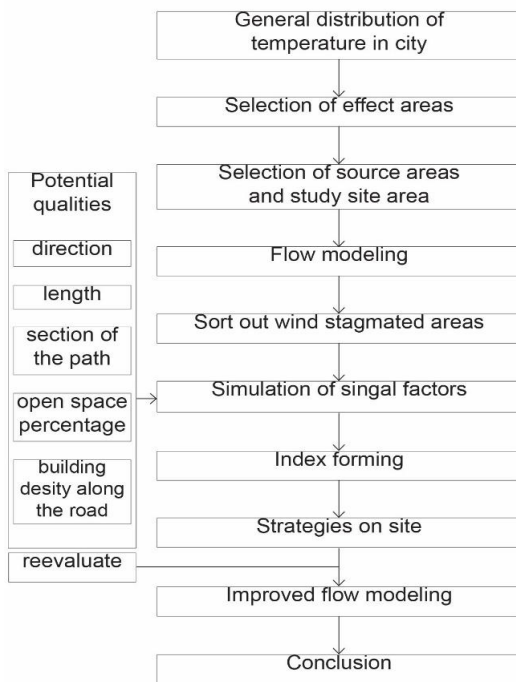


Fig. 2. Technology roadmap

In block scale and at pedestrian level, local circulation of wind is much more complex and needs sophisticated system to measure the methods of utilizing existing conditions like temperature, air pressure and building arrangement to create more comfortable air condition in specific areas. At the same time, city like Tokyo is not able to have spaces that are wide and open enough to create the city's wind corridor in large scale, so it is necessary to try to find ways to stimulate wind circulation in smaller areas. Since the Marathon course links most important areas for both sources and sink of wind.

Then the study selects a specific site in Tokyo downtown area and improve method system using the assessment to form wind bridges within the area.

The study mainly focuses on exploring what landscape can do under the existing condition of the city's structure and building

arrangement, figure out a framework for improving wind and temperature condition.

First, choose target areas to lead the wind. Secondly, select surrounded areas that have potential to be wind source. Then measure the spaces between these above-mentioned places to choose, modelling the site and using CFD model to simulate the wind condition and find the key points where wind is blocked and have potential to be improved. Next, Using CFD model to testify each kind of factor by control variable method. We sorted five influencing factors improved. Next, Using CFD model to testify each kind of factor by control variable and using CFD modelling to simulate how these affect wind circulations at stationary exterior wind condition. After testifying different influencing factors, propose modifying methods and apply them in the city model to recalculate the wind condition in same exterior environment.

3. Compensation area, effect area and paths

Based on the heat map of Tokyo downtown area and route of Marathon, sort out inferior areas with higher temperature along the route.

The basic lines for choosing potential places for forming the ventilation path in city scale is as followed. Firstly, relatively low temperature areas linked with targeted areas with road. Secondly, with flexible open spaces that could be rearranged and modified between source and sink. The research picks the core area of Tokyo between the Imperial Palace and Tokyo Dome, since the Marathon course in north part of this area is relatively stagnated wind and the Imperial Palace is the biggest cool area downtown, which make it the source of wind. After building the model of the site

and CFD simulation, we find out key points within the wind paths where the wind is stagnated.

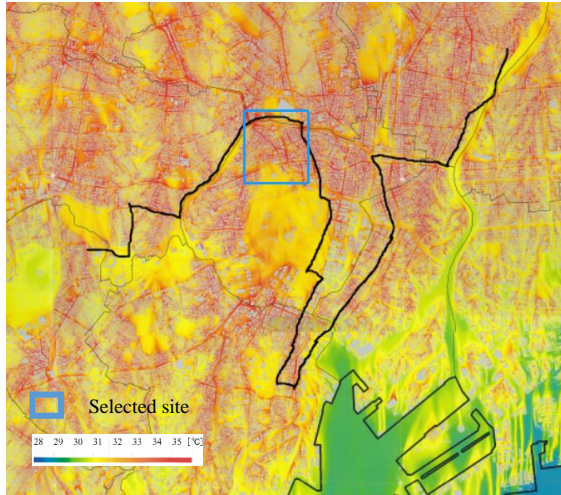


Fig. 3. Tokyo Heat Map
 (Source: National Institute for Land and Infrastructure Management of Japan)

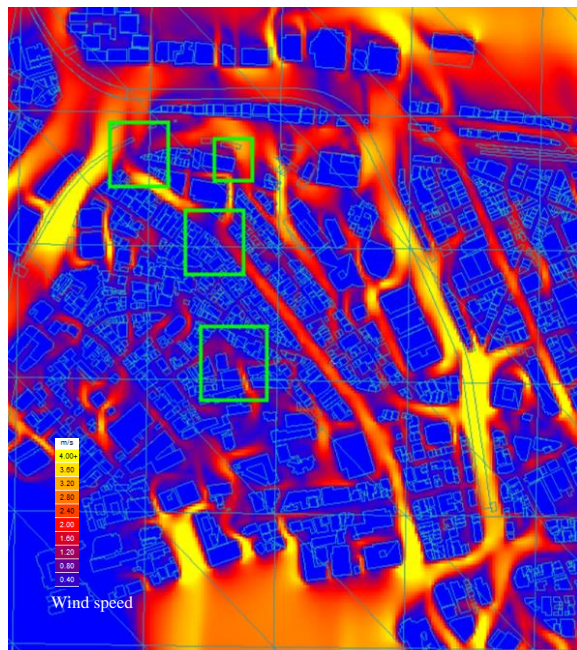


Fig. 4. Tokyo downtown wind simulation and key points

4. Wind related single factor effect simulation and index forming

According to current studies in environment field, factors that have influence on the city's wind condition and could be adjust in renovation scale rather than planning scale are mainly as follows: Density of structures within wind path, the arrangement of specific amount of structures, the rugosity of the building, the section of street including depth-width ratio and Roadside Structure pattern. Then forming an assessment table by simulating and contrasting each factor.

The study supposes to simulate the wind environment under Winair CFD calculating extension under Ecotect system. We set same wind direction and speed in all the single factor simulation to control the variate under same air volume. In order to ensure the degree of accuracy and control the stability of the weather factor, we set the same input and output air temperature, the same wind direction and same 2m pedestrian level's air condition in these five factors simulation to figure out how is the wind flow out in the urban street scale. In the simulation in this study, the colour ranges from yellow, red, purple to blue means strongest air flow to the breeze air flow.

In the study of getting more air flow run through the roadside buildings towards the target roads, we consider about three influencing factors including density of structures within wind path, the arrangement of specific amount of structures, the rugosity of the arrangement.

4.1 The Density of structures within wind path

We set up a number of same size building (10m×10m×15m) in the simulation. As shown in the fig.5, density of buildings in a

city area not only influence air temperature but also has impact on the airflow.

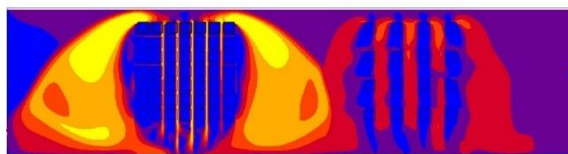


Fig. 5. The Density of structures within wind path

It can be noticed that for the simulation examined higher density buildings causes stronger output wind as we set up all the buildings with the same height of 15m and the same layout pattern. That means the road can get more air flow from the higher density roadside buildings. In this case, we should figure out some methods to reform the Marathon course roadside building into high density to enhance the air ventilation condition.

4.2 The arrangement of specific amount of structures

This simulation involves a number of same size buildings (10m×10m×15m). As shown in the fig.6, we change the arrangement of specific amount of structures with the same building height of 15m and the same number of the buildings.

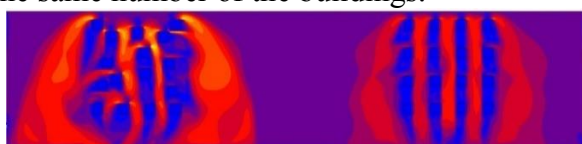


Fig. 6. the arrangement of specific amount of structures

It shows that comparing with regular pattern, the random pattern causes stronger output wind. That means changing the

arrangement of specific amount of structures into random pattern can supply more air flow to the target road. In the existing urban planning layout, the random pattern are much more than the random pattern.

4.3 The rugosity of the arrangement

As shown in the fig7, we change the height of the building model in the simulation with the range of 15m-30m to create 3 kinds of urban underlying surface. One is the flat underlying surface with 20m height buildings, one is regular rugosity underlying surface with 15m and 30m height buildings, another is random rugosity underlying surface with 15-30m height buildings. In this case, with the same arrangement of specific amount of structures, we get different underlying surface by change the height of buildings.

It shows that for the simulation examined random rugosity underlying surface causes strongest output wind while regular rugosity underlying surface causes stronger output wind than the flat underlying surface. That means with the relatively low range of roadside building height, it can create an underlying surface that allow more airflow to the target road. In this case, we should figure out some methods to reform the Marathon course roadside building's height at less reform into regular rugosity underlying surface to enhance the air ventilation condition.

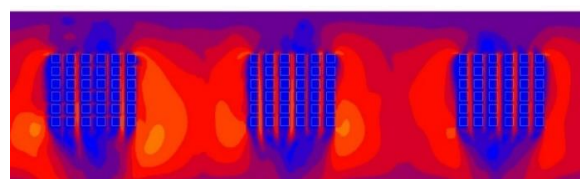


Fig. 7. the rugosity of buildings

4.4 Section pattern of streets

The section pattern of the target road also can be the influencing factors in affecting wind circulation along the target road. In this study, we consider about two kind of situations including depth-width ratio and Roadside Structure pattern.

As shown in the fig.8, we set up the same height of the roadside building with 40m, while change the width of the road width with 60m and 30m in order to get different Depth-width ratio of the target road. In this case, with the same arrangement of specific amount of structures, we get different depth-width ratio by changing the road width.

It is clear that when the value of the Depth-width ratio gets smaller, the air flow on the target road gets stronger. That means under suitable conditions, taking some measures to lower the depth-width ratio to some degree could help enforcing the wind along the target roads.

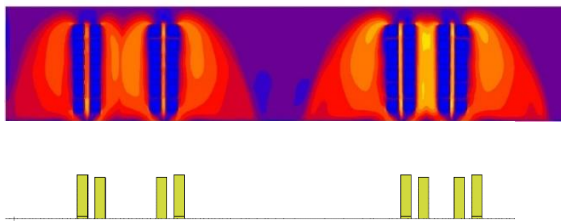


Fig.8. Depth-width ratio of streets

As shown in the fig.9, the purpose is not to change the road width anymore with the same road width 30m while setting up different roadside structure pattern by enhance the buildings forming a valley section model. The height of valley buildings is from 15m to 40m, while the control model is all with 15m height. In this case, the valley model seems supply an airflow tunnel in the simulation to allow the airflow. It clearly shows that the valley model buildings can allow more airflow

along the target road than the flat-arranged type of street.

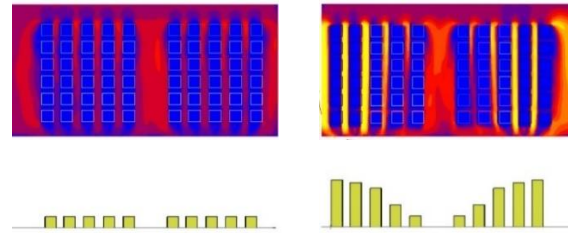


Fig. 9. Roadside structure pattern

That means we should try to figure out how to form the valley patterns in the roadside buildings by enhancing the building structure or adding some infrastructure on the building roofs to enhance the air ventilation condition.

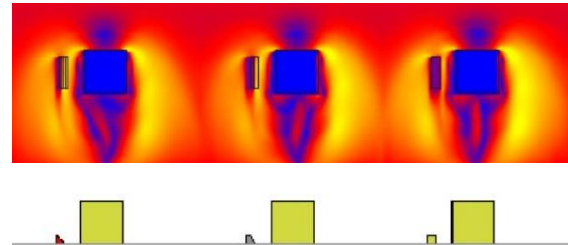


Fig. 10. Continuous structures of different section

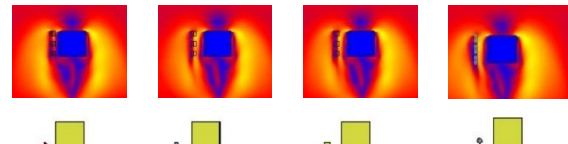


Fig 11. Separated structures with trees and shrubs combine

The small size structures on the target road also affect the airflow condition, the structures can be supposed to be green space, some structures, even landscape sketches. We set up different shape of the structures to simulate the airflow by controlling the structures size with around 10mx10mx10m. In this case we set up the model in 3 types, one is continuous structures alone the road (fig.10), one is

separated structures, another one is combine trees and shrubs (fig.11).

As shown in the fig.10 and 11, the structures with bevel shape can form stronger wind than the structures with flat shape. In addition, the continuous structures (fig.10) allow stronger airflow along the target road than the separated structures. And the trees and shrubs combined together (fig.11) also allow stronger wind flow than the separated structures.

That means we should try to figure out some method to build some continuous structures with bevel shape or just plant more trees and shrubs groups to allow more airflow to the target road.

4.5 Index of wind bridge forming

After single factors' simulation, the single factors can get score according to the superiority for ventilation. When adapting the research to practical renovation in urban design and landscape design, the difficulty of modify should also be considered. The conclusion of this index for picking factor to improving wind condition in small scale is as follows. Strengths and Weakness assessment is based on how the factor help with strengthen local circulation in pedestrian level.



Element	specific	Inferior-----superiority
Arrange-ment of structures	Building density	High Low
	Rugosity	
	Layout pattern	Scattered ranks
Section shape of the path	Depth-width ratio	Large Small
	Roadside Structure pattern	

Fig. 12 Space factors in suitability for ventilation

Table. 2. The difficulty of modifying the factor

Element	Specific	Degree of difficulty
Arrangement of structures	Density	4
	Average height	3
	Rugosity	3
Section shape of the path	Depth-width ratio of streets	5
	Roadside Structure pattern	4
	Heat absorption Coefficient	Surface material
Flat greening rate		2
Vertical greening rate		2
Open space planning	Spacial pattern from	3

The number in degree column describes degree of difficulty in transformation. One means the modification is in design level, with plants or structures or facilities, by using one method to achieve. Two is also in design level such as plants, structures, facilities, using two or more methods to achieve. Three is in systematic level, which involves amendment in urban design. Four is in planning level and five means hardly to be changed. In this study, however, we simulate only special factors and leave out material elements such as heat absorption coefficient.

5. Adapting methods in selected site

5.1 Existing condition analysis

The site is located at Chiyoda district and north of The Royal Palace. The large green space in Imperial Palace is a low temperature zone that can bring cooler

airflow to the high temperature areas. In this way, the air flows spontaneously to warmer areas of the surrounded area.

The area is about 1000 thousand square meters, and the main road in this area is about 3000 meters long, and the width of the all roads range from 10m to 60m. The height of the building in this area is from 10 meters up to 150 meters. Most of the buildings are business buildings. The road are mainly double vehicular roads with bicycle lane and single vehicular roads with bicycle lane. Some of the roads has lane separator with bushes and trees, but there is few big shade trees on the main roads.

5.2 Specific strategies for improving ventilation

On this route, the roads that run south and north mostly have a relatively good airflow condition, the surface temperature also gets lower than the roads run west and east. So mainly focus on how to lead the wind to the roads with directions not conform to predominant wind direction of the city in summer.

For target areas, we use three main strategies, adding stair-shaped facilities along the road, making wind path in block areas, and changing rugosity of the building by placing small blocks like flower beds above the buildings.

The figure below shows one strategy of adding stair-shaped structure in the street to stimulate the wind, which can also be the place for recreation.

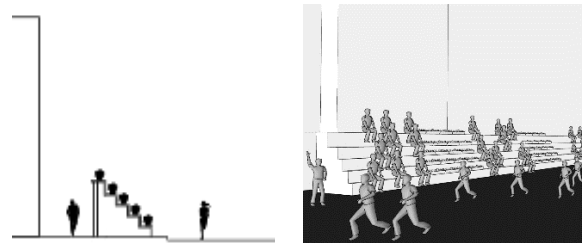


Fig.13. Strategy schematic example

5.3 Ventilate effect simulation

After the modification, the simulation shows where the wind gets stronger under the same input situation clearly.

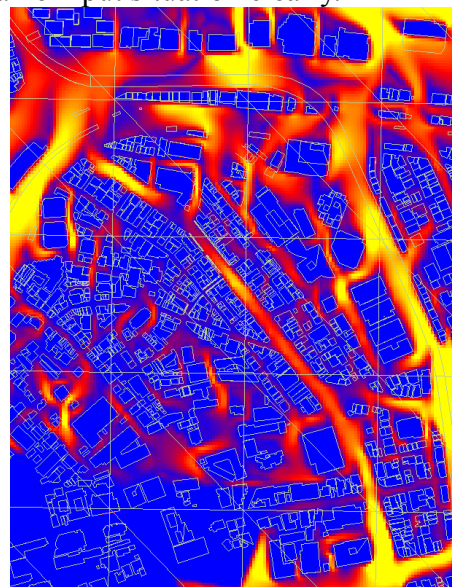


Fig.14. Simulation after modification

As showed in enlarged pictures, the stair-shaped facilities strengthen the wind greatly and affect the wind of few miles. By simply opening part of the first floor of blocking building, the wind is strengthened tremendously.

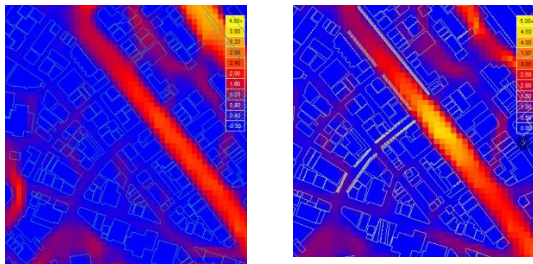


Fig.15. Contrast of original wind and modified in section

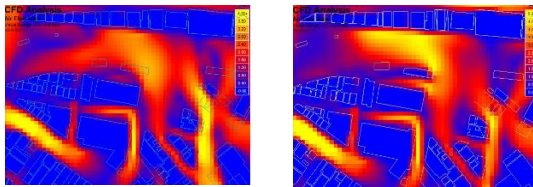


Fig.16 Contrast of original wind and modified in path

6. Discussion

By studying the possibility of modifying small-scale space elements to stimulate wind, the study testifies the methods in landscape design scale and forms an index for variable factors in space based on CFD modelling. In the application of the methods in specific site, the factors plays an important role in improving the wind condition of the site.

On the other hand, limited by the data source of climate and ventilation environmental science methods, the result of the simulation are limited. Mainly focus on space related factors and simplified the model of variable factors when simulating. The background climate condition in the simulation is not exactly as the actual situation because of lack of data and calculation methods.

Although the study has limitations mentioned above, the index of space related factors gives future urban renovation and landscape design a new perspective of considering the possibility of improving city

environment from tiny points and make tremendous difference in downtown area of metropolis.

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Upsurge, Misconception, and Prospect: Brownfields Regeneration in Landscape Architecture in China

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Abstract

The number of brownfields regeneration projects has increased dramatically in recent years in China, and more and more landscape architecture professionals found themselves involved in them. Based on statistics of articles published by the three key professional journals in China in the past 15 years, it can be observed that the number of articles focused on brownfields regeneration increases steadily every year. Among important professional awards given by CHSLA and ASLA, many were awarded to brownfields projects. Through analyzing the ASLA awards for the past 5 years, it can be found that almost half awards-winning projects are brownfields regeneration efforts. However, under such upsurge, we shall be cautious of couple dangerous misconceptions that have appeared in the public realm which either exaggerate or diminish the role of landscape architecture in relationship to site remediation of brownfields projects. During the 2016 International Conference on Brownfields Regeneration and Ecological Restoration held in Beijing, a declaration was passed unanimously by all attendees in which six principles were written out to guide future actions.

Keywords: architecture; brownfields regeneration; journal; professional awards; declaration

In recent years, brownfields regeneration projects have attracted much attention in the field of landscape architecture in China. A number of key academic conferences have set up forums or keynote speeches focusing on the theme of brownfields. Major domestic academic journals have also used brownfields restoration and related issues as topics or themes. With the issuance of the “Action Plan for Soil Pollution Prevention and Control” and the “Polluted Sites Soil Environment Management Measures (Trial)” and other related policy documents, the brownfields regeneration projects in China are rapidly

increasing, and more and more landscape architecture professionals are participating in them. However, brownfields is still a relatively new and unfamiliar field and China’s relevant regulations are still unsound. Therefore, some dangerous misconceptions we need to be cautious of have also been exposed in the rapid outbreak of brownfields regeneration practice. Under the current context, what are the prospects for landscape architects in brownfields regeneration process and what should be paid attention to are essential issues that we need to constantly ponder and discuss.

