Co-design of a stakeholders' ecosystem: an assessment methodology by linking social network analysis, stakeholder theory and participatory mapping

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Co-design of a stakeholders' ecosystem: an assessment methodology by linking Social Network Analysis, Stakeholder Theory and Participatory Mapping

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Abstract

Purpose: the need for Stakeholder Theory has been widely highlighted in the literature to develop solid strategies of a large organization. However, there is still a lack of user-friendly visualization tools and no unique approach exists to identify and engage stakeholders. This paper aims at proposing a general methodology to co-design the sustainability ecosystem at the local scale, to explore it, and to assess the impact of a large organization within the identified ecosystem.

Design/Methodology/Approach: the methodology consists of two main processes: 1) identifying an ontological map of the Sustainability Topics Network and 2) designing the local Sustainability Stakeholders Ecosystem. Both processes are based on a Nodes Identification phase and a Nodes Prioritization phase. The Identification phase was achieved by engaging 160 citizens, for the Topics Network, and nearly 40 relevant stakeholders, for the Stakeholders Ecosystem, with a collaborative participatory mapping process. The Prioritization phase was conducted thanks to three indicators, i.e. the closeness, the betweenness, and the eigenvector centrality.

Findings: betweenness centrality results to be the best indicator to assess the importance of a stakeholder with respect to the whole network, while eigenvector centrality highlights the quality of the already engaged stakeholders of an organization, since it mainly depends on the number of links of the first order neighbors. On the contrary, the closeness centrality, when applied to a small network, seems to be not appropriate to assess the centrality of a stakeholder.

Research limitations/implications: this approach revealed some criticalities in the mapping process, as in the weighting link procedure. Further investigations are needed to generalize the approach to a dynamic one, to allow real-time mapping, and to develop a robust interconnection among centrality degrees and the power, interest, and legitimacy concept of Stakeholder Theory.

Practical Implications: obtained results for a case study, i.e. the position of the University of Turin Green Office within the City of Turin sustainability ecosystem, are discussed showing how Social Network Analysis centrality degrees can be used to quantitatively assess the role of an organization within a stakeholders' ecosystem.

Social Implications: centrality analysis allows to identify emergent topics/stakeholders within a network of words/actors that, at a first sight, should not be considered by decision-makers and managers.

Originality Value: a new methodology for stakeholder identification and prioritization is proposed exploiting online data visualization tools, participatory mapping, and social network analysis.

Keywords: Stakeholder; Social Network Analysis; Participatory Mapping; Ecosystem; Sustainability

Introduction

Stakeholder Theory explains how an organization manages relations with everyone that can influence or be influenced by its operations, to develop robust strategies to realize a specific social contract within communities (R. E. Freeman, 1984). Universities are not an exception. Although Stakeholder Engagement is worldwide recognized as a fundamental approach for companies and large organizations to strategize over stakeholders' relations, there is still an open debate on which stakeholders must be engaged and on how to identify priorities (Myllykangas, Kujala, and Lehtimäki, 2010; Kujala, Heikkinen, and Lehtimäki, 2012). In the specific context of universities, there must be said, that the creation of partnerships to improve the sustainable development of their communities is seen applicable mostly for research projects and public engagement (L. D. Parker, 2002). How universities are managing relations with stakeholders, through which technologies and to what extent is a research field that is growing.

While the stakeholder salience model affirms principle-based techniques to prioritize stakeholders (Hillman and Keim, 2001; Mitchell, Agle, and Wood, 1997), on the contrary, other organizations like public universities might need tools for mapping their local context to understand who advocates for a particular topic or how a theme is stewarded (or not) by local actors. The application of the salience principle should come next to an a priori mapping of the relevant actors present on the territory. The need for a map is because while private corporations are expected to have a quite good knowledge of their markets, universities, known in the past as ivory towers, are still quite disconnected from a stakeholder management approach of names and faces invoked in the literature (McVea and R. E. Freeman, 2005), privileging a sort of institutional legitimacy. Nowadays, universities are more active than in the past in interacting with their environment but, unfortunately, usually that interactions are one-to-one personally/research group based, or one-to-one institutionally based (Leydesdorff, 2012; Oztel, 2020). However, specific topics such as poverty issues, access to education of vulnerable people, environmental concerns, are strongly place-based, in the sense that the priority and the urgency of coping with a particular issue can vary within the same community and over time. Institutional legitimacy means that public universities too often take for granted their legitimacy on a specific community, developing a strong relationship capital with other relevant local institutions (such as hospitals, municipalities, big industrial partners, museums, other public institutions), completely ignoring other potential actors less institutionalized that are working on the same issue (Pritchard et al., 2018).