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1. Upsurge: The increasing attention on brownfields regeneration in landscape architecture

1.1. The number of brownfields-related articles published by major domestic professional journals has steadily increased

Based on statistics of articles published by the three key professional journals of landscape architecture, “Chinese Landscape Architecture”^①, “Landscape Architecture”^② and “Architecture Frontiers”^③, it can be observed that in the 15 years from 2001 to 2015, the number of articles focused on brownfields regeneration reached a total of 105, representing an increasing trend year by year (Fig. 1).

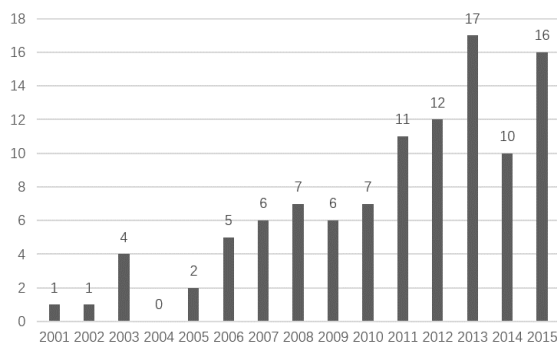


Fig. 1. Number of published articles related to brownfields in China's three major landscape architecture journals from 2001 to 2015.

There are two issue with brownfields as the theme in “Chinese Landscape Architecture”, namely “Brownfields Restoration” in February 2013 and

“Brownfields Regeneration” in April 2015, which were both organized by the first author. Three other issues also focused on similar areas, including “Waste Land Renovation and Reconstruction” in February 2008, “Ecological Restoration” in August 2011, and “Mining Heritage” in July 2012.

Among the above-mentioned brownfields-related articles, 47 were project introduction, accounting for 44.8% of the total approximately. The focus of articles on brownfields regeneration project is mainly landscape design and ecological restoration, in addition to restoration technology, brownfields management, industrial heritage protection and etc.. From the perspective of project location, more than half of the brownfields regeneration projects introduced are located in China, which mainly distributed in Shanghai, Wuhan, Beijing and Shandong. Foreign ones mainly include projects in the United States, Australia, Germany, and UK (Fig. 2). From the perspective of project categories, 22 vacant lands of industrial and infrastructure facilities accounted for nearly half of the total, and 14 mining waste lands (Fig. 3). The projects of high concern include the London 2012 Olympic Park, the Duisburg Nord Landscape Park in the Ruhr, the Gas Works Park in Seattle, Fresh Kills Park in New York, and the South Lake Ecological Park in Tangshan city.

^① Founded in 1985 and hosted by CHSLA, “Chinese Landscape Architecture” is a “Chinese Core Journal” and “Chinese Core Journal of Science and Technology”. It is also a cooperative publication authorized by the International Federation of Landscape Architects (IFLA) in China.

^② Organized by the Ministry of Education and hosted by BJFU, “Landscape Architecture” was founded in 1985. It mainly publishes design practice and academic research articles in landscape architecture and related disciplines such as architecture and urban planning.

^③ Organized by the Ministry of Education, hosted by Higher Education Press and Peking University, and prepared by the School of Architecture and Landscape Design of Peking University, “Landscape Architecture Frontiers” (bimonthly) was founded in February 2013. It is published bilingually in Chinese and English.

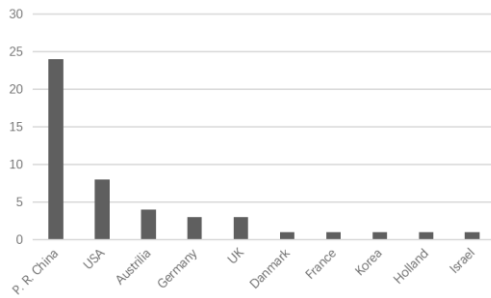


Fig. 2. Distribution of projects location in the project introduction articles of brownfields in China's three major landscape architecture journals from 2001 to 2015.

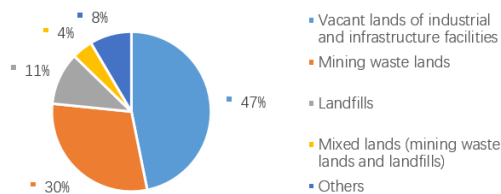


Fig. 3. Project categories in the project introduction articles of brownfields in China's three major landscape architecture journals from 2001 to 2015.

1.2. Brownfields projects have won significant professional awards at home and abroad.

The "Outstanding Landscape Engineering Award" and "Outstanding Landscape Architecture Planning and Design Award" awarded by the Chinese Society of Landscape Architecture (CHSLA for short) from 2010 to 2015, and the "General Design Award" and "Analysis and Planning Award" awarded by the American Society of Landscape Architects (ASLA for short) during the same period of time have been selected for statistical analysis in this research (Table 1).

Table. 1. Comparison of Basic Information of Statistics Awards between CHSLA and ASLA.

	CHSLA Outstanding Landscape Engineering Award	CHSLA Outstanding Landscape Architecture Planning and Design Award	ASLA General Design Award	ASLA Analysis and Planning Award
Award Criteria	1) It must be a new project that has been proved qualified, and no quality problems and hidden dangers are found after a management period or warranty period for one year; 2) With more than 30,000 m ² in size or more than RMB 10 million in cost; 3) Comply with the national and professional design standards and specifications; 4) Meet the national and professional construction technical specifications and relevant technical requirements.	1) The projects should conform to the relevant national laws and regulations, guidelines and policies as well as relevant technical standards and specifications; 2) Adhere to the principle of "ecological, low-carbon, applicable, aesthetics and safe"; 3) The content, depth and quality of the planning and design documents meet the requirements and the construction needs, and the architectural nature and purpose of use is clearly set in these documents.	1) The quality of design and implementation; 2) Context and environment background; 3) Environmental sensitivity and sustainability; 4) The project has been built; 5) Value to clients, the general public and other designers.	1) The quality of analysis and the depth of planning; 2) Context and environmental background; 3) Environmental sensitivity and sustainability; 4) The possibility of successful implementation; 5) Value to clients, the general public and other designers.
Reviewers	It is composed of experts hired by CHSLA who are familiar with the landscape engineering.	The landscape architects shall possess senior professional titles with more than 20 years of work experience, and have a certain influence on and academic attainments in the professional field, and in good physical health. The age shall not exceed 70 in general, but no age limit for academicians.	The wide-ranging jury shall be selected from representative professions, including private and public institutions and academic practice, varying from professional experience, geography, gender, ethnic diversity and etc.	

Brownfields regeneration projects are divided into four categories for statistical purpose: vacant lands of industrial and infrastructure facilities, mining wastelands, landfills, and comprehensive reclamation of river basins. Among which, the projects of comprehensive reclamation of river basins mainly refer to the projects that clearly indicating in the project descriptions that there are illegal waste dumps and other pollution sources in its basins, but the projects are dominated by water pollution control or water system dredging.

1) Professional awards awarded by CHSLA

The “Outstanding Landscape Engineering Award” is set up by CHSLA. The award winners are landscape projects or traditional garden buildings that were built by formal members of CHSLA in China after a management period for one year. About 200 awards are awarded each year. A total of 1,145 Outstanding Landscape Engineering Award were awarded from 2010 to 2015. Among them, brownfields regeneration projects account for 4% to 12% of the total each year. The awards-winning brownfields projects are dominated by comprehensive reclamation of river basins, accounting for 91%. Thus it can be observed that the projects focusing on soil pollution remediation are still very limited (Table 2, Fig. 4, Fig. 5).

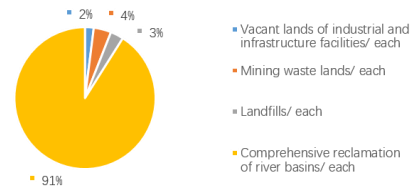


Fig. 5. The percentage of various categories of the brownfield projects in the CHSLA Outstanding Landscape Engineering Awards from 2010 to 2015.

The “Outstanding Landscape Architecture Planning and Design Award” is another important professional award awarded by CHSLA. It has been selected once every two years since 2011, and 285 projects have been awarded in 3 sessions so far, among which the brownfields regeneration projects in the 3 sessions were accounted for 11%, 6.1%, and 10.5% respectively, with an average of 9 awards per session. Among the brownfields regeneration projects that won the Planning and Design Award, the projects of comprehensive reclamation of river basins also accounted for the largest part, reaching 62%, followed by landfills projects (Table 3, Fig. 6 and Fig. 7).

Table. 2. Number of Brownfields Projects in CHSLA Outstanding Landscape Engineering Awards from 2010 to 2015.

	2010	2011	2012	2013	2014	2015	Total
Vacant lands of industrial and infrastructure facilities	1	0	0	0	0	0	1
Mining waste lands	1	1	0	1	0	0	3
Landfills	1	0	0	0	0	1	2
Comprehensive reclamation of river basins	12	6	7	6	18	12	61
Total number of brownfields regeneration projects	15	7	7	7	18	13	67

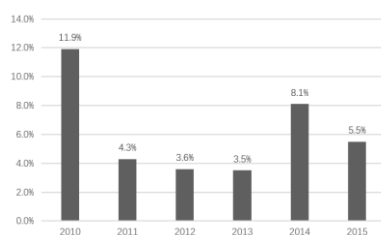


Fig. 4. The percentage of the brownfields projects in the CHSLA Outstanding Landscape Engineering Awards from 2010 to 2015.

Table. 3. Number of Brownfields Projects in CHSLA Outstanding Landscape Architecture Planning and Design Awards from 2010 to 2015.

	2011	2013	2015	Total
Vacant lands of industrial and infrastructure facilities	1	0	0	1
Mining waste lands	2	2	0	4
Landfills	1	1	3	5
Comprehensive reclamation of river basins	4	3	9	16
Total number of brownfields regeneration projects	8	6	12	26

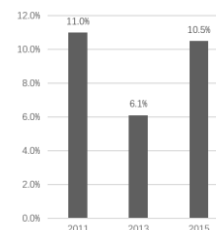


Fig. 6. The percentage of the brownfields projects in the CHSLA Outstanding Landscape Architecture Planning and Design Awards from 2010 to 2015.

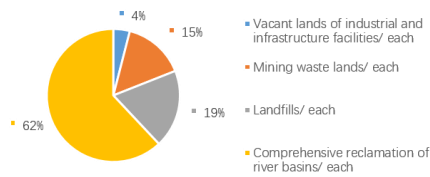


Fig. 7. The percentage of the brownfields projects in the CHSLA Outstanding Planning and Design Awards for 2011, 2013 and 2015.

2) Professional awards awarded by ASLA

Founded in 1899, the American Society of Landscape Architects (ASLA) has more than 100 years of history, representing professionals from 50 states in the United States and 42 countries worldwide. The annual ASLA Professional Award is one of the most influential landscape architecture professional awards in the world, including the General Design Category, Analysis and Planning Category, Residential Design Category, Communications Category, Research Category and Landmark Award. Only the General Design Category and the Analysis and Planning Category were selected for statistical analysis in view of the purpose of this study.

ASLA awarded 61 “General Design Awards” from 2010 to 2015, including 27 brownfields regeneration projects, accounting for 44.3% of the total. The projects of vacant lands of industrial and infrastructure facilities accounted for 70% (Table 4, Fig. 8 and Fig. 9). At the same period of time, ASLA awarded a total of 51 “Analysis and Planning Awards”, among which brownfields projects also accounted for about 33.3%. In this category of awards-winning brownfields regeneration projects, the projects of vacant lands of industrial and infrastructure facilities reached up to 70% (Table 5, Fig. 10 and Fig. 11).

	2010	2011	2012	2013	2014	2015	Total
Vacant lands of industrial and infrastructure facilities	4	3	3	3	5	1	19
Mining waste lands	0	0	1	0	0	0	1
Landfills	0	0	1	1	0	2	4

Table. 4. Number of Brownfields Projects in ASLA General Design Awards from 2010 to 2015.

Comprehensive reclamation of river basins	1	0	0	1	1	0	3
Total number of brownfields regeneration projects / each	5	3	5	5	6	3	27

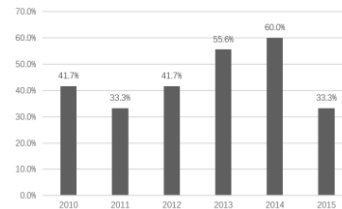


Fig. 8. The percentage of the brownfields projects in the ASLA General Design Awards from 2010 to 2015.

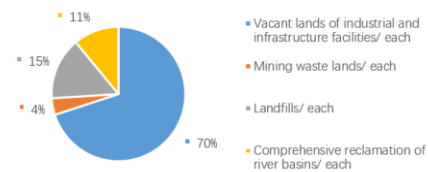


Fig. 9. The percentage of various categories of the brownfields projects in the ASLA General Design Awards from 2010 to 2015.

Table. 5. Number of Brownfields Projects in ASLA Analysis and Planning Awards from 2010 to 2015.

	2010	2011	2012	2013	2014	2015	Total
Vacant lands of industrial and infrastructure facilities	0	2	3	4	2	1	12
Mining waste lands	0	0	1	0	0	0	1
Landfills	0	1	0	0	0	0	1
Comprehensive reclamation of river basins	1	1	1	0	0	0	3
Total number of brownfields regeneration projects	1	4	5	4	2	1	17

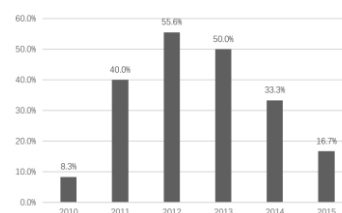


Fig. 10. The percentage of the brownfields projects in the ASLA Analysis and Planning Awards from 2010 to 2015.

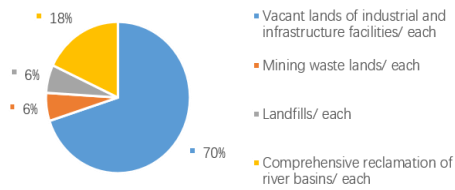


Fig. 11. The percentage of various categories of the brownfields projects in the ASLA Analysis and Planning Awards from 2010 to 2015.

It can be seen that in the "General Design Awards" and the "Analysis and Planning Awards" awarded by ASLA, the proportion of brownfields projects is much higher than that of the brownfields projects awarded by CHSLA. Taking the projects of vacant lands of industrial and infrastructure facilities as the main part, it attaches more attention to environmental issues and soil pollution remediation.

2. Misconception: Be cautious!

2.1. Misconception 1: "As long as the trees are planted, the brownfield site is clean and the process can be very quickly."

Due to the special restrictions of brownfield sites, and the advantages of outdoor open space featuring low cost, short cycle and flexibility of programs, there are indeed a large number of brownfields projects that take urban parks as the end use for transformation and regeneration [1]. However, we must avoid a misconception. That is, as long as we plant trees on brownfields and we have green plants, the brownfields will be "greatly turned", and people can feel relieved to use them. Meanwhile this process can be very short, and the shorter the time is, the more "great" the achievement is.

One extreme example: the explosion in the Tang Gu Development Zone in Tianjin

Binhai New District on August 12, 2015 was a tragic accident that caught the attention of the whole world, causing 165 deaths in total. The explosion took place in the area of dangerous cargo warehouses. The magnitudes of two successive explosions were equivalent to 3 tons of TNT and 21 tons of TNT, respectively. However, in less than a month after the explosion occurred, the conceptual plan for transforming the accident site into an ecological park was posted for input from the general public on the internet on September 5. Regardless of whether it is possible to make a landscape design that pays tribute to the deceased and recounts the painful lessons in a month, the pollution distribution and composition investigation of the accident site alone can be very intense or even difficult to accomplish. It is really worrying that in the absence of the pollution information, the opinions of more than 400 citizens were mainly concentrated on the "planning and construction of ancillary facilities, transportation links on both sides of the Haibin Road, and the noise effect of the Haibin Road" [2]. There was neither a questioning about the pollution situation after the explosion of dangerous cargo warehouses, nor a query on how to carry out pollution remediation in the plan.

Charles Waldheim, former chair of the Department of Landscape Architecture at Harvard University in the United States, once pointed out that in the contemporary landscape architecture practice, the landscape system has been used as "a healing balm for wounds made in the industrial age" with its remarkable corrective effect [3]. However, we cannot regard the landscape as a "green patch" that handles brownfields problems in an oversimplified and crude way. Not all the places with "brown scars" can be quickly healed by the "green patch" with "eco-label". The landscape project of brownfields regeneration is much more complex than that of general sites in the early stage of site analysis and investigation. The design process also requires close cooperation with

the remediation process of environmental engineering. The project timeline must follow scientific and objective laws. Landscape architects can and should play a greater role in brownfields regeneration, but meanwhile it is necessary to avoid playing down the complexity and difficulty of transforming the brownfields into parks under the pressure of market development. Whether within the field of landscape architecture, or facing the government officials, developers and the general public, we must be alert to the spread of this misconception.

2.2. Misconception 2: "The original commercial development was changed into an ecological restoration park, and pollutants have not been eliminated."

It is necessary for us to avoid insufficient understanding of the complexity and difficulty of brownfields regeneration landscape projects. Meanwhile, there is another misconception we need to be wary of, that is, the transformation into landscape end use is not a good solution to polluted sites.

Another example of national concern is also thought-provoking. Changzhou Foreign Language School has been in dispute and turmoil since its relocation to a new site in 2015. More than 400 students had abnormal symptoms such as dermatitis, eczema, bronchitis, abnormal blood parameters and leukopenia. Some students were also diagnosed with malignant diseases such as lymphoma and leukemia. The problem was an empty "toxic land" separated only by one road from the school's new site. After investigation, the site was once home to three pesticide chemical plants including Changlong Chemicals. It is reported that pollutants mainly composed of organic pollutants such as chlorobenzene and carbon tetrachloride have been detected in the soil and groundwater of the vacant land with an amount far exceeding the general standard.

The following discussion focuses on the analysis of the reasons causing such serious consequences in major public media after the outbreak of the incident. Basically including: First, the new school site is too close to the polluted land, which does not comply with the national regulations; Second, the school used groundwater, violating the regulations of the environmental assessment report; Third, the excavation of soil made the organic matter to evaporate and thus the pollution spread more quickly; Fourth, "the original remediation plan was changed from soil excavation to clay covering, and the original commercial program has also been transformed into an ecological leisure park. For such soil remediation, some experts believe that pollutants have not been eliminated and that it is still an environmental bomb under the ground sooner or later."^[4]

The last reason needs special attention and vigilance. Although the methods and techniques for soil remediation are diverse and polluted soil can be transported out, in fact, they are more encouraged to be treated in-situ or on-site to reduce the risk of secondary pollution. The "Polluted Site Soil Environment Management Measures (Trial)" clearly stated that "management and remediation should, in principle, be carried out on site." The purpose of site remediation is no longer in the phase of "complete elimination" of pollution. Currently the more commonly used strategy internationally is site remediation based on risk assessment, that means to take the risks to the environment and human body will be controlled within the safety zone as the purpose of pollution control. Due to huge pressure on capital, time cycle and technology, the method of "completely" eliminating site pollution in the early phase led to delays in the cleanup and transformation of many brownfield sites. It is misleading to include the "original commercial program has also been transformed into an ecological leisure park" in the reasons, as if suggesting that ecological

leisure parks have shortcomings in pollution remediation. However, the fact is that no matter what the end use of the final transformation is, as long as appropriate remediation methods are adopted, the pollution remediation of the site can achieve the expected goal.

3. Prospect: Action Plan

The theme of the “Chinese Landscape Architecture” journal in February 2013 was “Brownfields Restoration”. Professor WANG Shaozeng, the late chief editor, wrote in the Editor’s Words: “I suddenly realized that this (“brownfields restoration”) is the most important contribution our discipline has made since 20th century... After several years, brownfields restoration may be the most important job in the field of landscape architecture.” Professor Waldheim of Harvard University also told the author during his term as the chair that he believes brownfields projects should be chosen as the research subject in landscape design studios at Harvard Graduate School of Design, because we should no longer teach students to build on green lands that need protection. In the face of such a pressing demand for brownfields regeneration effort, what are the cutting-edge academic thinking and successful practices at home and abroad? What aspects should we focus on in future actions?

On September 10 to 11, 2016, the 2016 International Conference on Brownfields Regeneration and Ecological Restoration was held at Tsinghua University with the theme of “Brownfields Regeneration and Healthy Cities”. As one of the important academic activities of the 70th anniversary of the School of Architecture at Tsinghua University, the conference was co-organized by the School of Architecture of Tsinghua University, the Technology and Environment Center of Harvard Graduate School of

Design, and the Foreign Economic Cooperation Office of the Ministry of Environmental Protection, and was hosted by the Department of Landscape Architecture of the School of Architecture at Tsinghua University. The conference set up five forums, including themes on policies and regulations, win-win cooperation, design and technology, ecological restoration, and international experience and exchanges. 24 invited speakers from the United States, the United Kingdom, Germany, Israel, and China conducted inspiring speech and had lively exchanges and discussions with more than 250 delegates on policy, practice and theoretical issues in the field of brownfields regeneration. The relevant leaders from the Ministry of Environmental Protection, the Ministry of Housing and Urban-Rural Development and other ministries and committees addressed the opening ceremony. In the Brownfields Regeneration Workshop of Beijing Shougang Group held in the same period of time, joint design activities was conducted by nearly 60 students from the United States, Spain and China under the guidance of the teachers of the three countries, and the results were reported at the conference.

It can be said that this conference is another important academic conference in the field of brownfields regeneration, following the two important international conferences held in Harvard Graduate School of Design—the “Manufacturing Site, a landscape conference focusing on site technology in contemporary practice” in 1998 and the “Brownfields Grey Water: Rehabilitation Process and Design Practices” in 2001. It is also the first international conference with multi-discipline and multi-professional participation in China’s landscape architecture field that takes brownfields regeneration as the main topic.

At the end of the conference, the Declaration of the 2016 International Conference on Brownfields Regeneration and Ecological Restoration was read out at

the closing ceremony and all participants approved it by acclamation. The Declaration was initiated by Professor Kathryn Moore, the present president of the International Federation of Landscape Architects (IFLA), discussed with Professor Niall Kirkwood of Harvard Graduate School of Design, and wrote by the first author. The Declaration put forward six core actions, hoping to provide guidelines and references for scholars and practitioners in the field of brownfields regeneration:

1) Support a detailed survey of the current brownfield situation in China, including distribution and contamination extent etc., and construct a thorough public database.

2) Involve all related sectors and adopt a multi-disciplinary approach for brownfields regeneration process.

3) Take a long-term view providing enough time for proper remediation process of brownfield sites.

4) Ensure a regional and holistic approach which examines and envisions the future of brownfield sites' redevelopment in the larger context.

5) Raise public awareness on the risk of brownfield sites, as well as opportunities offered during the regeneration process, through educational events and actions, and ensure public participation through the regeneration process.

6) Revisit and facilitate revisions of academic pedagogy and curriculum setup to be in line with and advance required new knowledge associated with brownfields regeneration challenges.

Acknowledgments

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The Benefits of Increasing Blue-Green Infrastructural Ecosystem Services:

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Abstract

Urban decision makers are faced with many complex issues related to balancing urban development and environmental impacts today. Expectations for increased demand for new infrastructure construction are the natural phenomenon (Wouters et al., 2016). The infrastructure that relies on the mono-function with high complexity system results in a chain of failures in interconnected systems, which lead a significant loss for properties of the physical, social and economic (Little, 2003). This is the reason why we who are engaged in the discipline of the landscape architecture pay attention to the new approaches of Green Infrastructure.

Among the various concepts of Green Infrastructure, this study has focused on the values in including the role of urban hydrology within urban water management. Many of the symptoms of climate change are related to water. Recent changes in rainfall patterns and the increase in impervious water due to urbanization have resulted in increased urban floods, decreased groundwater, increased heat island phenomena, and worsened water pollution. In response to these, the terms of “sustainable urban drainage”, “low impact development”, “water sensitive urban design”, “Water Sensitive Cities”, and “Modified rainwater management” have been appeared. Taken together these terms, Wouters et al. (2016) uses the term Blue-Green Infrastructure (BGI) instead of Green Infrastructure.

BGI not only includes rainfall runoff and pollutant abatement technology elements that are applicable to urban areas in a narrow sense, but also encompasses major ecological infrastructure in urban areas, meaning open space conservation and interconnection in the broad sense. In addition, it can provide sustainable multi-dimensionally sustainable various social, economic and environmental benefits of urban areas as well as water cycle recovery in urban areas.

The purpose of this study is to explore the various potentials and possibilities of the "Blue" area in the BGI, particularly the ecological services aspect associated with water by examining the case of Bishan-Ang Mo Kio park and Kallang River project in Singapore. Briefly to sum

up, there are four fundamental ecological processes occurring in these cases, including the water cycle, nutrient cycle, energy cycle and community dynamics.

In this study, we would like to articulate the functions and roles of ecosystem services of urban hydrology within urban water management in BGI. There are many questions to be answered about the ecosystem services integration of BGI into cities. The answer to the most important questions from the designer's point of view is that, beyond the quantitative expansion of the BGI for the restoration of the city's water cycle, there is a need for a systematic approach to provide citizens with an ecological environment and aesthetic satisfaction at the same time.

Keywords: Blue-Green Infrastructure; Ecosystem Service, flooding; mitigate the impacts of climate change

1. Riverine Ecosystem services in Infrastructural Ecologies

Cities and their decision-makers today face many complex challenges that are associated with balancing urban development and its impact on the environment. Consequently, the demand for new infrastructure construction is expected to increase commensurately. These infrastructure expansions are aligned with enormous costs (Morrish, 2008).

Particularly, conventional, mono functional infrastructure is prone to catastrophic failure cascading failure of interrelated systems, which results in a significant loss for the physical, social and economic properties (Little, 2003).

Among the various elements that jointly constitute a city's infrastructure there is one in particular that, perhaps more than all of the others, shapes a city and supports urban activity and human life – that element is water. Water is necessary for human life and a broad variety of economic activities.

The conventional approach to urban water infrastructure has been to use quantitative models to predict future water demand and then to construct additional infrastructure to meet this demand. That approach prioritizes technology and large physical interventions which attempt to manipulate natural

processes to suit the needs of humankind. However, that focus on “grey” infrastructure – due to the massive amounts of concrete and metal typically involved – is progressively showing deficiencies and limitations in meeting the additional stresses to urban water supply and management, induced by rapid urbanization, impervious land cover, and climate change.

Riverine ecosystems provide important ecosystem services such as clean water, flood protection, habitats, biodiversity and recreational and social amenities to urban residents. However, riverine ecosystems belong to the ones most degraded by humans (Naiman and Monica, 2000). The hydrology of rivers has been altered by the construction of structures, such as dams and weirs, and water diversions for hydropower and other industrial purposes, irrigation and domestic uses (Jackson et al., 2001). These activities profoundly change the processes that drive ecosystem function and structure (Jansson et al., 2000). A central tenet of the meeting was that any riverine ecosystem is embedded in heterogeneous landscapes consisting of several landscape components that each may have an effect on the target ecosystem (Wiens, 2002). A corollary of this notion is that ecosystems to be restored are not only affected by activities in the target area, but also by processes in the surrounding landscape, making connectivity among landscape components a central

concept (Pringle, 2001). Analysis of the process of recovery is another central field in restoration science as it addresses whether or not ecosystems respond to restoration in the expected way and whether or not the project objectives are met.

This paper introduces key messages from the case of Bishan-Ang Mo Kio park and Kallang River project, focusing on river restoration. First off, we will illustrate the Bishan-Ang Mo Kio park and Kallang River as Blue Green Infrastructure based on the principles of infrastructural ecologies (Brown, 2010). Specifically, we would like to articulate the functions and roles of riverine ecosystem services. we also discuss the critical resources needed to sustain the stream ecosystems in the form of the minimal stream flow, or discharge, necessary to maintain stream ecological and hydrologic function, and how that consideration relates to the ecosystem services concept. Although my emphasis is on the hydrological system, we include domains of institutional management of ecosystem services where relevant. only.

2. Bishan-Ang Mo Kio park and Kallang River as Blue Green Infrastructure

Brown (2010) argues that the next generation of infrastructure cannot resemble the hard, single-function and carbon-intensive structures of yore. Rather, we need more diversified, distributed, and interconnected infrastructural assets that simulate the behavior of natural systems. She suggested the principles for next-generation infrastructure—“infrastructural ecologies” that simulate the behavior of natural systems. Such systems are multipurpose, interconnected, and synergistic; contribute few or no carbon

emissions; work with natural processes; improve social contexts, serving local constituencies; and are resilient, adapting to predicted changes from unstable global climate.

Bishan-Ang Mo Kio park and Kallang River project is suitable case for explaining these principles as a new ecological infrastructure. First of all, the systems of Bishan-Ang Mo Kio park and Kallang River are multipurpose, interconnected and synergistic. This project is one of Singapore’s most popular parks in the heartlands of Singapore. As part of a much-needed park upgrade and plans to improve the capacity of the Kallang channel along the edge of the park, works were carried out simultaneously to transform the utilitarian concrete channel into a naturalized river, creating new spaces for the community to enjoy.

Bishan-Ang Mo Kio park and Kallang River project is part of the Active, Beautiful, Clean Waters (ABC Waters) Program, a long-term initiative to transform the country’s water bodies beyond their functions of drainage and water supply, into vibrant, new spaces for community bonding and recreation (Public Utilities Board of Singapore, 2012). Singapore’s ABC Waters Program aims to improve the water quality, physical appearance, recreational value, and biodiversity of Singapore’s waters. While targeting waterways and reservoirs, the ABC Waters Program also addresses the stormwater runoff generated from the urbanized catchment. A landmark project of the program, the Bishan-Ang Mo Kio Park is one of Singapore’s biggest and most popular parks. Construction began in October 2009, and the park was officially opened in March 2012. It showcases the transformation of a 2.7 km concrete channel of the Kallang River into a 3 km naturalized

river integrated with the surrounding green space (Holmes, 2012).

Bishan Park, with more than three million visitors each year, holds a significant role in the heartlands of Singapore (Landezine, 2014). The longest river in Singapore, Kallang River, flows for about ten kilometers through the city center. The 62-hectare park was designed between 2007 and 2010 by Ramboll Studio Dreiseitl (Ramboll Group, 2012). The main aim of the project was to improve the capacity of the concrete canal and to transform the existing park into a functional park, which is fully integrated with nearby neighborhoods, with a water-sensitive urban design approach.

Before the restoration project, Kallang River, like many waterways around the world, was forced into a concrete channel to reduce the impacts of extensive flooding. The existing park around the river, which could receive some migratory birds due to its geographical location, had wide lawn areas which did not function ecologically. The urban park, with randomly located trees, did not have considerable biodiversity value. Also, the population of the district increased dramatically after the district was completely urbanized.

Second, Bishan-Ang Mo Kio park and Kallang River works with natural processes. Bioengineering techniques were applied to re-construct the river channel. Although the use of bioengineering is common in the developed world, it had not been used in Singapore before. The design team experimented with ten different techniques in combination with native plant species on a 60 m stretch of a side drain within the park, before applying bioengineering to the Kallang River (Channerl News Asia, 2012). Seven of these techniques were selected in the naturalization of the channel, including fascines, riprap with cuttings, geotextile-

wrapped soil-lifts, brush mattresses with fascines, reed rolls, gabions, and geotextile with plantings. A hydraulic model was developed to simulate the flow dynamics to help the design of the channel. For example, more robust plant species would be used at locations identified by the model to be subject to higher flow velocity for erosion control. The naturalized channel is the highlight of the park with meander bends, varying channel width, rock beds, and vegetated banks that generate diverse flow patterns. Being aesthetically more pleasing, the heterogeneous geomorphology is also an attempt to provide a variety of wildlife habitats (National Parks, 2012). Several sustainable storm water treatment elements are incorporated into the redesign of the park, among which is the cleansing biotope – the first in Singapore. The cleansing biotope is at an upstream location in the park and it helps to supply clean water needed for the park facilities, such as the water playground, to avoid the use of chemicals (Channerl News Asia, 2012).

Third, Bishan-Ang Mo Kio park and Kallang River project improve social contexts and serve local constituencies. The concrete canal at Bishan - Ang Mo Kio Park was once a vital part of the neighborhood's drainage system and allowed water to flow to a meandering river, the concrete was cut into slabs and stacked to form Recycle Hill. This was a deliberate effort to preserve a part of the park's history, and reuse the concrete in a creative way. Perched on the hill is a sculpture - 'An Enclosure for A Swing' uniquely created to represent the fusion of nature and design.

Lastly, Bishan-Ang Mo Kio park and Kallang River project has designed for resilience, to adapt to foreseeable changes brought about by an unstable global climate. The park is essentially a floodplain river that allows for multiple uses – when flow is low,

people can play in the river channel; when flow rises during storms, the entire park functions as a conveyance channel to pass the flow downstream to prevent flooding of the surrounding residential areas. The naturalized channel, along with its floodplain, was designed to safely convey a 1-in-25-year storm (Public Utilities Board of Singapore, 2012). Any new development in the catchment is subjected to a drainage design code that prohibits the generation of additional stormwater runoff –stormwater should be retained onsite and cannot be discharged into the river until after the storm.

3. Ecological process and ecosystem services of the project

There are four fundamental ecological processes occurring in the case of Bishan-Ang Mo Kio park and Kallang River project, including the water cycle, nutrient cycle, energy cycle and community dynamics, which are as follows: (1) Water cycles; that the increased roughness of the natural riverbed with rocks, pools and riffles means the velocity of river has been slowed down, so fewer particles are transported downstream to the Marina Reservoir where they would need to be extracted through filtration. The increased conveyance capacity of the river and decreased velocity means flood protection for the dense urban areas surrounding the park as well. (2) Nutrient cycle; The restoration of the river has created a huge variety of micro-habitats which not only increase biodiversity but the resilience of species within the park, meaning their long term ability to survive is greatly improved. (3) Energy cycle; the cleansing biotope increases the ecological value of the park's biotic systems, cleansing water naturally through plants and filtration

media. (4) Community Dynamics; no wildlife was introduced to the park but the introduction of the naturalized river into the park has seen the park's biodiversity increase by 30%. 66 species of wildflower, 59 species of birds and 22 species of dragonfly have been identified in Bishan Park; not bad for a city park.

The key constructed ecosystems of this project are naturalized river and variety of micro-habitats and this constructed ecosystem has offered regulating services, provisioning services, cultural services and supporting services. Cleansing biotopes in the park offer an effective water treatment while maintaining a natural and beautiful environment. This helps to maintain the water quality of the ponds without the use of chemicals. They consist of carefully selected plants in a filter medium which helps to cleanse the water by filtering pollutants and absorbing nutrients. Aside from its unique waterways, the park features a lush greenery, pond gardens and river plains help climate regulation. It was envisioned as a leisure destination for residents ranging from children to nature-lovers, containing facilities such as a football field, a floating amphitheater, and a natural pond. Moreover, new bridges, stepping stones in the water and a riverside gallery were built to encourage increased interaction with water. Existing features such as the foot reflexology feature, community garden, dog run, and fitness areas were refurbished (NG Mee Kam, 2012).

The use of soil bioengineering techniques (a combination of vegetation, natural materials and civil engineering techniques) to stabilize the river banks and prevent erosion was a first for Singapore and is a new reference for soil stabilization in the tropics, which have otherwise rarely been used or documented. In 2009, a test bed was constructed, testing about 10 different soil

bioengineering techniques and a wide variety of tropical plant species along a length of 60 meters at one of the side drains in the park. Within the water park, a new water playground was designed to increase the attractiveness and visitor enjoyment. Water for this playground is supplied by cleansed pond water that has been filtered through the cleansing biotope, which has undergone an ultraviolet (UV) treatment to eliminate any harmful biological contaminants without introducing any chemicals into the water (Harris et al., 2013). Restoration of the river has created a huge variety of micro-habitats which not only increase biodiversity but the resilience of species within the park, meaning their long term ability to survive is greatly improved.

4. Potentials for increasing riverine ecosystem services in Blue Green Infrastructure

Ecosystem service provisioning areas and service benefiting areas are not necessarily co-located, so humans may choose to increase service-connecting areas through infrastructure. Given the diversity and complexity of river ecosystems, it is a significant challenge to synthesize the many ecosystem services that river ecosystems provide to develop clear insights to inform better management of rivers. Numerous tradeoffs exist in the management of ecosystem services from rivers, some of which include: navigation vs. water storage; recreation vs. industrial usage; irrigation vs. fish habitat; and cultural services vs. hydropower production. Over-emphasis on any one ecosystem service (e.g., provisioning of hydropower) can cause the reduction or even elimination of other valuable ecosystem services (e.g.,

provisioning of native fisheries), and hence it is critical to achieve a balanced approach that considers multiple ecosystem services in any management for river ecosystems across different scales. Although questions that face riverine management may extend beyond the application of an ecosystem services approach, this concept can provide a mechanism for broadening the perspective of linking humans to river systems. When I analyze the scale aspect of the project and the historical context into the results and driver elements, they are mostly related to ecosystem services related to water.

5. Conclusion

In this article, we focused on the riverine ecosystem services embedded in blue green infra structure with the case of the Bishan-Ang Mo Kio park and Kallang River project. This project shows us Brown (2010)'s the principles of a new ecological infrastructure such as ingenious, multi-purpose, carbon-neutral and resilient systems how to systemically work.

Ecosystems in the new ecological infrastructure contribute to human well-being via the provision of goods and services where the benefits are direct, such as in the production of food and raw materials, and indirect as is the case in the regulation of water quality and supply. In order to manage and enhance ecosystem services provision, understanding the underpinning these services as a suite of ecological functions becomes of a dire importance (Banerjee et al., 2013).

As we can see with the Bishan-Ang Mo Kio park and Kallang River project, ecosystem services are provided by riverine ecosystems in the form of provisioning, supporting, regulating and cultural benefits to both ecosystems and the human societies that depend upon them. River ecosystems

vary greatly in scale, from headwater streams to vast river deltas, and the relative importance of various types of ecosystem services changes dramatically with spatial and temporal scales.

The future of river science may require clearer articulation of the complex problems facing specific river systems and the development of novel methods for integrating the suite of ecosystem services into natural resource management paradigms. One promising approach, for example, lies in the concept of environmental flows, which posits minimal flow regimes for the recovery and/or continued maintenance of critical ecosystem services such as supporting healthy conditions for aquatic species in rivers. This approach is most appropriate when the threat of irreversible damage exists for critical services, and parallels the literature on creating safe minimum standards for such resource systems.

As the supply and demand of riverine ecosystem services continue to shift due to changing climatic, demographic and land use conditions, research on riverine ecosystems that examines the dynamic feedbacks in the coupled human and natural systems that produce different services is vitally needed. A useful tool may be a hierarchical approach combining qualitative and quantitative models to address how changing river governance affects the management of riverine ecosystem services and thus the provision of specific ecosystem services across different scales. Equally important is having an understanding of how different stakeholders may perceive these changes and potentially affect policy decisions. Incorporating experiential knowledge provided by stakeholders can improve the long-term management of rivers and their ecosystem services.

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Landscape architecture and urban agriculture: between discourses and practices

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Abstract

Urban agriculture has been largely acknowledged as a multifunctional topic. Academic studies from different disciplines and countries have been highlighting urban agriculture as one of the strategies to promote landscape justice, food security, social inclusion and community development; to increase biodiversity, reduce environmental conflicts, and bring into life abandoned and neglected urban areas, among other important aspects. It is therefore one of the approaches towards the idea of a resilient city. This flexibility of the conceptual and practical constructions of urban agriculture allows it to be appropriated and discussed by several fields of knowledge, including landscape architecture. Building on studies of urban agriculture in Rio de Janeiro, this paper argues the importance of landscape architecture to enhance multiple values of urban agriculture for social people.

Landscape; architecture; urban; agriculture

1. Introduction

Since the wave of academic literature on urban agriculture at the turn of the 21st century, much has been discussed and written about the various benefits of reintroducing food production in urban areas. Urban agriculture has been acknowledged as “a practice that encompasses a wide range of contexts (...) and many possibilities to consolidate itself as a permanent, flexible and multifunctional activity” (Santandreu & Lovo 2007, p 4).

This flexibility of the conceptual and practical constructions of urban agriculture allows it to be appropriated and discussed by several fields of knowledge - such as geography, biology, agronomy, sociology, nutrition, psychology, among many others, including landscape architecture. But is landscape architecture currently bringing significant contributions to urban agriculture practices? Or would it be only a spark compared to the great contribution that could be made by landscape architects to structure urban agricultural areas by

thinking about processes and dynamics, impermanence and, above all, the multifunctionality inherent in the practice of food production within cities? How could landscape architecture contribute to enhance the multifunctional roles of urban agriculture within cities social and environmental dynamics?