Identifying which local ecosystems are present on a territory and how these are composed and work is of paramount importance for letting universities able to actively co-create partnerships for sustainable development, as requested by Sustainable Development Goals number 4 of the United Nations (Rieckmann, 2017). With the identification of such a social network, a university is in turn, able to develop its civic and political role, creating public value (S. B. Page et al., 2015). Design a tool to map and to graphically represent a specific local socio-ecological system can be essential for safeguarding and environing a community and creating bonds and bridges with stakeholders (Raum, 2018; Patulny and Svendsen, 2007). For environing, we intend here improving the adoption of an environmentally conscious governing mindset in the society, and the explosion of global movements for environmental stewardship like Friday for Future is an example.

With an ecosystem perspective, which category an organization thinks that is non-salient, like private citizens, small NGOs, or other local marginal subjects is considered as equal as a salient institutionalized stakeholder. This is important when it comes to deal with topics that are generalized and universal, such as environmental concerns, where NIMBY movements, opinion leaders, politicians can reach mediatic attention although they have low institutional power. Unfortunately, traditional approaches based on sorting salient and non-salient stakeholders are organizationally centred, where the relationships are seen as a dyadic tie between the organizations and a specific group, letting aside the existence of a web of interconnections between other groups (M. M. Fritz et al., 2018a; Ackermann and Eden, 2011; Rowley, 1997). Besides, studies on bottom-up grounded approach for stakeholder recognition and mapping are still rare because most of the techniques and researches on stakeholders' engagement support a top-down management approach (Roloff, 2008). Conversely, through a bottom-up approach in designing an issue-focused ecosystem, a university can reach the local political debate and can create future local leaders (Cottafava, Cavaglià, and Corazza, 2019).

This work aims at proposing new glory to Social Network Analysis (SNA) into a generalized and universal framework to map a local stakeholders' ecosystem that can be used by every large public, or private, organization. The framework is based on web and real-time data visualization tools, developed over two mapping processes: (A) the first one is based on a conceptual map which allows identifying the most relevant and actual topics within a local territory and (B) the second one aims to identify the most relevant stakeholders within the same local area. Both approaches may be split into two steps. The first step consists of identifying the network of relevant words (A) and stakeholders (B), while the second step exploits SNA in analyzing the obtained graphs interpreting centrality degree measures (degree, closeness, betweenness, and eigenvector centrality). Centrality analysis allows identifying emergent topics/stakeholders within a network of words/actors that, at first sight, might not be fully considered by decision-makers and managers. Moreover, SNA allows to assess and evaluate the ranking and the position of an organization within its local ecosystem. Depending on which centrality measure is adopted, various information useful for decision-makers can be extracted to assess the position of an organization in a real context, or to shorten the path between one organization and another graphically representing bonds and hubs. The case analyzed is an example of interventionist research within an Italian public university where its Green Office (UniToGO) needed to establish its public policy and research outreach within its community on environmental concerns. The paper implied interventionist and grounded filed research in applying SNA (J. C. Dumay, 2010; J. Dumay and Baard, 2017).