This study is part of a broader research that looks at different urban agriculture experiences, addressing how people have fair access to the benefits deriving from their landscapes. The theoretical approach of the study understands landscape as a context always in movement, where discourses and design practices are in constant interaction and transformation. From this perspective, it is clear the need to understand the processes rather than landscape forms only. From a methodological approach the study draws both on field work and literature review. The paper is organized in the following way: initially it brings a discussion on urban agriculture; then the paper addresses a context in which urban agriculture experiences occur with a focus in Rio de Janeiro. The paper concludes arguing for a more active role of landscape architecture in urban agriculture experiences in order to enhance its multifunctional aspects.

2. Urban agriculture in Rio de Janeiro: discourses and design practices

A number of studies highlight the need of a better engagement of landscape architecture with food production practices in cities. This engagement could occur from different perspectives, specially aiming to

enhance the multifunctional roles of urban agriculture.

Name (2016), for instance, looking particularly at the Global South and Caribe, argues that landscape architecture should look at the possibilities of native flora in order to enhance access to a larger range of food alternatives for vulnerable communities. He points out that “food sovereignty is the result of a critical and purposeful approach that understands food as human right, so its condition of merchandise is secondary” (Name 2016, p. 4).

This perspective looks particularly at the reduction of environmental conflicts and against the logic of the food industry - focused on monocultures, food homogenization and the de-characterization of cultures and ancestral knowledge about food. Kinupp & Lorenzi (2014) contribute to the work of landscape architects through their book on non-conventional food plants, revealing a path for the financial sustainability of urban agricultural spaces, biodiversity maintenance, food security and the permanence and resistance of some non-conventional species. This work is particularly relevant for landscape architecture, for it opens up a new plant vocabulary which is little explored in landscape design. But how these and other researches could be revealed in landscape design?

These findings may help landscape architects to understand that edible plants could easily replace non-edible plants used in landscape design of urban areas in

different scales. It might be possible to think, than, of an urban agricultural practice that goes beyond the species normally used on the standard vegetable garden. Some edible species, for instance, due to their strong aesthetical character, could be used in well-defined urban open spaces typologies, such as sidewalks, squares and parks. In this case, the choice of plant species would be the determining factor that would differentiate a space that produces human food from another that does not produce it.

Although food and food sovereignty have been the focus of urban agriculture studies in a variety of current research - mainly in the global south - urban farming areas also contribute to other services to cities and their inhabitants. Some of these services require a better attention of landscape architects, such as to promote landscape justice; to generate social inclusion and community development; to reconnect citizens and food production; to reduce environmental conflicts; to generate positive urban sociabilities; to bring abandoned and neglected urban areas back to life, and many other important aspects. For these and other services within the urban space, there is a diversity of areas where agricultural activity can be developed in the city, such as vacant lots, terraces, schools, hospitals, prisons, favelas, railroad transmission and abandoned areas are just a few of the examples. This diversity in terms of typologies and spatiality of urban agricultural areas might bring a complexity enhanced by the contradictions of scale and forms of occupation. It brings therefore, new questions concerning uses and functions related to form and design.

As regards the multifunctional landscape concept, De Groot (2005) defends the idea that landscapes are imperative multifunctional and that, nevertheless, people tend to turn them into nonfunctional landscapes. Since urban agriculture is an interdisciplinary activity and involves different functions and services to the city, reducing the various programmatic possibilities inherent to this activity is to contribute to a reduction in the social and environmental gains of the practice. In an increasingly urbanized world, the idea of multifunctional landscapes brings a malleability that can foster new experiences and urban solutions, especially considering the connections between the environmental dimension and the cultural dimension.

For some of these different environmental and cultural contexts in which urban agriculture experiences occur, we bring an example from the city of Rio Janeiro, which emphasize the challenges related to the architectural design of the urban agricultural area.

3. Urban agriculture in Rio de Janeiro: discourses and design practices

Rio de Janeiro holds a number of different urban agriculture experiences – running from those organized by NGOs, by private or local initiatives, and by public authorities. This paper look particularly at a municipal initiative, named “Projeto Hortas Cariocas” (PHC) - Hortas Cariocas Project . This is an institutional programme created by the City's Environment Department, which the main objective is to support initiative of

food production in favelas and state schools. More specifically, the project aims to assist locations in the city where poverty and exclusion rates are more alarming.

The “Hortas Cariocas Project” supports citizen intervention initiatives aimed at the use of underutilized open spaces for food production in the city. In addition to the authorization to use the area, the city provides supplies and grants as financial aid for those who are deeply involved in the work on the vegetable garden. For food reinforcement, part of what is produced is divided between state schools, public day care centers in the surrounding area and families at social risk indicated by residents' associations. The surplus goes to the local market and the profit is left to the partners, and part of it must be reinvested. In the long term, the project, aims at the emancipation of the vegetable gardens, thus promoting the financial autonomy of those directly involved in the food production. It focuses at the strategy of local socioeconomic development by training the population in



Fig. 1. “Hortas Cariocas Project”- urban agriculture in Rio de Janeiro

vulnerable communities that have areas able

of implanting and managing urban and community gardens, reducing rates of irregular occupation of neglected land, raising levels of social inclusion and offering basic human right to a healthy and quality food, free of GMOs”. (O’Reilly 2014, p 35).

Around 30 urban agriculture areas are linked and supported by the PHC, including



Fig. 2. “Hortas Cariocas Project” - Manguinhos vegetable garden

favelas and state schools. One of these areas in the one located at a favela named Manguinhos. This used to be one of the most insecure favelas in the city. The PHC managed to organize the largest urban agriculture area of the project, a large strip that was left unoccupied because it was located under towers of electric wires.

This urban agricultural space is nowadays one of the most important public spaces in the community. Besides providing cheap and safe vegetables, it is also a meeting place, a working space, a trade space, a leisure area, and, above all, a place at the favela that contributes to rise the self-esteem of its inhabitants. In other words, it plays an important role in the process of urban inclusion of the community.

However, it can be noticed that the layout of the vegetable beddings shows a composition of several large rectangles organized along the strip. Perhaps it shows an inheritance of a typology of the agriculture planting in rural areas, an arrangement of rectangular shapes with circulation axes in between. Our research has shown that this morphology does not have important functions related to agricultural production. However, it does not explore other powerful social functions claimed by the open space where the vegetable beddings are inserted. Our field work has show how heavily the area is used for community meetings. Local people pop up not only to by vegetables, but to meet other people, to take the children to play or for a walk, and many other social activities.

It is noteworthy that Manguinhos community, like most of the Brazilian favelas, lacks public spaces with basic infrastructure for positive urban sociabilities. With its non-flowing layout, Manguinhos vegetable garden loses the opportunity to operate also as a public square, a public park, a public classroom, among many other functions. In other words, in looses the opportunity to expand the socio-environmental gains that urban agriculture can offer.

From this perspective, landscape architecture has a lot to contribute to enhance the capabilities of the urban agriculture areas to fulfil their multiple roles, particularly the social ones.

4. Final comments

Urban agriculture is, of course, one of the paths to create more resilient cities. Landscape architecture, within the other disciplines related to urban agriculture, has an important role to play in enhancing its multifunctional aspects. It is crucial to reconcile the experience of several professionals to the execution of a plan that meets the biophysical and socio-cultural demands of an area.

However, when it comes to agricultural production in the city, improvisation - both related to agricultural technique and standardized spatial distribution - gains a prominent role rather than a more careful landscape design. Such agricultural spaces have particular processes, dynamics and



Fig. 3. “Hortas Cariocas Project” - standardized spatial distribution

functions, and therefore require a look and a design with specific characteristics.

Faced with a scenario of little involvement between landscape design and urban agricultural, as well as the rigid layout and social program found in these spaces, one can perceive the urgent demand for a

more active role of landscape architecture in urban agriculture experiments. Landscape architecture can lead a path to increase the socio-environmental gains of these areas in order to improve their multifunctional aspects, their spatiality and contribute to the resilience of cities.

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Acknowledgments

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Resilient parking lots

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Abstract

Parking lots were born with the standardization of the car in the early twentieth century, intervening decisively in the architecture of the contemporary city and becoming one of the most important components of urban living [1], requiring huge urban surfaces shared by pedestrians. But they are valued largely for their technical character neglecting its landscape potential [2]. However, in the American context, parking lots are probably one of the outdoor public spaces most used in everyday life [3]. They might not be exceptional and even unpleasant but their magnitude and ever increasing presence deserve new hybrid tactics and programs to help their insertion in the urban fabric.

Maybe due to their humble nature as result of left over space [4], parking lots have been forgotten in landscape architecture and public space studies. But parking lots are public spaces in their use by the community and their great impact on land use. The fact that they are very lucrative spaces cannot discriminate them from having a good design or becoming aesthetically attractive spaces that enrich our cities [5]. If traditionally their use was limited to parking cars, in the contemporary city, more and more parking lots are presented to us as hybrids. Several projects in the last decades have shown the possibilities and success of this coexistence in programs [6]: the alternation in uses in Topotek 1's Kaiak Market or Büro Kieffer Playing-Parking Lot in Berlin's Flämingstrasse, Parcal Cribier's elegant and multifunctional Parking Lot surface in Bonnelles, the new city parking in Villajoyosa (Spain), that use de covering of the semi-underground parking in a really interesting way as an absorbent tree surface for the people or the parking lot as part of the gateway experience of the DIA Art Foundation in Beacon (NY) where the lobby of the museum abandon the building to welcome the visitor in the outdoor area.

If we don't want to revisit its importance as a public urban space, we should at the least consider their importance within an ecological and sustainable framework where the proper use of its materials can help reduce impervious surfaces, fight heat islands, and contribute to the control of water runoff and effective groundwater recharge [7]. Diana Balmori was correct when stating that "A Parking lot seems an unlikely place to begin the design of a new building and landscape" [8] but she managed to make it the main public space of the Botanical Research Institute of Texas and key for the collection and reuse of rain water on the whole site.

These are flexible and multifunctional spaces, even for spontaneous appropriations, spaces that can positively contribute to urban ecology and as relievers of the increasing presence of cars in our cities. The disappearance or the reduction of these parking lots constitutes a way to obtain

new special relations between the city and the complex environments of the public or private buildings and to improve social realm.

Parking lots; Urban spaces; Multifunctional public spaces; Lost space; Urban gaps

1. Introduction. The dichotomy of Parking Lots

Due to the standardization of the car, our cities and streets have been modified and modeled following the necessities of traffic and parking demand. The car has become such a huge part of our civilization that it is hard to find any streets that do not contain them, and parking below our house is mandatory to have a certain quality of life. But while the streets are being adjusted to meet the needs of different local identities, we should question ourselves why have parking lots always looked the same, especially when cars stay parked approximately 90% of their life.

Instead of establishing an approach to the parking lot as a place of opportunity to integrate activities, regulations tend to care more about how to hide these spaces to the city. Roger Trancik defines parking lots as "those undesirable urban areas that are in need of a redesign –antispaces, making no positive contribution to the surrounding or users...on the other hand, they offer tremendous opportunities to the designer for urban redevelopment and creative infill and for rediscovering the many hidden resources in our cities" [9]. Parking lots can be considered urban lost space at the same time they are an essential part of our urban environment.

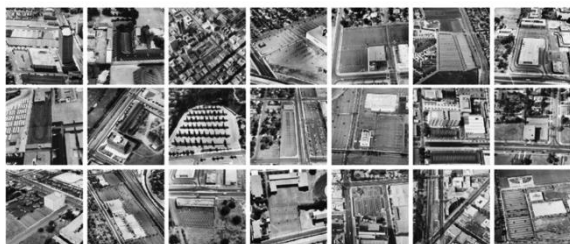


Fig. 1. Thirty-four Parking Lots by Ed Ruscha

This dichotomy is also present in how citizens perceive these spaces: they are often seen as "ugly" and "a waste"; we pay little attention and creativity to its design, planning and innovation and as early as 1981, Lewis Mumford stated: "The right to have access to every building in the city by private motorcar, in an age when every-one possesses such a vehicle, is actually the right to destroy the city" [10]. At the very same time, artists have been fascinated by parking lots due to their figurativeness character, mainly in photography. It was already in 1967 (printed in 1974) when Ed Ruscha published his book *Thirty-four parking lots* looking for its graphical standardized character and the bi-dimensionality of these spaces.



Fig. 2. Parking Lots' aerial views by Alex MacLean

Contemporary photographer Alex MacLean's work is instead pointing out how parking lots are a disruption in the urban fabric creating abandoned concrete islands. Using, as Ruscha did, an aerial view, his photographs cover a wider range of contexts (not always urban) just to show the dramatist of these scissions. Is in this solitude and isolation where these parking spaces anchor to beauty. This sort of fascination can be summarized in Paula Meijerink words: "*Can anyone imagine something more beautiful and fascinating*

than a brand new, vast and desert parking lot?” [11]

In 1991, renowned landscape architect Peter Walker proclaimed: “the day will come when parking lots routinely win top design honors” [12] but this prediction has not yet materialized. Few parking projects have ever won a prize. There are only a few books that help us with their design as most publications are about standards and regulations. For example, since 1990, only one parking lot design has won an award from the American Society of Landscape Architects (the project “12000 factory workers meet ecology in the parking lot” from Michael Van Valkenburgh Associates) [13]. Designers should not forget that when people are at a place that is looked after, they will also feel looked after and parking lots should become hybrid spaces and not mere asphalt extensions where to storage cars. Their condition as urban gaps should have already been overcome.

2. Three considerations about parking lots

Through the review of some main projects decomposed in their principal achievements, this paper aims to restore some dignity and find a remedy for the ills of traditional parking lot design. “As suggested by Paul Groth, parking lots should be considered gardens in terms of their relationship to nature and to culture. Parking lots probably cannot be transformed into gardens in the traditional sense, but designers can greatly increase their utility by incorporating ecological, aesthetic and social factors” [14] The review is mandatory to accomplish the research. The projects analyzed are divided into three big categories: the parking lot as

part of the gateway experience (or how the way we “arrive to” has always been essential in architecture and landscape architecture), the parking lot as a multifunctional public space (or the necessity of finding new alternative programs to enrich the public experience) and the sustainability of parking lots (or how these kind of spaces can positively contribute to some of major problems in our cities)

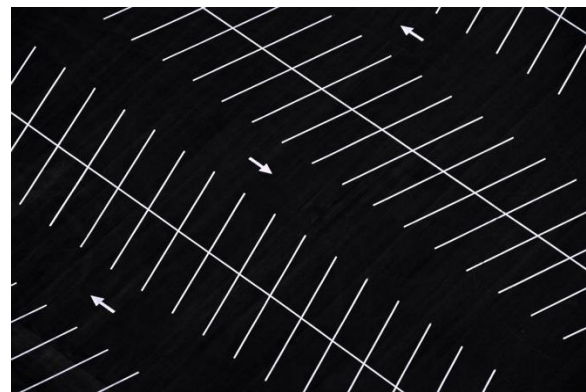


Fig. 3. Parking Lots’ aerial views by Alex MacLean

2.1. Parking lots are part of the gateway experience.

Nowadays we take for granted the possibility to park, but those parking spaces are not seen as the arrival point to an architecture or landscape project but are seen only as technical areas. We can appreciate the architecture of a museum but there are few instances when we consider the parking lot as part of it. Diana Balmori, founder of Balmori Associates based in NYC, wisely stated that “A Parking lot seems an unlikely place to begin the design of a new building and landscape” [15] but she managed to make it the main public space of the Botanical Research Institute of Texas.

From the moment you park the car in the area of the Institute, the botanical experience begins: a large sample of plant species that are under investigation, run along the paths leading from the parking lot to the building and a collection of native oaks shade and characterize this space. Where ever possible, porous pavements were used and roads were designed to follow the contour lines. The parking does its job, but the goal was to create a sustainable and pleasant space.



Fig. 4. Balmori Associates, “Botanical Research institute of Texas”, Fort Worth, TX, 2010

A similar attitude guided the design for the Dia Art Foundation by Robert Irwin and OpenOffice in Beacon, New York, where the whole parking lot was conceived by the authors as the lobby of the museum; a lobby that abandons the building to welcome the visitor in the outdoor area, while reducing the size of the inside lobby to a small room; a lobby where we can admire the time passing by and the changing seasons.

2.2. *Parking lots are multifunctional public spaces.*

Its spatial characteristics and its (so far) simple morphology as a paved extension aiming to have the maximum space to park cars, make parking lots highly versatile. Because these are governed by clearly defined schedules (working hours for residential and office use, weekdays for business, etc.) an alternative look at their use is almost an immediate parameter to be dealt with. Based on this superposition of uses and users, forms and functions, Büro Kiefer designed a parking lot in Flämingsstrasse (Berlin) with a small number of structural elements and a strong graphic character that gave a clear identity to a new residential building.



Fig. 5. Büro Kiefer “Parking Lot at Flämingsstrasse” (Berlin) 1998, and Sanfeliu/Martorell/Lamich architects “Verneda’s Parking Lot” (Barcelona) 1999

A more complex morphology was adopted by a parking lot of a residential block design by Sanfeliu/Martorell/Lamich architects in the Verneda’s neighborhood of Barcelona. This courtyard turns into a very dynamic urban plaza through a design based on a series of parallel strips of different paved sections that create a new artificial moving topography. These strips organize

the project and give character to the different activities on site; they fold, undulate and group themselves to create all of these different areas both horizontally and vertically, visually hiding the cars parked in the perimeter from the central pedestrian alley and creating some small steps.

Kaiak Market from Topotek 1, probably the most published parking lot of the last years, is an example of alternating uses where the main square of Kopenick reinvents the traditional market, rhythmically following the division of parking lot stalls. Its powerful color and huge umbrella indicating the activity in use at each moment, manage to create a public space of huge dynamism and identity.



Fig. 6. Büro Kiefer, "Parking Lot at Biosphere Platz", Postdam, Germany, 2001 (from Google Earth)

Vegetation can contribute very actively in reshaping parking lots instead of being a hiding tool. In the Project for Biosphere Platz, Büro Kiefer uses the confrontation between the historical models of open spaces (the tradition of formal gardens) and new uses of the contemporary city (such the

use of the car). Just by changing the scale and introducing a vegetated component as a construction element, he creates a sophisticated car park where shrubs are a maze of parking spots imitating the nearby Prussian gardens.

2.3. *Parking lots and sustainability*

There are a few environmental costs that large asphalt surfaces produce that mainly have related to soil, vegetation and water. Several studies support the importance of using permeable materials in order to reduce water runoff and to allow water to percolate recharging aquifers (an urban environment with 75-100% of impermeable surfaces produces more than 55% runoff) [16]. And not only that, but the heat accumulated in the impermeable materials heats rainwater decreasing oxygen levels. The pollution in the surface of the parking areas such oil and metals are dragged into aquifers, contaminating them.

The necessity to evacuate the rainwater as quickly as possible from large paved surfaces through the drainage system makes that, when the rains are very strong and we pour that huge amount water into a nearby stream, it quickly erodes the stream bed, dragging the vegetation and existing debris of its banks, and leaving a wide rocky water course. An on-site detention system with a progressive evacuation of the water avoids water runoff and promotes a constant influx into aquifers

Parking areas also highly contribute to the heat island effect that happens in asphalt surfaces that do not consider any vegetation, making these surfaces 20° to 40° warmer than a vegetated one. Asphalt accumulates heat all day and dissipates it during the night

hours creating constant heat islands that could be reduced by a simple addition of small-planted areas. These areas not only could provide a place of shade, but they could also become a moment of pause in the vastness of asphalt.

The water runoff from parking surfaces, the necessary roadways, and 330,000 square meters of rooftop would have a devastating impact on the surrounding ecosystem composed by fragile water streams in Michael Van Valkenburgh's project entitled "12000 factory workers meeting ecology in the parking lot". The first action taken by MVVA was establishing water collection as an essential priority for the project. They then considered its treatment and slow release afterwards into the surrounding landscape in order not to create further violent water intake into the adjacent ecosystem.

MVVA integrates ecology elegantly and honestly with enormous paved surfaces, creating a new model of environmentally friendly, low-maintenance landscape. This model can be applied with equal success in urban and suburban areas, and shows how landscape architects can play a crucial role in producing an effective hydrological management system with good design.



Fig. 7. Michael Van Valkenburgh, "Herman Miller Furniture Factory "12000 factory workers meeting ecology in the parking lot"

The large space required for 358 parking spots presents an important problem from an economical point of view in the Botanical Research Institute of Texas by Balmori Associates. But, if we consider the parking area together with the building roofs as part of an active system of collecting rainwater and a research field, it becomes an ecological operating system; it is no longer a problem to solve, but an element to delight visitors from the moment they park their cars.

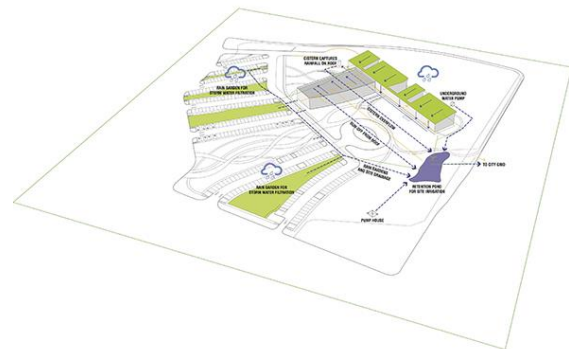


Fig. 8. Balmori Associates, water diagram of the Botanical Research institute of Texas, Fort Worth, TX, 2010

Also Agence Ter links the parking lot on Verdon's Beach (Martigues) to the hydrological and vegetative territorial system. Because it is located where the Verdon Valley meets the Mediterranean at a popular beach site, the area is prone to massive flooding in the rainy season. It was crucial to understand the hydrological functioning of the site, to avoiding flooding, to reorganize the parking area and to propose a system capable of regulating water flows.

Landscape can't be just a superficial practice to mitigate or embellish these antispace, but a methodology that allows us

to work with and from the contradictions of contemporary territories, assimilating all technical and engineering components and cityscape's figures.



Fig. 9. Agence Ter, Verdon's Beach Parking Lot, Martigues, France, 2001

3. Conclusions.

Parking lot's can be "rescued" from the urban imaginary just by adding some conscious effort to their design as we do to almost every other public space. We can consider three basic actions to change the role of the car parks in our cities, giving them an importance that relates to the occupied area and the impact they have on our daily lives, transforming standard spaces in places linked to a network of urban public spaces:

- Reinvent multifunctional programs according to the needs of contemporary cities with alternative uses. We need to abandon the static and already defined traditional open space and look for vibrant programs that can satisfy a large number of users. The spatial characteristic of a parking lot offers a unique opportunity of wide range alternatives. Their standardized character needs to be overcome by their innate ability to generate identity and its potential power to transform a space into a place
- Ensure the use of porous materials used in constructing parking lots to make them participate in the hydrological and

environmental performance of the area. Pervious materials allow water percolation and groundwater recharge, do not accumulate heat and can be easily maintained and kept in good condition as these areas generally depend on public administration.

- Rethink vegetation as part of a large scale system, not as a punctual intervention, giving continuity to green territorial systems that might be somehow crossing the site. Thus, the projects operating as public space can be constituted as networks to enrich intermediate scale projects.



Fig. 10. Public off street parking lot in Berlin, Stresemannstrasse at Niederkirchnerstrasse

Sometimes simpler actions have great echoes in designing urban environments and this last example proves it. Walking in Berlin we found this anonymous public parking lot; just a pervious paving and a dense tree canopy made the difference. When raining, the parking efficiently drains off the water; the trees provide shadow in summer and filter the view of the parking area from surrounding buildings. The whole site is not a gap in the fabric but another figure in the urban landscape, a sort of a small forest that enrich the urban experience. It is not hard to imagine it as a picnic area under the trees during empty-cars hours.

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Theorizing a landscape design approach to transform a dump yard into an outdoor public space with reference to Karadiyāna dump site

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Abstract

Urbanization and increase of urban population is a common crisis in urban areas around the world. As a result, urban consumption pattern and life style has changed which has caused a rise in intake and waste production. Solid waste accumulation has increased than the past and that has become a major environmental and social problem. The act of National solid waste management strategy is unable to control the problem because of the unbearable waste accumulation rate in and this spontaneously creates the demand for innovative ideas to answer the problem. Rehabilitation of waste sites is indispensable for sustainable city development in the vision of recovery and conservation of neglected urban spaces. The transformation of waste sites in to open public spaces represent a significant enhancement to the quality of life and land use. This transformation need a new planning approach based on ecological restoration, new technology and collaborative design. FreshKills landfill is being rehabilitated successfully by reclaiming dump site in urban area transforming it for the benefit of society and environment. Here in Sri Lanka, Karadiyāna dumpsite will be used to production of electric power by using methane gas in near future. Freshkills project will be analysed to find the fundamental theories and principles behind the dumpsite rehabilitation and according to that local case study will be analysed. The objective of the present work was to analyze the theoretical principles adopted in dump site rehabilitation and guided to build a theoretical frame work for the future rehabilitation of dump sites in Sri Lanka with landscape architectural approach. Study begins with specific approaches and fundamental principles, moving on to detecting patterns and regularities, then critically analyses the literature sources to find out the theoretical principles adopted to dump site rehabilitation. In FreshKills project it was found that the design strategies adopted to minimize the environmental impact forming a pleasing rehabilitation of the natural environment with assure. Reclaimed waste sites can be used for compatible uses in urban context rather than using wetlands or marshes filled with earth and this should be a sustainable solution for land scarcity in Colombo. Lack of technical and deign knowledge, limited financial resources may clog the commencement of such a rehabilitation project in Sri Lanka.

Keywords: Urban Solid waste, landscape architecture, dumpsite rehabilitation, landscape approach, ecological restoration, urban open space.

1. Introduction

Need of the human begins increased with the evolution in parallel with the population growth, urbanization and diverse consumption patterns. Then the rate of resource consumption has been increased. Eventually, High rate of resource consumption will led to rapid waste accumulation because of the leftovers.

“Due to an increase in the standard of living and population levels, a growing economy, rapid urbanization and changes in consumption patterns have greatly accelerated the solid waste generation rate in developing countries” (Troschinetz & Mihelcic, 2009) (Marshall & Farahbakhsh, K., 2013) Urbanization in developing country will caused to enormous quantities of waste generation and significant environmental degradation. Poor planning strategies of responsible government institutes has been chosen sensitive eco systems such as marshes, wetlands for waste disposal as well.

“The available statistics show that the current generation of municipal solid waste in the western province, Sri Lanka is around 3,200 to 3,500 metric tons per day. Waste generation rate increase by 1.2 to 2 percent per day and it is predicted that in 2050 the waste generation in the western province will increase up to 5,800 metric tons per day.” (Wijayapala, 2012)

This is the present condition of waste disposal practice in Sri Lanka.

1.1. Research Problem

When those open dump sites completely filled with waste where it cannot bear anymore. We let those to abandon without

any treatment and this caused controversial social and environmental issues.

Recent literature has shown that rehabilitation of landfill plays and important role on critical issues in solid waste management, including biodiversity conservation, global warming mitigation and land reclamation.

Initiate landfill rehabilitation is a must when considering all the issues which are led by the existing open dumping practice.

1.2. Research objectives and Aims

With the role of Landscape Architect,

- To find out underlying theoretical principles, and strategies behind dump yard transformation which determine approaches implemented by other developing countries.
- Identify the issues occurred when doing this dump yard transformation.

1.3. Methodology

The landscape design approaches of rehabilitated waste landscapes and experiences of dump site rehabilitation in local and foreign context had to be studied.

Begins with specific approaches and fundamental principles, moving on to detecting patterns and regularities, then critically analyses the literature sources to find out the theoretical principles adopted to dump site rehabilitation. Formulate tentative

Frame work base that can be explored, and finally end up developing some general conclusions. (See appendix for Table 1).

1.4. Research Outcome

Present study will be guided to build a proper theoretical frame work for dump site rehabilitation in terms of Landscape architecture with other related professions and elaborate the sustainable land use practice in urban context.

2. Urban Society and Solid Waste Management in Sri Lanka

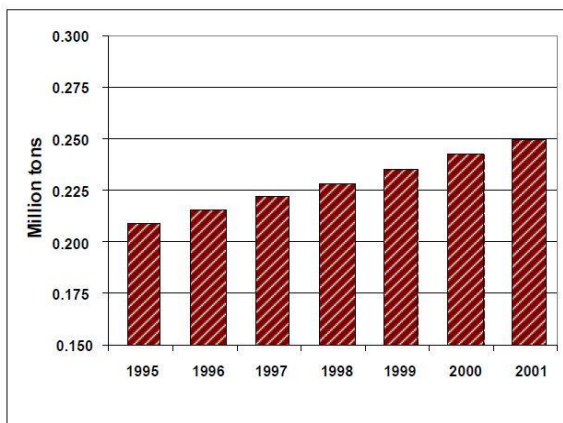


Figure 2: Municipal solid waste generation in Colombo, Sri Lanka. Source: NRI Sri Lanka, 2003

Wasting is a necessary part of living, yet if the processes are not well managed, life itself is threatened. Even when waste is prevented, the result can be deadly, but in a different way. What would a world be like where waste was out of control? (Lynch, 1990, p. 3) Improper waste disposal action has become one of the general cause of environmental degradation in Colombo and its suburbs regions. As a result of that Meethotamulla,

Karadiyana, ultimately has become huge dump yards.



Figure 1: Resource recovery nearby Karadiyāna dump site Source: by Author

National strategy for solid waste management was introduced by ministry of forest and environment in 2000 which based on wide range of policies of waste management from gathering to final disposal and after care. Also the approaches such as resource recovery and biological treatment but those are not implemented well in Sri Lanka.



Figure 3: On going composting process at Karadiyāna dump site Source: by Author

Composting percentage of collected waste in Sri Lanka is more than 50%. Lack of public

awareness is limited the composting facility to residential level while other developed countries are developing it in to profitable mega scale level.

Lack of public awareness is a disadvantage for the solid waste management as well. The famous 3 R's of waste management; Reduce, Reuse and Recycle is a good notion which provides best chances for the public to participate in waste management.

More than 95% of waste collected in Colombo disposed in open dumpsites located at low lying lands which are used as flood retentions areas.



Figure 4: Final disposal at Karadiyāna dump site
 Source: Karadiyāna waste management facility

2.1. Landscape Approaches on Landfill Reclamation and Design Strategies in Sustainable Landscape Reclamation

Landfill reclamation projects become more dominant with new design strategies which are devised in recent years, focusing on the sustainability, quality and multi-functionality of the space, with attention to environmental and socioeconomic aspects.

This is a valuable move in highly urban areas because of the high land value and the land scarcity for recreational open spaces.

“Mira Engler, a landscape architect and researcher, presents contemporary approaches to the treatment of landfills. These approaches oscillate between the romantic perception, which reconstructs the pristine natural landscape of the site, through an approach that hides the site's past in favour of converting it into a location for intensive recreational activity, to approaches that empower the essence of the site as a ritual field or monument, or as a place for personal investigation and discovery” (Engler(As cited in Tal Alon-Mozes, 2009). Variations among contemporary waste related design projects elaborate eight approaches:

- Camouflage
- Restoration
- Recycling
- Mitigation
- Sustainable
- Educative
- Celebrative
- Integrative

Above approaches will explain how to intervene a waste related landscape reclamation design project in a different perspective.

As Patricia Phillips noted, “Even with an enhanced awareness of the environment, consciousness requires new image to see the changed conditions.” (Phillips, 1990). Recently many landscape architects have begun to look at the landscape not only as a setting in which to intervene, inserting an

indefinite variety of objects, but as a tool through which to design and manipulate complex material.

Understanding of temporal and dynamic character of the landscape & design solutions and design process which represent the existing attitude toward and expectation of the site is prominent for success. A place sensitive to different transformations, which records the movements and event that cross it.

It is important to recognize and interpret the significance of the landscape and to understand how “landscape ecology and design can invent alternative forms of relationships between people, place, and cosmos so that landscape architectural projects become more about invention and programs rather merely corrective measures of restoration” (Corner, Ecology and landscape as agents of creativity. In ecological design and planning., 1996).

And also punter explains that, “Any attempt to define principles for good design must embody the principles of sustainable development. Building design, landscape design and urban design must be brought together to deliver a more integrated, skilled and effective design process. According to Punter, landscape reclamation design should integrate five fundamental principles” (Punter, 2002).

- Protect and conserve quality landscapes.
- Develop a clear vision and strategy for an area.
- Apply collaborative design principles.
- Allow resources for long-term aftercare of new landscapes.

- Enhance biodiversity, social stability and economic development.

3. Landscape architectural intervention to dumpsite rehabilitation

3.1. Case Study 01: FreshKills Park, Staten Island, New York.



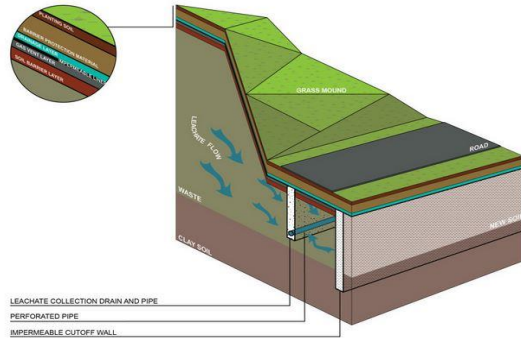
Figure 5: Fresh kills park, Staten Island, New York
 Source: Google Earth

FreshKills Landfill is located on the western shore of Staten Island in New York City. This spreads across approximately 2,200 acres of landfill. FreshKills is a well-planned site, with various schemes put in to practice in order to protect public health and environmental safety.

The innovative engineering of Fresh kills Park is one of the major features, which allowed the conversion of this place from been a landfill to a human friendly public recreation space.

This project reveals that, what we must manage in this kind of a project. Such as,

Leachate Management System



Leachate at the site is collected in subsurface trenches surrounding each of the landfill mounds and piped to the on-site treatment plant.

Figure 6 : Leachate collection sys: at Fresh kills park
 Source: <http://freshkillspark.org>

A toxic liquid mixture discharged from the landfill which known in the field as “leachate”. This could ooze out of the landfill unless it is controlled through special structure.

Landfill Gas Collection System

Landfill gas consists of about 50% methane and the Landfill Gas Collection System (LGCS) is designed in order to collect the gas and course it to an on-site LFG recovery plant. This is used for energy generation,

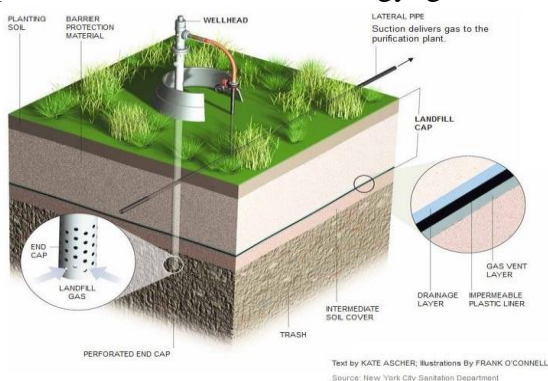


Figure 7: Capping & LFG collection system at Fresh Kills Park
 Source: <http://freshkillspark.org>

while preventing the gas from escaping the landfill.

Capping System

Capping System at Fresh kills is the key method for reducing the production of leachate, assisting with the capture of landfill gas, and sealing all contaminants in the landfill from the Park above.

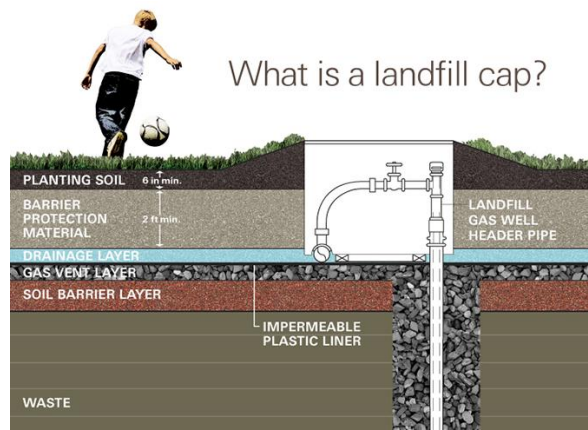


Figure 8: Capping System at Fresh Kills Park
 Source: <http://freshkillspark.org>

Storm Water Management



Figure 9 : Storm water is collected via a network of storm water swales, channels, and down chutes
 Source: <http://freshkillspark.org>

Rainwater dipping on the top of the last cover must be carefully collected and carried off the mound to safeguard and make sure that it does not destabilize or erode the layers of soil that make up the cover of the mound. Storm water is gathered via a series of storm water swales, channels, and down chutes.

Landfill infrastructure at Freshkills is designed in order meet and surpass the environmental standards set by the New York State Department of Environmental Conservation for landfill closures and it helps to rectify the environmental and health impacts caused by the landfill. The project provide extensive ecological benefits through reclaimed eco-systems that would offer both wildlife habitat and natural open spaces for users.

“The reclaiming of sites might be measured in three ways: first, in terms of the retrieval of memory and the cultural enrichment of place and time; second, in terms of social program and utility, as new uses and activities are developed; and, third, in terms of ecological diversification and succession” (Corner, Recovering Landscape: Essays in Contemporary Landscape Architecture).

Freshkills is an ecological progression of environmental reclamation and renewal on a vast scale and this is the best example for post landfill reclamation project in all-time. Finally produce the fresh spatial conditions through the new landscape and also does not forget to show the consequences of waste.

3.2. Case Study 02 (Local context): Karadiyāna Dump Site – A dump



Figure 10 : Karadiyāna Dump Site, Piliyandala.
 Source: Google Earth

site is being rehabilitated.

Karadiyāna was initially converted into a dump yard since more than two decades. It is situated at Thumbovila area of Kesbewa and it comprises of 37 acres. Two sites consist of the total area of 9.6 acres with 20m in height.

Site is located in an eco-sensitive area thus discharging waste into the wetland caused environmental and social catastrophes to the immediate surrounding. Such as, Water pollution is a major issue due to leachate from the site, all water resources contaminated and surround environment degraded.

Number of illegal settlements increased around the landfill. The property value of immediate surround of Karadiyāna dump site is less which reasons for the vast population of illegal settlements.

Future proposal of Karadiyāna is to transform the methane gas in to electric power.



Figure 11: Slope stabilization process
 Source: Karadiyāna waste management facility

Slope stabilization is a must due to heavy rains on monsoon seasons because waste heaps can be collapsed. After established the slopes project management has plans to plant on those slopes to avoid erosion and provide stability (perennial native grasses and rapidly germinating annual grasses are more suitable).

At the base of the dump site leachate ponds were created to collect the leachate. Leachate is treated before discharged into constructed wetlands that contain plants which can absorbed the heavy metals.

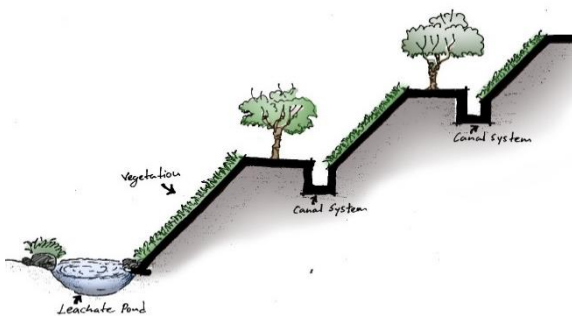


Figure 12 : Leachate collection system at Karadiyāna
 Source: Prepared by Author

Existing wetland eco system is connected with the Weras ganaga and Bolgoda Lake. Wetland eco system serve their service to this urban environment, especially during flood seasons. When the wetlands fill with waste impulsively flood retention area gets reduced. Then lower lands get flooded. Due to waste disposal activity topography has been changed at the area. Hydrological sources and Aquatic eco systems has been contaminated and degraded with by-products of waste, chemicals. At the end total environment has been affected.



Figure 13: Degraded environment at Karadiyāna dump site
 Source: by Author

4. Analysis

In developed countries they turning this neglected landfill spaces into extraordinary sustainable landscapes to get the optimum benefit of it. In Sri Lanka it is totally different and the lacking point of local context is that there is no systematic frame work to do this transformation.

Two case studies has been selected for the study. One is an ongoing project located on the western shore of Staten Island in New York called Freshkills Park by James corner field operation.

Karadiyāna dump site in Colombo, Sri Lanka has been selected as a local case study.

Literally this waste site affects day to day life of people who surrounded by here. First contaminated site need to be recovered before the development. Then, site has to be protected and conserved. So actions need to be taken with ecological processes such as restoration, succession with the understanding of how nature works.

Design principles should be applied to wrap up the whole project as a unit. (As an example on going waste treatment facilities and park facilities should be integrated with whole design).