The rest of the paper is structured as follows. In section 1, a brief literature review on Stakeholder Theory, Social Network Analysis, and Participatory Mapping processes is outlined. In Section 2 the two adopted approaches are described. First, a crowdmapping approach, i.e. a citizens' engagement process, is illustrated. Secondly, the three steps adopted during the workshop "Co-design of the Sustainability Ecosystem" (i.e. (1) Relevant actors of the network and (2,3) Relations within the network) are explained. In Section 3, the results of the two approaches are discussed and analyzed. The two obtained networks are analyzed in terms of centrality degrees and scale invariance law to point out and highlight the crucial nodes. A process to identify the current position of an organization within the network (in this case the University of Turin Green Office) is discussed. Finally, in Section 4 some insights on future applications are presented to fill the gap between and to link participatory mapping, Stakeholder Engagement, Social Network Analysis.

1 Background

1.1 Stakeholder Theory

While in recent Freeman works', he has affirmed that Stakeholder Theory has not to be taught as a theory with such an impressive impact on management studies, the process of identifying, mapping, prioritizing, and engaging stakeholders has become popular in every business organizations since its beginning (R. E. Freeman, 2018; R. E. Freeman, Phillips, and Sisodia, 2020). Two different strands of the literature on stakeholder management process exists, the supporters of Mitchell, Agle, and Wood (1997) model of stakeholder salience, and who think that prioritizing stakeholders' and their needs can be a leverage for discriminating legitim interests by managers to privilege the most convenient ones (Kujala, Heikkinen, and Lehtimäki, 2012; Kujala, 2001). According to the other perspective, when it comes to deal with complex problems such as poverty issues affecting local communities or environmental concerns, or, more in general, in the case of complex organizational context, the salience model fails. It fails because solving complex problems requires cooperative efforts that cannot be guaranteed through a selection of privileged actors; indeed such cooperative actions are grounded on a different type of relationships that are continually changing, and they include a complex web of liaisons, interests, values, and expectations (Kujala, Heikkinen, and Lehtimäki, 2012; Corazza and Cisi, 2017).

From the Mitchell et al.'s model, more than twenty years are passed, and nowadays sustainability studies have unequivocally demonstrated that only through collaboration and coopetition, organizations and societies can work for sustainable development (Ranängen, 2015). Consequently, studies on stakeholder engagement are evolving from prioritizing to networking. Specifically, the phase that in Mitchell et al. is called identification, is still of paramount importance, but the sense-making of that action is different. While in the past the identification phase was due to apply a prioritization next, now, stakeholder identification is needed to create a cross-mapping activity oriented to social cohesion or to act or mobilize stakeholders (Crane and Ruebottom, 2011). One of the most evident shifts is, in fact, the end of the view of stakeholders relationships as a dyadic approach (Rowley, 1997), organizational centered, and the born of an eco-systemic view with multiple-actors, that in most of the case is issue-based (Roloff, 2008). For instance, in one of the recent contributions of Mitchell, J. H. Lee, and Agle (2017), there is written that of particular interests for the future development of their model are studies on stakeholder dynamism, and how the engagement may vary, varying the relationships between stakeholders in a network.

Exploring the interactions between stakeholders in a network allows several reasonings. First, it can be easier to have a complete outlook on formal and informal relationships and how they evolve. Second, it allows a view of the most powerful actors in terms of interconnections highlighting new stakeholders or revealing new ties. Third, in the case of complex problems, there may be possibilities for building a coalition and partnering (Ackermann and Eden, 2011). As clarified by R. Freeman (2017), to understand an organization is fundamental to know how these relationships work with a sort of "business as relational" framework, without having an organizational-centered perspective (2017, 3). Moreover, recently M. M. Fritz et al. (2018b) have defined nine main requirements to bring stakeholders management useful for strategic management, such as to define system boundaries, integrate an iterative process to avoid top-down approach bias, include the time dimension, adopt visualizing tools, as well as adopt a holistic view, review the literature and combine different methodologies.

Specifically, in our paper, we present a methodology that is significantly grounded on visualizing stakeholder network, to help managers and decision-makers to understand stakeholder dynamism in the context of universities for ecological stewardship. In this sense, the link between systems theory and the Social Network Analysis (SNA) will be discussed, because the visualization of ecosystems through the implementation of a technological new method can overcome the problem of organizational centricity and manipulation, to let crystal clear the complexity of ties and bonds between actors.