Sustainable use of waste sites should be emphasized equally in three parameters which are namely environmental uplift, economic development, and social stability. Fresh Kills project is larger than Karadiyāna project and the severity of waste composition is less in Karadiyāna. Those things can be considered as an advantages for the rehabilitation program and environmental variables should be considered

Camouflage approach

This continues the traditional disguise of waste related site using screening or cloaking techniques to conceal the waste. At fresh kills they have used capping system to cover and seal the waste. Basically a much needed step to take for the safety of people in this kind of reclamation project. The key method for reducing the production of leachate, assisting with the capture of landfill gas, and sealing all contaminants in the landfill from the Park above. (See figure7)

This capping is the base that can gives the new image to see the changed condition of this reclamation project because all the planting materials should be plant on this. All the design elements have to be built on this as well. This is what camouflage approach reveals.

At Karadiyāna they have planned to use soil cover to conceal the waste and there is a possibility to use the above capping method in here as well.

Restoration approach

Elaborates on fixing the temporary land-use disturbances caused due to unorganized disposal of waste. Finally try to bring back the previous condition into site through ecological restoration. The Freshkills project provide extensive ecological benefits through reclaimed wetlands, grasslands, and new woodlands that would offer both wildlife habitat and natural open spaces for park visitors.

In Karadiyāna they have done the slope stabilization to stop the waste heap collapse during rainy seasons and introduced perennial native grasses and annual grasses (rapidly germinated) to avoid slope erosion. At the base of the slopes leachate ponds were created to treat the leachate before it discharged into constructed wetlands and wetlands consists of heavy metal absorbent plants.

Recycling Approach

One of the main intention of Freshkills project is to reuse the landfill site as public amenity and land development. This is the whole idea of two projects which are taken to study. Provide public amenities through the design and reuse and developed the land for

needs. In Freshkills projects this is being happening.

Mitigation Approach

Landfill gas extraction, leachate treatment, slope stabilization, capping system were introduced to mitigate the damage, reduce the severity of pollutant and restore the damaged site and turn it into a viable environment. Finally try to weaken the impact.

In both case studies they have used and mention about this scientific solution which must be added to these kind of a projects to protect and conserve the quality of landscapes.

Sustainable Approach

Sustainable approach is concerned with the economics, conservation and self-sufficiency of a waste processing site. It engages a range of diverse programs often including elements of renewable waste resource. For example; at Freshkills they have extract the methane gas and synthesis for power generation while recreational functions are going on at the same time. New ecologies has been introduced to the site which was there before to conserve the newly introduced landscapes. They have planted various varieties of trees, grasses, shrubs, etc. storm water management system and reclaiming waste water from on-site treatment facilitates to irrigate vegetation and water bodies.

Main idea of the Karadiyāna project is to extract methane gas and transform that into electric power. According to sustainable approach there is a potential to develop this site for recreational purposes as a public park which can generate alternative income source. Ongoing composting process can be

developed into profitable level with above activities as well.

Educative Approach

Emphasizing public awareness and changing of attitudes of general public towards waste. Existing waste facilities are opened to public tours and special education facilities are built in the site to creatively inviting people to experience the realities of waste. Freshkills Park is a platform for generating knowledge applicable to a broad range of urban environmental issues, at this site and others: reforestation, habitat restoration, wildlife biology, soil productivity, water quality, alternative energy generation, and even attitudes toward park usage. While parts of the park are under construction other areas will remain undeveloped; with 2,200 acres of land there is opportunity for research projects in a variety of disciplines.

Freshkills Park offers classroom resources and field trips that centre around three major topic areas: biodiversity and the environment, history and social studies, and art and design. The landfill-to-park transformation is a poignant backdrop for education.

As same as at Karadiyāna these kind of educational and awareness programs can be implemented with the proposed project and it will be a great opportunity to public participation.

Celebrative Approach

This approach promotes and dramatizes waste sites and waste management facilities through works of art, special design features. Combine all the elements to see the final product as a one system. Design of Fresh Kills Park allow people to get close with the

ongoing processes. That is what celebrative approach reveals and that can be added to Karadiyāna project as well.

Integrative Approach

This is a multifaceted one, combining elements from the celebrative strategies. It integrates the “principles of ecology with the philosophy of art” – scientific rigor with express metaphors. The integrative strategy elaborates on changing an abused site or waste facility while at the same time amplifying its reality. Creating Visible Connections is integral to this strategy. Karadiyāna site and Fresh Kills site are contextually quite similar but not totally. (See Appendix for Table 02)

5. Conclusion

As an issue of early stages of urban planning, changes are not accepted in urban context in most of the developing countries such as Sri Lanka. Rapid urbanization, growth of population and migration of people to the urban areas, industrialization are reasons behind the change of life pattern. In a situation like that consumption pattern naturally changes. A definite area with more people there is a higher rate of resource consumption. At the end it persist a higher amount of left-overs of used resources. Then where to discharge those remains in urban context is a problem. Most probably at next derelict land or eco sensitive environment has to pay the price. This is how most developing countries including Sri Lanka faces the huge amount of waste accumulation in urban areas. Meethotamulla, Karadiyāna, Bloemendhal were the results of it in the city of Colombo.

Poor quality of technical standards of waste collection and final disposal ends up with massive heap of waste. Good appearance is an indication of a place. Those waste heaps have destroyed the beauty of place as well as the quality of environment.

Landfill gases from dump site is contributed to global warming (Landfill rank third in anthropogenic sources). Finally those by-products of wastes obviously causes irreversible health issues. Urban environment and landscape is being degraded in Sri Lanka and throughout developing countries due to questionable waste discharging and final disposal.

Open dump sites are selected without any scientific assessment as a result of less involvement of technical expertise such as urban planners, landscape architects, environmental engineers etc.

Rehabilitation of these dump sites need to be an ultimate option to improve the urban environment, social acceptance, quality of life, economic prosperity, resource preservation, worth use of space and finally should support the sustainability.

Landscape architectural involvement to the waste site rehabilitation has brought out some extraordinary urban recreational spaces around the world. FreshKills at New York, United State of America, Nanjido at Seoul, Korea, and Hiriya at Tel Aviv, Israel are some of these which are about how to turn the waste sites into resource and get the maximum benefit out of it.

In city of Colombo most open recreational spaces have been constructed on wetlands or marshes filled with earth. By earth filling on wetlands or marshes in Colombo area floods keeps causing damages during the monsoon seasons. As an alternative, rehabilitated

waste sites can be used to construct open public spaces since there is a land scarcity in Colombo urban areas. The wetlands and marshes in Colombo areas act as flood retention areas and when those were filled with earth other areas get flooded.

Likewise there are more advantages in using rehabilitated waste sites for compatible urban uses. Renewable energy from landfill gas, as a land reclamation, to increase of the urban green cover/vegetation, as significant recreational, cultural and educational amenities etc. Finally it will help in order to vanish the poor visual appearance of the city because city appearance is the mirror of its planning and development.

Above case studies reveals the Landscape architectural involvement (with other related professionals) to reclaim the damaged sites and how can we apply those engineering applications with an artistic manner. Turning those notorious waste heaps into an extraordinary public space will explained that what landscape architects can do? And the importance of landscape architecture on these kind of projects Instead of distancing ourselves from waste, design can bring people closer to waste operations and help foster creative solutions to problems. Landscape design should not be used to wipe out technological guilt. Rather it should be used to move the public to new level of awareness.

Appendix

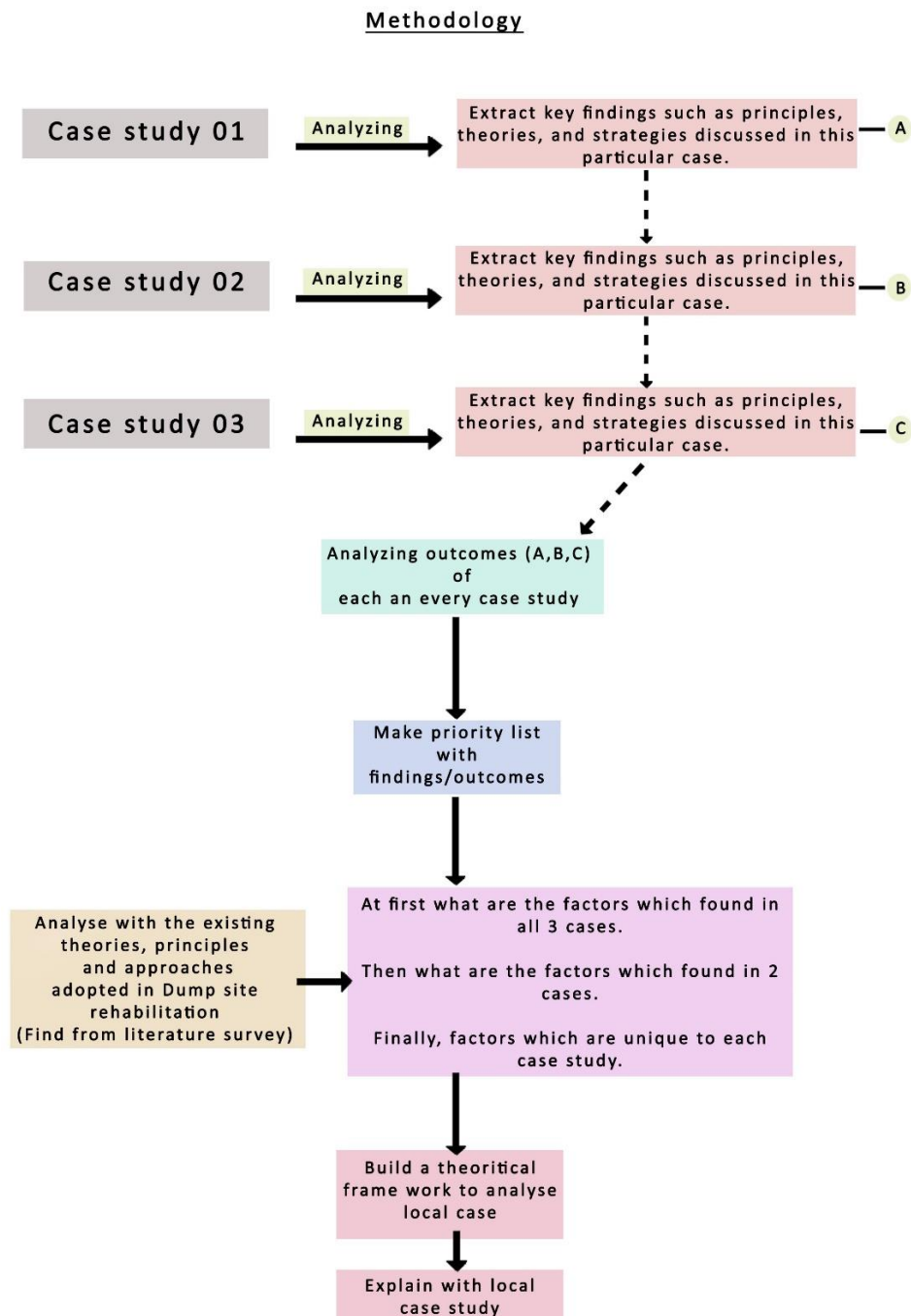


Table 1: Methodology
 Source: by Author



Freshkills Park, Staten Island, NY.
 (Freshkills Park, n.d.)

Karadiyāna, Piliyandala, SL.
 (By Author)

Table 2: Contextual Similarities of Selected Case Studies
 Source: by Author

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Landscape Architectural Approach to Urban Flood Management with Special Reference to Diyawanna Oya, Colombo, Sri Lanka

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Abstract

Urban flooding in recent times have become a challenge for the development of cities. In addition to climate change, lack of drainage caused by urbanization contribute greatly to the increasing impact of urban floods. Previous studies conclude that loss of natural flood detention areas has a greater effect on aggravating floods. Hence, it is evident that a shift from gray infrastructure to an approach of blue and green infrastructure is required. A landscape architectural approach focuses on a holistic solution and considers how flood can be part of our natural landscape.

Flooding in Colombo, Sri Lanka, is a significant threat due to the city's socio-economical importance. Flood management include several landscape developments focused on the Diyawanna water body and surrounding wetlands in the capital city of Sri Jayawardenepura Kotte. This study investigates the effectiveness of these solutions in the management of floods. A literature review was carried out in order to understand broader notions of the problem and to develop the theoretical framework. The attributes focusing on adaptability to flood, landscape character and social responsiveness were identified as the significant factors for an effective landscape architectural solution.

The research carried out through on-site observations and studies, questionnaires and mapping point out that the landscape developments around Diyawanna Oya are socially responsive and the designs are multifunctional. However, the continuous decrease in natural flood detention areas would affect the adaptability of these solutions to large scale floods. Moreover, these landscape developments have the potential to enhance the ecology and the character of the natural environment better. Hence, it was established that these landscape developments are moderately effective in managing the urban flood situation in Diyawanna Oya.

Keywords: Urban Flood; Flood Management; Landscape Architecture; Wetland; Resilient cities; Colombo

1. Introduction

Natural disasters have become significant global challenges in recent times, of which floods are the most frequent. Floods are generally caused by high runoff rates due to intense rainfall [1]. Urban flooding is associated with inadequate urban planning and effects of climate change and urbanization acting on the lack of drainage in urban areas [2]. Urban floods impact the development of cities, considering the higher concentration of population, assets and economic activities that are exposed to floods in the urban environment.

Many studies have identified that the urbanization process of a city changes the natural landscape, increasing imperviousness and promotes the occupation of flood plains, aggravating flood problems [2-6]. Research by Brody et. al (2008) confirm that “the alteration of naturally occurring wetlands is the most important built environment indicator of flood damage” (p. 13).

Colombo, the Capital city situated in the wet zone of Sri Lanka, experiences rain throughout the year. Flooding in Colombo has worsened in recent years primarily due to the city’s inability to absorb water as the natural flood storage capacity has been reduced by inadequate planning and wetland encroachment. The most recent major floods in the year 1992 recorded the highest ever rainfall (493mm) followed by the years 2010 and 2016. As a result of several studies, five wetlands including a “green belt” around the Diyawanna water body were established as flood detention areas in Colombo [8]. The recent developments in the green belt aimed

to preserve the flood detention area through sustainable landscape developments, which are considered significant and influential for flood mitigation in Colombo.

A landscape architectural approach combines the environment and society through design with emphasis on aesthetic quality. A city resilient to floods is considered a city living without flood control [9]. Thereby, in order to ensure a holistic solution for urban floods, greater landscape architectural influence is necessary.

Globally, many studies have been done and measures have been taken related to urban flood management. However, in the Sri Lankan context, this concept is still developing. The aim of this study is to establish the importance of implementing such solutions in Colombo as the sustainable method of mitigating floods, by considering the effectiveness of the solutions currently implemented in and around the Diyawanna water body.

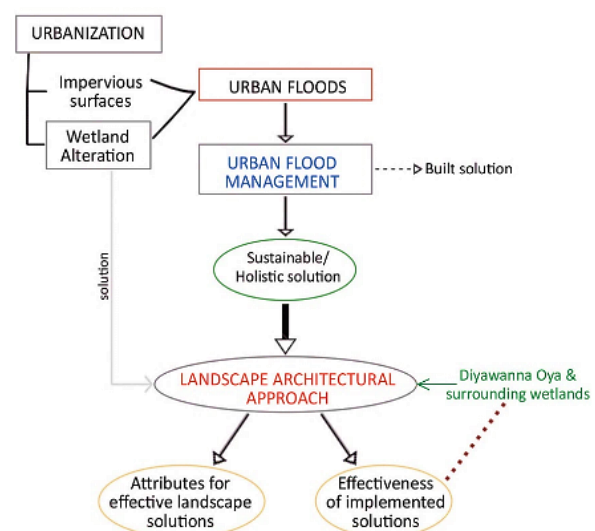


Fig. 1. Framework for research background

2. Literature Review

2.1. Need for a Landscape Intervention

Urban flood management does not necessarily mean absolute prevention of floods. According to Wong & Eadie (2000) stormwater management practices have always followed an attitude of “out of sight out of mind”. However, due to urbanization, there is unpredictability of the nature of floods and restrictions in space in future. Jha, et al. (2012) states “Defending against future floods will require more robust approaches to flood management that can cope with larger uncertainty” (p. 30).

Several early researches demonstrated the ability of wetlands to store water [3,7]. The management of natural landscapes such as wetlands for the purpose of mitigating flood impacts provide a solution by itself [10], restricting the need for built methods. However, to achieve both economic growth and environmental protection, sustainable management through landscape needs to be implemented [11]. This includes not only addressing water quantity and flow issues but integrating society and enhancing the character of the area.

2.2. Multifunctional landscapes

Miguez (2007) argues that in densely urbanized environments, an effective option is the introduction of multifunctional landscapes, using existing parks and squares. By facilitating an area to fulfil different functions and objectives, city revitalization and flood control can go hand in hand [4]. In addition, a multipurpose landscape should not only manage the quantity of water but

focus on water quality, social responsiveness, recreation, education and aesthetic values [6,12].

2.3. Theory of Urban Resilience

Several scholars have presented their views on urban resilience to flood focusing on the transition from acting against water to living with it [9,13]. Liao (2012) states, “the theory of urban resilience to floods challenges the conventional wisdom that cities cannot live without flood control” (p. 01). It indicates that flood adaptation should replace flood control in order to build urban resilience. According to this study, depending on flood control infrastructure which are “resistant to floods” (p. 06) could have an impact on the overall character of the city, which is an important aspect of the landscape.

2.4. Principles of Urban Flood Management

With the increase in the need for sustainable solutions, several principles for urban flood management have emerged through studies. These principles take into consideration the theories of urban resilience, multifunctionality and the enhancement of the landscape.

- Best Management Practices (BMP) associated with the concept of green infrastructure [4,14]
- East Asian water management principles which focus on waterfront developments helping the city adapt to flood situations while creating visually pleasing and social interactive landscapes [10,15].
E.g.: Ang Mo Kio Park, Singapore

- Blue-Green cities which explore the concept of designing open spaces integrating water managements and green infrastructure [16,17].

3. Methodology

Principles and concepts for the landscape architectural implications for flood management are identified through a literature survey. Following this, the theoretical framework is developed considering the views of significant scholars on the implementation of effective solutions for flood mitigation. The recent public open space developments carried out around the Diyawanna Oya, Sri Jayawardenepura Kotte in lieu of flood mitigation and landscape development, were identified for further study.

Data was collected through existing literature, mapping, on-site observations and documentation, and interviews with resource personnel. A research questionnaire was given to a random sample of 30 respondents, to obtain data on social responsiveness of the selected landscapes. Both quantitative and qualitative analysis methods are used to analyze the data based on the framework prepared. However, the effectiveness of landscape solutions is discussed qualitatively.

4. Attributes for effective Landscape Architectural solutions

With the review of existing literature and aspects taken from the theories and principles, key factors are identified. Most

scholars express the need for similar factors with few stating otherwise (refer Appendix 1). The most significant attributes for landscape architecture and those commonly addressed have been extracted and summarized to form a framework to assess the effectiveness of landscape architectural solutions for flood management (fig. 2).

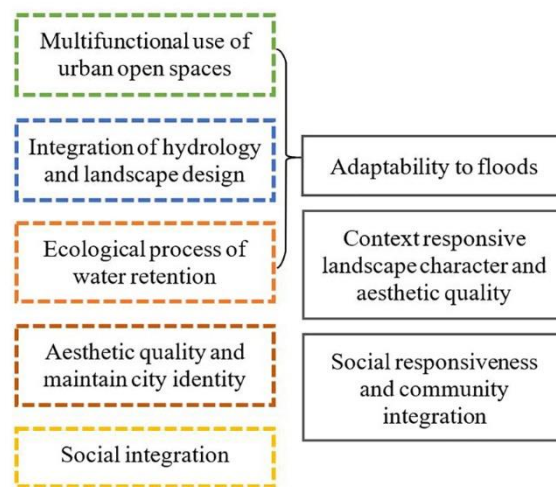


Fig. 2. Framework of most significant attributes identified through literature

The attribute of adaptability to floods is analyzed through multifunctional use of space, the integrated landscape elements and variation of the wetland footprint of the region.

Context responsive landscape character and aesthetic quality has not been addresses sufficiently in literature, however, it is selected as an essential factor for landscape architecture. This attribute is analyzed amalgamating the criteria for landscape types identified by Simonic (2003) and the methodology of Landscape Character Assessment developed by Swanwick (2002) as given in Table 1.

Simonc (2003)	Naturalistic Landscape Geometric Landscape
Swanwick (2002)	Topography <u>Elements:</u> Buildings, Hydrology, Materials, Significant elements <u>Aesthetic Factors:</u> Scale - Intimate, Small, Large, Vast Enclosure - Tight, Enclosed, Open, Movement - Still, Calm, Busy Form/Pattern - Random, Organized, Formal

Table. 1. Selected criteria for the analysis of landscape character

Many scholars have also stressed on the need to address society, in order to achieve an integrated solution for urban floods. As stated by Kaplan [2011; as quoted from Kaplan et al., 1998, p. 149], people do not engage when a certain environment “block their understanding, lack opportunities for exploration, fail to foster experiences that are enjoyable and when they feel they are not welcome” (p. 168). Therefore, the final attribute aims to assess the social responsiveness of the landscape solutions for flood management, determining;

- Previous flood experiences and impact
- Frequency of visit and perception of landscapes

5. Diyawanna Oya and the flood mitigating wetlands

While the city of Colombo remained as the commercial capital, the administrative capital of Sri Lanka was shifted to Sri Jayawardenepura Kotte in the early 1980’s. The Diyawanna Oya is located within this context.

Colombo is historically a large area of wetland and natural landscapes. Due to imbalanced development and mismanagement of water-related landscapes, the wetlands began to deplete and risk of flooding has increased. Diyawanna Oya and the surrounding wetlands are some of the last remaining extensive areas of wetland in Colombo which have the capacity to mitigate floods.

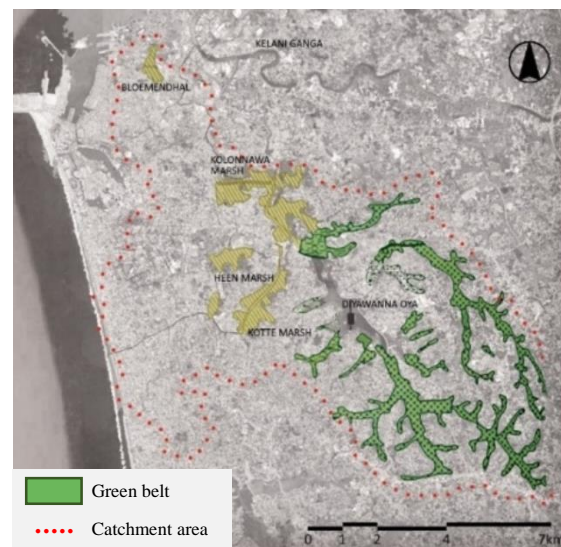


Fig. 3. Colombo Flood Detention Areas
 Source: CEA & Euroconsult, 1995

5.1. Landscape character of Diyawanna Oya and surrounding wetland

The Diyawanna Oya is a significant historic reminder of the ancient kingdom of Kotte. The Parliament now stands as the nucleus of the new capital with the Diyawanna Oya surrounding it; including several water bodies which were introduced for beautification and water retention purposes. The city also includes the natural flood detention area of the green belt around the Oya. This natural landscape of the wetlands and the recently declared wildlife

sanctuary within the city are unique landscape characters of a rapidly urbanizing city. Although these wetlands are meant to be temporary storage basins for flood water, according to current land use the area has reduced greatly due to reclamation and encroachment. Hence, for the purpose of conserving the remaining wetlands, the local authorities carried out several landscape developments in the area.

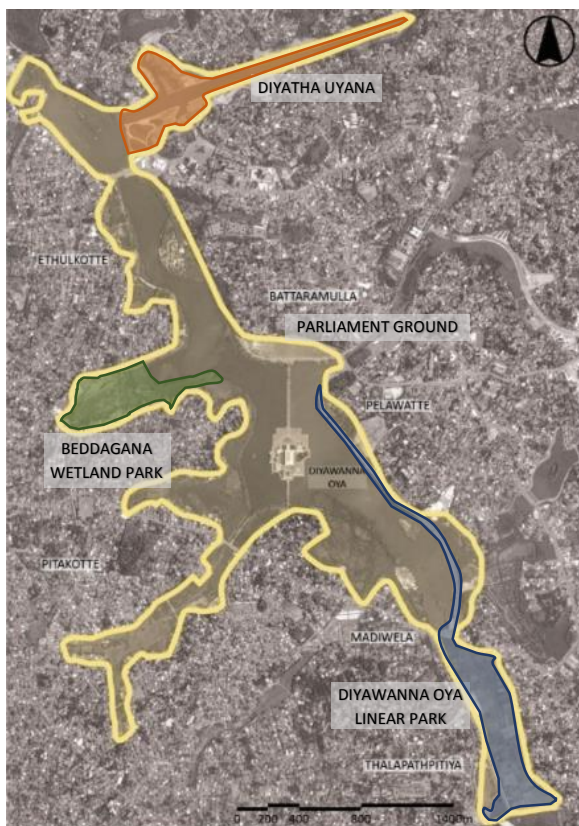


Fig. 4. Map of defined study area and landscape developments

5.2. Area of Study

Figure 4 indicates the public open space developments of the Diyatha Uyana, Beddagana wetland park and Diyawanna Oya linear park which are studied and analyzed

based on the theoretical framework, in order to assess their effectiveness for urban flood management.

6. Analysis of attributes

Landscape Architectural solutions for flood management could have subjective outcomes. The identified attributes for an effective landscape architectural solution takes into consideration these variations.

6.1. Adaptability to Floods

Wetland footprint variation

Sri Jayawardenepura Kotte was home to more than a 1000 Ha of wetland before the administrative capital was shifted here. The dredging of the wetlands for the construction of the Parliament complex and surrounding lake resulted in reclamation of about 272 Ha of natural flood retention area. Since then this area has seen a rapid decrease in wetlands [8]. The variation in the wetland footprint and water bodies was calculated using aerial images of the years 1999, 2007 and 2016 within an area of 1860 Ha (refer Appendix 2).

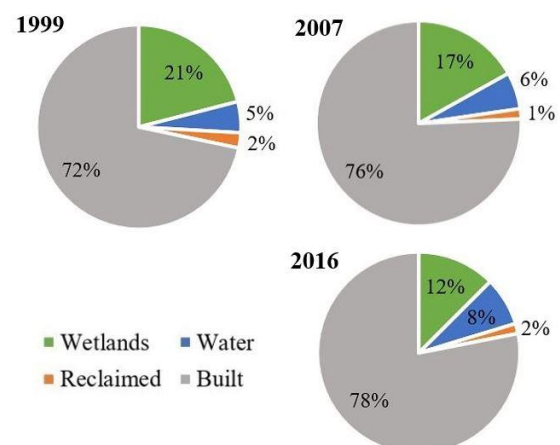


Fig. 5. Land use variation in the years 1999, 2007 & 2016

A significant increase is seen in the area of water bodies due to the flood management and development activities that took place after 2010. Few wetlands along with several reclaimed areas have been converted to water bodies. Hence, considering flood retention capacity, there is currently an imbalance between open water and marsh wetlands.

Multifunctionality and integration of landscape elements

- **Diyatha Uyana**

The activities of this open space include a water retention lake, constructed wetlands, jogging track, waterfront seating and lawn, vehicle parking, children's play space and weekly sales outlets. Most functions incorporate supplementary functions such as inundation space during floods, social gathering and public performance spaces, alternative seating etc.

Figure 6 shows the three main walkways, designed at different elevations. In the event of a high precipitation, the lower area will get inundated creating a new high-water level. This multifunctional use of open space enables flood to occur without causing great inconvenience in this particular area. The adjacent part of the Diyawanna lake has been dredged to increase the water retention capacity but there are also problems of silting. The retention ponds and constructed wetlands directly contribute to flood management. However, they are regularly maintained thereby, disturbing ecological succession.

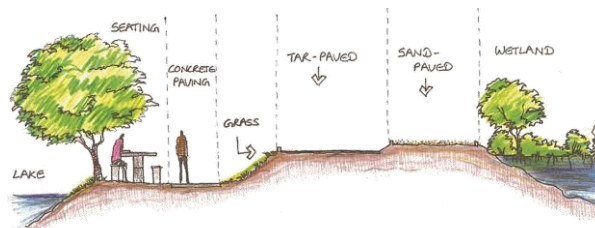


Fig. 6. Different levels of walkways and spaces for flood resilience

- **Beddagana Wetland Park**

This park focuses on conserving the natural wetland to maintain flood detention capacity. Therefore, the main activities of a jogging path, boardwalk, birdwatching, dry weather playground, nature trail involves the public in effectively conserving the wetland. This ensures that the natural wetland is protected through multifunctionality combining both the hydrological/ecological benefits of wetland and social awareness.

The landscape has been designed considering historical flood levels and ensuring least impact to the flood retention/detention capacity of the wetland. Use of compacted earth/gravel-paving encourage ground water absorption, while the raised timber walkways, ensures minimum impact on the natural landscape. Similar treatment has also been given to the other built structures. The area as a whole, including the dry weather playground, acts as a detention basin for flood water at source and excess water from the Diyawanna Oya.

- **Diyawanna Oya Linear Park**

The linear park along the Diyawanna Oya was developed upon the idea of increasing water retention capacity of the lake and a

water front development to provide recreation and health benefits to the community. Most activities and elements incorporated in this development are designed to be multifunctional in events of high precipitation.

The main element in this area is the jogging track. Most part of it including the carpark has been infilled. They are at a lower level than the main road and is a high-water level for the lake in the event of a flood. The paddy fields in the vicinity act as a natural flood detention area. However, due to the significant absence of natural or constructed wetland or any other BMPs it is possible that excess water will continuously flow downstream and not be detained at source. The slopes of the water bodies are turfed discouraging natural slope vegetation required for conserving biodiversity and water quality.

6.2. Context responsive landscape character and aesthetic quality

Sri Jayawardenepura Kotte is a city of cultural significance and unique in terms of its landscape and character, home to a protected wildlife sanctuary within an urban context. Hence, it is important that landscape developments respond to this character. The landscape character of the four significant landscape developments are analyzed in the tables below.

• Parliament Ground

CRITERIA	Parliament Ground
Simonik (2013)	
<u>Naturalistic landscape</u>	
• Free plant growth	
• Grouped planting	
• Partly/entirely vegetated water edge	
• Irregular arrangement of elements	
• Irregular water edge	
<u>Geometric landscape</u>	
• Regular tree arrangement	X
• Open lawns	X
• Formal landscape design elements	X
• Regular maintenance	X
Swanwick (2002)	
Topography	Flat
<u>Elements:</u>	
Buildings in the surrounding	Residential Administration
Hydrology	Lake
Ground cover materials used	Grass Concrete
Significant elements	War monument
<u>Aesthetic factors:</u>	
Scale	Large
Enclosure	Open
Movement	Busy
Form/Pattern	Formal

Table. 2. Analysis of the landscape character of Parliament ground

• **Diyatha Uyana**

CRITERIA	Diyatha Uyana
Simonik (2013)	
<u>Naturalistic landscape</u>	
• Free plant growth	X
• Grouped planting	
• Partly/entirely vegetated water edge	X
• Irregular arrangement of elements	
• Irregular water edge	X
<u>Geometric landscape</u>	
• Regular tree arrangement	X
• Open lawns	X
• Formal landscape design elements	X
• Regular maintenance	X
Swanwick (2002)	
Topography	Undulating
<u>Elements:</u>	
Buildings in the surrounding	Administration Recreation Residential
Hydrology	Lake Ponds
Ground cover materials used	Grass Concrete Timber Sand Tar
Significant elements	Sales pavilions Fountain
<u>Aesthetic factors:</u>	
Scale	Large
Enclosure	Open / Enclosed
Movement	Busy
Form/Pattern	Organized

Table. 3. Analysis of the landscape character of Diyatha Uyana

• **Beddagana Wetland Park**

CRITERIA	Beddagana Wetland Park
Simonik (2013)	
<u>Naturalistic landscape</u>	
• Free plant growth	X
• Grouped planting	X
• Partly/entirely vegetated water edge	X
• Irregular arrangement of elements	X
• Irregular water edge	X
<u>Geometric landscape</u>	
• Regular tree arrangement	X
• Open lawns	X
• Formal landscape design elements	
• Regular maintenance	
Swanwick (2002)	
Topography	Undulating
<u>Elements:</u>	
Buildings in the surrounding	Residential Religious
Hydrology	Lake Ponds Canal
Ground cover materials used	Timber Gravel Sand Concrete
Significant elements	
<u>Aesthetic factors:</u>	
Scale	Large
Enclosure	Enclosed / Open
Movement	Calm / Still
Form/Pattern	Random

Table. 4. Analysis of the landscape character of Beddagana Wetland Park

• **Diyawanna Oya Linear Park**

CRITERIA	Diyawanna Oya Linear Park
Simonik (2013)	
<u>Naturalistic landscape</u>	
• Free plant growth	
• Grouped planting	
• Partly/entirely vegetated water edge	
• Irregular arrangement of elements	
• Irregular water edge	
<u>Geometric landscape</u>	
• Regular tree arrangement	X
• Open lawns	
• Formal landscape design elements	X
• Regular maintenance	X
Swanwick (2002)	
Topography	Flat
<u>Elements:</u>	
Buildings in the surrounding	Residential Religious Recreational
Hydrology	Lake Pond Canal
Ground cover materials used	Sand Concrete
Significant elements	Food vendors
<u>Aesthetic factors:</u>	
Scale	Large
Enclosure	Open
Movement	Busy
Form/Pattern	Organized

Table. 5. Analysis of the landscape character of Diyawanna Oya Linear Park



Fig. 7. Geometric slopes of the wetlands (top) vs. The naturalistic character of the context (bottom)

6.3. Social Responsiveness and Community Integration

In the sample of 30 respondents, there was an equal distribution of male and female respondents. 93% of the respondents were residents within the study area or in the immediate surrounding. 30% of the respondents were also employed in this area.

Year	Experienced floods			Did not experience
	Only observed	Inconvenienced due to minor impacts	Directly affected	
1992	17%	23%	0	60%
2010	13%	44%	0	43%
2016	30%	50%	3%	17%

Table. 6. Comparison of flood experience of respondents

Most respondents could not recall particular information of the flood in 1992. It is evident that from the number of

respondents who had experienced floods, many had been inconvenienced by it and the number has risen each year. Further, 57% of the respondents agreed that the occurrences of floods have increased over the years, with only 43% agreeing that the recent development projects reduced the risk of flooding.

Public landscapes	No of respondents		
	Frequently	Occasionally	Total
Diyatha Uyana	8	22	30
Diyawanna Oya linear park	8	14	22
Beddagana wetland park	2	13	15

Table. 7. Frequency of visit

Diyatha Uyana is a park with diverse activities that cater to a wider range of users and it is clearly the more popular public space. It is evident that these multifunctional landscapes have been accepted by the community as 87% of the respondents stated that they prefer spending time in public open spaces.

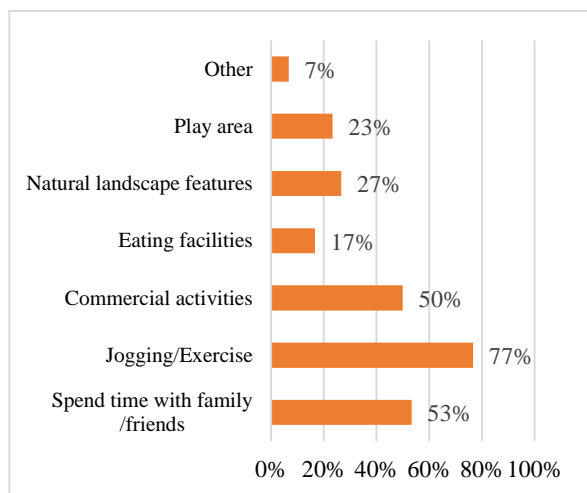


Fig. 8. Reasons for visiting public open spaces

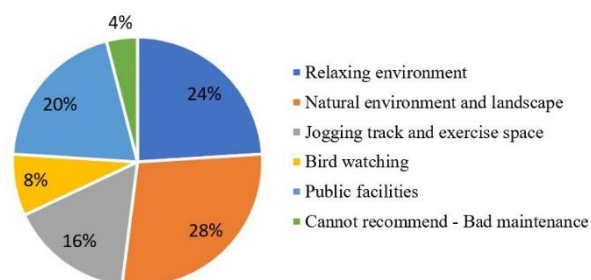


Fig. 9. Distribution of the reasons for recommendation of the landscapes

Considering the public perception of these open spaces, most people preferred these spaces and would recommend it to others due to their natural landscape and relaxing environment. Therefore, the landscape character of the space plays a vital role in the social responsiveness of a landscape.

6.4. Discussion

The landscape developments aim to conserve the natural flood retention capacity but were focused on increasing the water retention capacity of the Diyawanna Oya. Constructed wetlands would be a more effective water management system for flood detention rather than open water wetland. Although an effort has been taken, the water retention capacity has not reached a satisfactory level for flood management due to the continuous loss of natural wetland.

All three landscape developments incorporated multifunctionality in the designs. In the Diyatha Uyana and Linear park, there is a concern that the dredging of large areas may not be effective in the case of a 50-year flood situation but is resilient to minor floods. The Beddagana wetland park,

however, effectively integrates the natural hydrological functions of the area to ensure an effective and flood resilient landscape design. Considering the overall adaptability of the analyzed area, it is not completely effective to manage urban floods of large scales.

The character and aesthetic quality of these landscape developments vary. The geometric character of the parliament grounds is justified due to its formality in the context. The Beddagana wetland park has ensured least disturbance to the ecological habitats and flood detention capacity, effectively responding to the aesthetic quality and landscape character. Although there is an integration of the natural landscape in the designs of the Diyatha Uyana and Linear park, the need to address requirements of a public space has negatively influenced the geometric character of the landscape. However, the use of significant natural elements reduces this highly formal landscape effect to a certain extent. Large open spaces can be made more responsive to the natural environment and predicted flood lines (levels), through clustered vegetation, naturalized lake slopes, abstract land forms and effective BMPs in place of hard landscape material.

Considering the social responsiveness of the above developments, people interact with these public open spaces and it addresses public recreation and well-being of the society. Nevertheless, the community as a whole need to be given a clear understanding and awareness on the objectives and outcomes of such developments in order to have a better a sense of ownership of public

landscapes. It can be deduced that people feel welcome in these spaces and have the freedom for exploration and interaction with the landscape, hence making them socially responsive.

7. Conclusion and recommendations for future development

A framework developed based on existing literature identified three possible attributes to assess landscape architectural solutions for urban flood management. Based on this, the study of the public open spaces of the Diyawanna Oya and its surrounding identified a significant contribution to sustainable flood management in the local context. The landscapes were found to be socially responsive and effective in establishing multifunctionality through the integration of landscape elements and spaces for flood management. However, with the continuous decline of wetland, the adaptability of these landscapes to large scale floods is affected. The landscape character and aesthetic quality of the spaces conformed to the immediate context to a certain extent, however, it was identified that common aspects such as vegetated slopes and clustered vegetation in all landscaped spaces were required to support the ecology and natural surrounding better. Hence, these landscape developments can be considered to be only moderately effective as a landscape architectural approach for flood management.

In future, it is recommended that left-over spaces from the years of continuous economic and commercial development in Colombo are developed with green

infrastructure to create a network of public and private open spaces for flood management. Further, strict policies for regulation including mandatory landscape regulations for more permeable ground cover and BMP's in private lands should be implemented. Flood lines could be part of the landscape designs to create different social experiences and unique flood awareness landscapes. Similarly, a holistic solution including the combination of the human influenced land, wetland and water can be further developed as the 'LAWW' concept (LAnd, Wetland, Water) illustrated in figure 10, for future landscape design approaches for flood management.

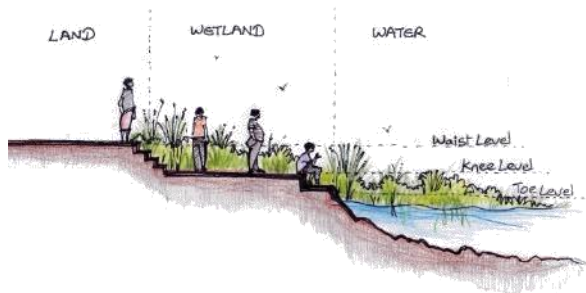


Fig. 10. Integrating naturally created flood lines with respect to human perception

Several aspects relating to the topic have not been discussed. The ecological components of the biodiversity and water quality, and future maintenance are points which would contribute to better understanding and implementation of effective landscape architectural solutions for flood management. With further studies in this field, future developments for sustainable flood management through landscape architecture have the potential to successfully manage any degree of floods, thereby establishing flood resilient cities.