1.2 Social Network Analysis

The Social Network Analysis emerged in modern sociology as a fundamental tool to analyze the dynamics and the behavior of the society and was introduced to investigate the concept of social stratifications in the early of the XX century (Hess, 2001) while, nowadays, it can be used to study a wide range of processes such as opinion spreading dynamics (Fortunato, 2005; Lama, López, and Wio, 2005), epidemic models (Stehlé et al., 2011), neuroscience (Bullmore and Sporns, 2009), innovation ecosystem (Rubens et al., 2011) and so on. A graph is defined as an ordered pair $G = (V, E)$, where V is the set of the nodes and E is the set of edges and it is described by a square $N \times N$ matrix, the *Adjacency Matrix* where N is the number of elements of V ($|V|$). Each link between node i and node j is defined by the weight w_{ij}. Given k_i the degree of the node i, the degree distribution of a scale-free network (Newman, 2003) obeys to the power law $P(k) = {}^{n_k}/_{N} \sim k^{-\gamma}$ where $P(k)$ is the the probability to find a node with k links (with degree k), n_k is the total number of nodes with degree k and γ is a constant for the analyzed network. To punctually analyze a network in order to assess the single node impact, Centrality degrees are crucial. The meaning of relevant or important node depends on the used indicators (Stephen P. Borgatti and Everett, 2006). To show how a nodes is considered central, Freeman (L. C. Freeman, 1978) analyzed a 5-nodes star-graph arguing that the middle central node may take advantage of three features with respect to the other ones: it has more links, it is closer to all other nodes and every path/flow must pass through it. The degree centrality is used to quantify the number of links of a precise node (i.e. the number of nearest neighbors) without taking into account the whole structure of the graph and it is described by $k_i^{in} = \sum_{j=1}^{N} w_{ij}$, $k_i^{out} = \sum_{j=1}^{N} w_{ji}$, $k_i^{tot} = k_i^{in} + k_i^{out}$, where k_i^{in} and k_i^{out} represent the number of inbound (or outbound) links. In the case of weighted graphs, degree centrality brings to misleading interpretation due to the introduction of the capacity of the ties (Newman, 2001; Barrat et al., 2003). Other centrality measures, instead, help to analyze a single node with respect their neighborhoods or the whole graph: (1) the Closeness Centrality (Sabidussi, 1966), i.e. the average of the shortest paths between a node and all other nodes, $C(i) = N / \sum_{j=1, i\neq j}^{N} d(i,j)$ where $d(i,j)$ is the shortest path between node i and node j; (2) the Harmonic Centrality (Rochat, 2009), defined for not necessarily connected graph, $H(i) = \sum_{i\neq j} 1/d(i,j)$ where $1/d(i,j) = 0$ when there is no path between node i and node j; (3) the Betweennes Centrality (L. C. Freeman, 1977; Brandes, 2001), $C_B(i) = \sum_{i\neq x\neq y} \sigma_{xy}(i) / \sigma_{xy}$ where $\sigma_{xy}(i)$ is the number of shortest paths between nodes x and y passing through node i, while σ_{xy} is the total number of shortest paths between nodes x and y; (4) the Eigenvector Centrality is based on the eigenvector equation associated to the adjacency matrix $Ax = \lambda x$ where x represents the vector of N nodes of the graph and λ is the highest eigenvalue. The eigenvector centrality is a measure which includes the influence of the node neighbors (Segarra and Ribeiro, 2014) and could be exploited to identify community structures (Newman, 2006).

1.3 Social Network Analysis and Stakeholder Theory convergence

In this paper, two different fields of literature are proposed in convergence: Social Network Analysis and Stakeholder Theory. Having clarified before that grand challenges and complex problems require both a combination of efforts to be addressed (Reid et al., 2010), it is clear now that organizations can no more use a self-centered perspective when it comes to identifying stakeholders with whom collaborate. Consequently, through Social Network Analysis, organizations can better frame their role in a complex ecosystem. In literature, researches on Social Network Analysis are focusing on Stakeholder Engagement and Natural Resource Management (Prell, Hubacek, and Reed, 2009), on Stakeholder Identification (S. Fritz et al., 2019) and on social-ecological systems (Virapongse et al., 2016), as well as on supporting strategic collaboration (Cross, S P Borgatti, and A. Parker, 2002).