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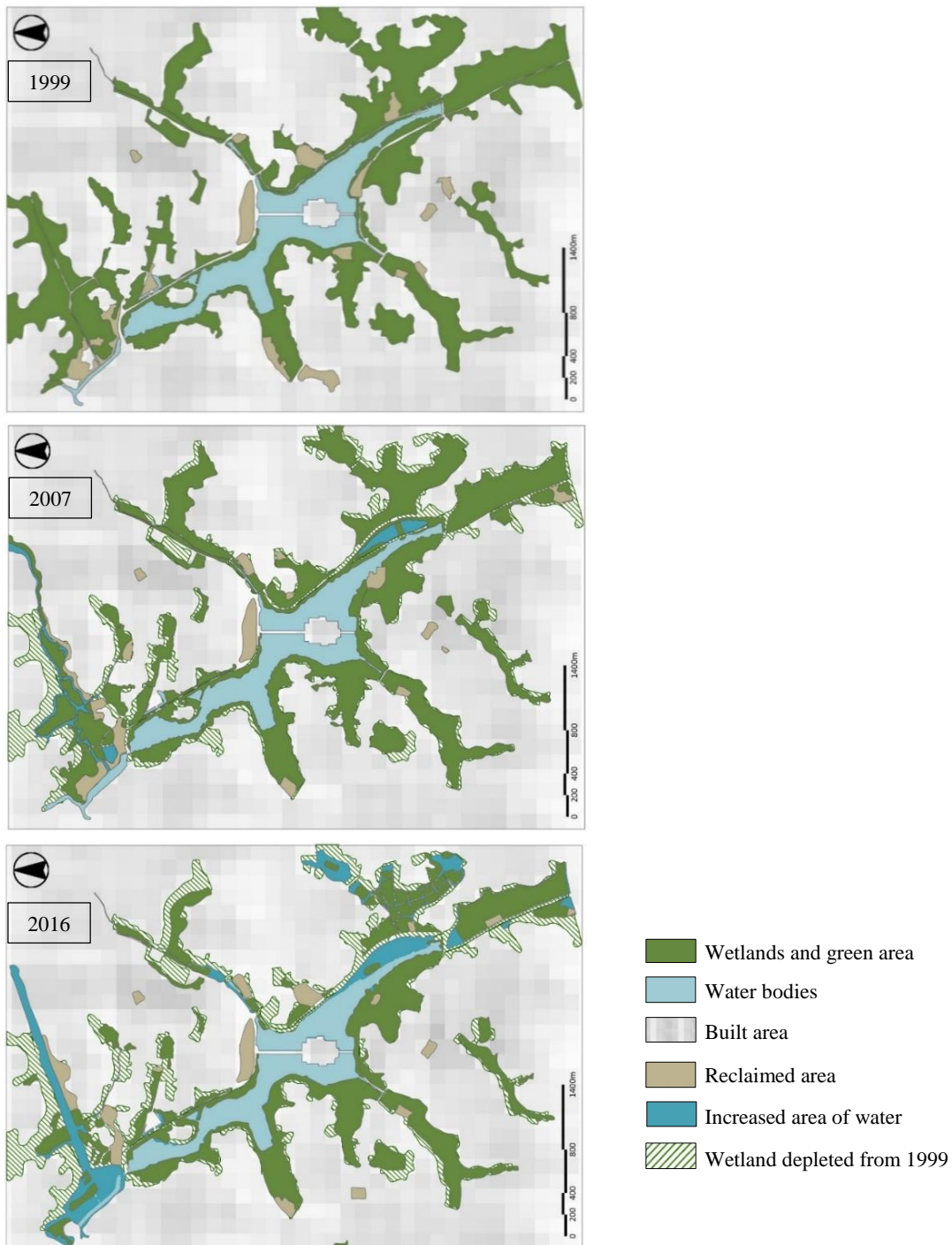
Appendix 1

Comparison of the summary of reviewed literature

Liao, 2012 ⁹	Miguez, Mascarenhas, & Magalhaes, 2007 ⁴	Bacchin, et al., 2014 ¹⁶	Rezende, Carneiro, & Miguez, 2011 ²¹	Wong & Eadie, 2000 ⁶	Cesar, et al., 2007 ¹²
Open space for multifunctional use	Multifunctional use of open space	Green blue infrastructure as multifunctional system	Use of public space as multifunctional	Use open space for urban amenities	Public open space for multifunctional use
Social adaptability	Urban solution + Hydraulic functions	Integrate nature into urban environments	Integrate hydrology and urban design	Community empowerment	Respond to local community
Floodable land – Adaptability and flexibility	Restore natural processes of storage and infiltration	Liveability – Social interaction and activities	Water quality improvement	Holistic approach to flood mitigation	Landscape aesthetics and culture
Maintain city identity	On-site water detention	Retention and percolation are critical	Social interaction and responsiveness	Aesthetic quality	Incorporate ecological and hydrologic features
Ecological resilience for management		Quality of urban life	Water retention and detention in open space		

Appendix 2

Land use variation in the years 1999, 2007 & 2016 and comparison of wetland depletion



Air pollution influence on Silesian health resorts

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Abstract

Both Jedlina-Zdrój and Szczawno-Zdrój are well-known, traditional health resorts, located in industrial region of Walbrzych. Their history began in 16th century, when mineral spring waters were discovered. After quick development in 19th century and modernisation before II World War, they are no more popular touristic destinations. The limits of air pollution are exceeded, and Polish government and local authorities are acting to prevent the destruction of local cultural heritage. Analysis of threats and possibilities to protect local environment.

Spa Town; Silesia; health; air pollution

1. Introduction

According to the Polish law, health resorts are separated areas for using and protecting natural medicinal resources. The status of a spa town is given to the city, that must have:

- local climate with healing qualities,
- unique, natural deposits of spa resources,
- health care institutions providing services in the field of spa treatment by highly qualified medical staff,
- hospital and sanatorium facilities and full technical infrastructure,
- requirements specified in the provisions of the law on environmental protection,
- an appropriate area allowing for the separation of spa protection zones,
- meaning in the scale of region and country.

Requirements for clean air and healing qualities of a local climate were set to provide best possible conditions for patients. According to World Health Organization, clean air is a basis for human health and well-being, so it should be provided not only in spa towns, but in every place, where people lives[1]. Further studies are published in which air pollution is identified as the cause of death[2]. At the same time, quality of air in Silesia, is the worst in Europe, and one of the worst on Earth.

2. Development of Jedlina-Zdrój and Szczawno-Zdrój

2.1. Jedlina-Zdrój

Jedlina-Zdrój is a small city, located in Sudety mountains, with the population of 5 000. Spa town in picturesque valley, surrounded by forests is famous for its

mineral spring, mentioned in 1694[3]. Chemical additives of water are mainly carbon dioxide and sodium. Patients come to the town, to heal respiratory system diseases, allergies and neuroses[4].

The development of Jedlina-Zdrój as a health resort began in 1723,. The owner was Austrian general, Johann Christoph von Seherr-Thoss. He brought the town into cultivation and gave the name of Charlottenbrunn, in honour of his second wife. In 1835 another mineral spring was discovered, called after next town owner's wife- Theresienquelle[5].

In 1724, as one of the first spa towns, Jedlina-Zdrój had a hall for patients social meetings and entertainment. On the begging of 19th century, existing bath facilities were not enough. In 1823 new bathrooms were built and in 1885 spa bath was opened. As medical season began to last longer in the year, local authorities tried to increase the comfort of patients.

On the beginning of 20th century, Jedlina-Zdrój was connected to the water supply network, with usage of natural water pressure. At this time spa town was visited by 3 000 patients every year, but it was still one of the smallest Silesian health resorts. Before II World War, in Jedlina-Zdrój were such entertainment places as promenade, spa park and walking routes. In 1935 new colonnade was opened [6].

One of the most important factors in developing modern health resort were a rail line and railway station. In most of the spas summer population doubled after building the railway connection [7]. Jedlina-Zdrój was connected by, the full of beautiful views, rail line number 285, with the local capital city - Wrocław, via Świdnica, in 1904.

During The II World War, Jedlina-Zdrój had an important function for German army. In the first years of war, in the town was a healing center for soldiers and injured civilians. In next years, when the Nazi-German army leadership found out, that Sowie Mountains would be a perfect location for the system of shelters and underground factories, they located a management of this project (project called *Riese*, build to provide a new shelters and factories in the mountains connected to the General Headquarters buildings in Książ Castle) in the palace building in Jedlina-Zdrój [8].

Despite the great past of the town, in the second half of 20th century, Jedlina-Zdrój had to face problems. Many owners of spa buildings, necessity of a restoration. Paradoxically, water in a spa pool wasn't clean, and patients wouldn't take baths. They also complained about poor entertainment offer[9]. Now, the spa offers healing vacations, but is no longer popular touristic destination.

2.2. Szczawno-Zdrój

Szczawno-Zdrój is the biggest Spa Town in Middle Sudetes. It was popular spa town before II World War. The spa character of Szczawno-Zdrój has been known since the Middle Ages. For the first time, the healing properties of waters was examined and confirmed by the court physician of Hochbergs - Caspar Schwenckfeldt in 1597. The chemical composition of waters, their medical application and the results of the analyzes carried out were described in 1777 [10]. Szczawno-Zdrój gained popularity in the first half of the 19th century. Spa developing and a theater and spa park were established in the town. The biggest building

of a town was built in 1910. Great, empire styled building was a Grand Hotel. It was state-of-the-art and biggest hotel in Silesia [11].

Healing properties of bicarbonate-sodium-calcium-magnesium water: "Mieszko", "Dąbrówka", "Młynarz" and "Marta" are used in diseases of the musculoskeletal system, upper and lower respiratory tract,

2.3. Spa towns today

Szczawno-Zdrój, as a bigger and more popular in the past, is still more popular than Jedlina-Zdrój. They never got back their popularity from the past. Mostly, because of a development of medicine. Now, humankind can prevent or cure a lot of illnesses. Health resorts were created to help patients with chronic illnesses. They became a popular touristic destination on the beginning of 20th century because of entertainment possibilities and their social meaning. Szczawno-Zdrój was even visited by Winston Churchill. After II World War, health resorts were a destination for workers, who got holidays here from government. Today, patients are mainly elderly or pensioners. The stay is still paid by National Health Fund, but spa buildings, hotels and treatment processes are managed by companies.

Both Jedlina-Zdrój and Szczawno-Zdrój are municipalities with local authorities. They have a status of a spa town, but inhabitants of the city work mostly in other fields. They are close to Wałbrzych (Szczawno-Zdrój borders with it, Jedlina-Zdrój is 10 km away), and not far from local capital city of Wrocław (90 km away).

diseases of the digestive system and urinary tract treatment [12].

In 1946, the town was incorporated into the newly created Wrocław voivodship in post-war Poland. The spa functions to the present day, constantly improved and its attractiveness increased, but the city is not as popular as in 19th and beginning of 20th century.

Jedlina-Zdrój looks like a small village in the mountains. Szczawno-Zdrój is a bigger scale health resort, so it still has the spirit of great spa town, at the same time becoming a commuter town of Wałbrzych.

3. Air pollution

3.1. Air pollution in Poland

The growing demand for energy causes that pollutants enter the atmosphere. The most important of them are: sulfur dioxide, nitrogen oxides, coal dust, carbon monoxide and dioxide, tropospheric ozone. The source of their emission is progressive industrialization, population growth, energy industry and transport.

Poland belongs to the infamous top European Union countries when it comes to air pollution. The very poor air quality that the inhabitants of many regions of Poland breathe, should be seen not only in terms of environmental degradation, but also as a huge development neglect of the country.

While over the last decade, using EU funds, Poland has made tremendous progress in the field of water management, waste management has been regulated over recent years, air protection issues have not been an

area of adequate solutions for the past decade. Polish air protection policy is largely reactive - air pollution emitted by industry and energy has been significantly reduced because the requirements for this sector have been introduced at the level of EU legislation. What is missing, however, is practically any regulation in the field of installations used in households, i.e. fireplaces and boilers for solid fuels or fireplaces. Also in the field of transport, there are no key legal solutions that would allow limiting the use of the most harmful cars. As a result of many years of neglect, Polish air is one of the most polluted in the entire European Union. European and Polish law regarding air quality standards has been broken for over 10 years.

Analysis of the highest annual concentrations and stations with the highest number of days when the permissible daily concentration of PM₁₀ is exceeded indicates, that the majority of stations with the worst results is located in southern Poland. It is highly negative that the reported results far exceed the norm - especially in the case of daily concentrations. With permitted 35 days, when the daily PM₁₀ concentration exceeds 50 µg / m³, many Polish cities and towns achieve a score of over 100 such days. These are often extremely high concentrations, up to 200 µg / m³, and even 300 µg / m³. It is also worth noting that the highest concentrations, both in terms of the annual average and the number of days exceeding the norm for daily concentration, are noticed not only in large cities, but also in smaller towns. This proves that the problem of polluted air is not only a problem of urban agglomerations. This should not come as a surprise, considering that the main source of PM₁₀ emission in the country is home

heating installations: coal and wood-fired boilers and fireplaces.

It should be noted that the weight of individual sources of air pollution will vary throughout the year, the situation will look different in the summer, and differently in winter. It will also depend on the location - the share of sources may vary depending on the type of building (multi-family housing, single-family houses), the size of the town or distance from the large communication artery.

In the scale of the country the largest source of air pollution with dust and benzo(a)pyrene, substances, of which extremely high concentrations Poland has the biggest problem, is the so-called low emission. It is emission from low chimneys (up to 40 m high), created as a result of combustion of solid fuels (coal, wood), and often also waste. The main reason for low emissions is heating households with solid fuels and their use in small production or commercial plants.

Combustion processes outside the industry, i.e. mainly low emissions, account for almost half of the emissions of all PM₁₀ particles emitted in Poland in 2014. Road transport led to the emission of 9% PM₁₀ dust (combustion of fuels, abrasion of brakes and road surfaces). Energy production and industry contributed to PM₁₀ emissions to a similar degree as road transport (9% and 8%).

The dominating contribution of low emission in PM₁₀ emission translates into very high concentrations of this pollutant during the heating season. Exceeding the daily norm for PM₁₀ dust outside the heating season is rarely observed, and high concentrations occur only from autumn to spring, that is when a significant part of Poles

heats homes with coal and wood, and often rubbish.

3.2. Air quality improvement programs

While all limits set by EU and WHO are broken, Polish government and local authorities try to improve the air quality by own regulations. In Szczawno-Zdrój in Jedlina-Zdrój, and in Wałbrzych region, local authorities published a report about the air quality an program to improve it. For pollutants such as NO₂, SO₂, C₆H₆, Pb, As, Cd, Ni, PM_{2.5}, acceptable levels, target levels and levels long-term ones were not exceeded. However, for PM₁₀, CO, and benzo(a)pyrene, the levels admitted by the margin of tolerance were exceeded.

The main cause of PM₁₀ and benzo(a)pyrene exceeded in winter is low emission, while in the summer emission from various communication sources. High concentration is characteristic of combustion processes in ineffective heating boilers. Benzo(a)pyrene is a dangerous, toxic and carcinogenic substance that has a negative effect on reproduction, cause hereditary genetic defects and impair fertility.

The analysis of air pollution showed that in the Wałbrzych region, in order to reduce emissions and immissions, activities aimed at improving the purity of the atmosphere are indicated. In relation with the tightening of environmental protection regulations, and in the interests of the residents, these actions should be taken by implementing the following goals:

- Systematic improvement of air quality in the Wałbrzych region communes
 - to develop or update a plan for supplying heat, electricity and gas fuels and its successive implementation,
 - for the development and implementation of a strategy for reducing the concentration of PM₁₀ fine particles and ozone ground level in the air,
 - to increase the awareness of the local community regarding the needs and possibilities of protectionair, including energy savings and the use of renewable energy sources.
- Support and promotion of ecological energy sources
 - replacement of conventionally fired furnaces with coal for gas heating or other friendly ones environment, energy carriers in both public and private housing (implementation of the low emission reduction program),
 - for an increase in the use of renewable energy sources,
 - for supporting and promoting the use of energy-saving materials in construction by residents,
 - for continuing thermo-modernization work in the communes of the Wałbrzych region,
 - for intensification of activities related to road modernization.

4. Air pollution effects on health resorts

Breathing contaminated air causes adverse health effects. Studies indicate that dust in the air can increase the risk of morbidity and mortality from lung and cardiovascular diseases, as well as increase the risk of cancer. Airborne contaminants primarily affect the respiratory system. The most harmful are small particulate pollutants, which due to their small size reach the smallest bronchioles and alveoli. Along the way, they cause irritating and inflammatory effects, which in turn facilitate the so-called allergy, i.e. allergies to vegetal and animal allergens occurring in our environment. In addition, people already suffering from bronchial asthma who, as a result of exposure to air pollution, experience an exacerbation of their disease, must take higher doses of medication and in some cases even be hospitalized. Inflammatory processes in the airways tend to recur, as a result people living in areas where air pollution is present in high concentrations may be more likely to have an upper respiratory tract infection.

As a result of long-term exposure for many years, chronic inflammation of the airways can lead to the development of chronic obstructive pulmonary disease. This is a very serious disease that leads to disability in the long run and the need to use a respirator. Inhalation of fine particles constituting air pollution originating in most of the living-communal sector, may cause inflammatory reaction in the lungs, which is associated with the release of specific mediators changing the conditions of blood clotting, thus contributing to ischemic disorders.

Irritating effects have not only dust, but also gaseous pollutants, such as sulfur

dioxide and nitrogen oxides. The smallest particles of dust are able to pass through the walls of the alveoli and go first to the pulmonary vessels, then to the whole circulatory system. As a result of not fully known mechanisms, they promote atherosclerosis. The consequences are extremely serious. As a result of atherosclerotic changes such cardiovascular diseases like hypertension, ischemic heart disease, disorders in the flow of blood through the brain arise. There may be heart attacks and strokes that often end in death.

Changes in the respiratory system in the form of lung cancer or cardiovascular disease have a negative impact on the length of our lives. Estimates made by the World Health Organization indicate that as a result of air pollution from the municipal-housing sector (i.e. the so-called low emission) about 48 thousand. deaths in Poland is premature. Estimated this means shortening the life of every citizen by an average of 10 months.

Air pollution particularly adversely affects children's health from the embryonic period. They probably impair the blood flow through the placenta, resulting in the fetus developing more slowly. The result of this is the observation that in areas with high air pollution more children are born with low birth weight. They are not premature babies, only children too small in relation to the duration of pregnancy. In extreme cases, like premature babies, they require intensive therapy. Such children then have a tendency to quickly gain weight and, paradoxically, often have problems with overweight or even are obese. Pre-school children living in polluted areas are more likely to have upper respiratory tract infections than older children or middle-aged adults. Pediatricians,

who know this problem, when they do not see improvement in their sufferers of chronic airway inflammations of small children, often recommend a longer stay at the seaside or in the mountains.

Another group very sensitive are people of an older age. On days when we observe high concentrations of air pollutants, especially connected with adverse weather phenomena such as high humidity, fog, lack of wind, older people experience exacerbations of respiratory and circulatory system diseases, requiring medical assistance, often even staying in a hospital. [13]

At the same time, the acid rain affects stone structures in two ways: they dissolve and cause changes on the surface. Buildings and monuments made of limestone or marble are particularly exposed. They consist mainly of calcite (calcium carbonate, CaCO_3), which is easily dissolved in weak sulfuric or nitric acid. On the surfaces of buildings or monuments one can observe cavities and damage, sometimes all architectural or sculptural details. On stone blocks or slabs one can observe surface or point only damage, depending on the material's resistance. Although in recent years the occurrence of acid rain has been significantly reduced in many regions, many buildings still have visible signs of their effects. This is because the acid rain permanently changed the structure and properties of the stone surfaces. Even metal parts corrode under the influence of acid rain. This applies to components made of carbon steel, nickel, zinc and copper. Damage is also visible on paint layers, some plastic, leather and textile parts. Stainless steel and aluminum are more resistant. Renovating monuments and monuments is very expensive. Economic

losses can be calculated and estimated, while aesthetic losses related to the destruction of treasures of world culture can not be estimated.

5. Summary. The future of Silesian health resorts

Health resorts are no longer safe for patients, they might cause negative effects on their health. Touristic movement will decrease, buildings will be destroyed by polluted environment. It is the negative scenario, but in the worst situation the status of spa town can be reclaimed, as towns will no longer have their healing climate values. Touristic region will lose its source of income. The cultural landscape of this place, originated in 16th century, will not survive.

It is important to protect local heritage. To help health resorts, all must operate together. Government should assist local authorities, and inhabitants must cooperate and get the knowledge about threats of air pollution, not only to the environment, but also for their homes, touristic movement in their city and, most importantly, for their health. It refers to whole country, but especially to the health resorts.

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