Quoting Rowley (2017, p. 102), it can be affirmed that “social network and stakeholder research was done for each other”. Unfortunately, theorists have not made significant signs of progress in developing such union, while practitioners are considerably exploiting the power of visualizing and understanding the dynamics of the relationships between stakeholders to design strategic policy, especially in terms of sustainability. Relational embeddedness and tie strength are a useful concept that should be applied in the case of public universities, especially considering that the process of dismantling the so-called ivory towers conduce to break silos and being more active in establishing interactions with the external environment. Universities are called to act as a promotor of sustainability leadership by SDGs (S. Fritz et al., 2019), and this means to assume a leading role in local ecosystems to guide, to connect, and to lead a civic initiative for sustainability. By consequence, identify stakeholders and understanding who is acting with who and where, it needed to be one of the leaders of a local socio-ecological system (Fageha and Aibinu, 2016).

Indeed, a Social Network Analysis approach may highlight if and how an organization is wholly embedded in a complex network of stakeholders without establishing a multitude of costly dyadic relations, by exploiting the nodes of the nets that are more dense than other. For instance, Rowley (1997) clarified that through Social Network Analysis, it is possible to speedily recognize the power ties, the centrality of actors, and other areas that are ignored or marginally considered. More recently, Rowley highlighted that i) organizations exist within an external network of relationships, ii) networks create advantages for some actors, so a leader should understand how a particular network is shaped and iii) networks evolve and they can be subjected to changes in the exogenous factors. Concretely, through Social Network Analysis, the concept of power, legitimacy, and urgency can be displayed as centrality, betweenness and closeness, that are common features of stakeholder theory, but no more seen applied to static relationships. However, on the contrary, they are applied to dynamic socio-ecological systems.

From the theoretical perspective, stakeholders possessing an important level of relational capital in the network can be employed to mobilize and influence the actions of all the other actors. To be effective, especially in the case of a local ecosystem, local actors, such as local citizens, should play a relevant role in a bottom-up process, to overcome the barrier of replicating another institutional-centric map, that does not depict the reality of the environment. Through involving communities (i.e. citizens, students, professors), a stakeholder network perspective can be created, with the goals of conceptualizing stakeholder environments (Rowley, 2017).

1.4 Participatory Mapping

The analysis and the resolution of social and environmental wicked problems need a collaborative sensemaking process in which all types of actors within a determined ecosystem collaborate in the decision-making phase (Conklin, 2005). In recent years, participatory community mapping, supported by proper visualizing and designing tools, has been recognized as one of the fundamental approaches to encourage actors to work together (Moor, 2015). Communities can be described as a thematic network, i.e. made by nodes/actors and links/relations, where every single actor collaborates for a mutual benefit (Andrews, 2002) or a common goal/challenge (Wenger, Trayner, and De Laat, 2011). De Moor pointed out the necessity of a participatory community network mapping methodology (Moor, 2015) to give a sense to the community; for this purpose, sensemaking, as defined by Weick (Weick, 1995), may create a common meaning to the stakeholders' experience. He defined a few crucial broad properties for sensemaking such as, "it refers to plausibility, not to accuracy", "it is based on identity construction for the community" and so on. In literature, a participatory community network mapping approach was applied to a variety of communities with different purposes. For instance, Iaconesi et al. (Iaconesi and Persico, 2016) mapped the Kansas City's innovation ecosystem community, the cultural ecosystem of the City of Rome or other communities through Social Network interactions (on Twitter, Instagram, and Facebook). De Moor (De Moor, 2015) analyzed the community around an urban farming, Novak et al. (Novak and Cañas, 2008) studied common concepts starting from a focus question while Antonini et al. (Antonini et al., 2016) developed a Neighborhood Social Network to engage people toward active participatory citizenship within geographical boundaries (i.e. a neighborhood). In each study, the participatory mapping process needs appropriate language, tools, and processes to be effective. De Moor (Moor, 2017), for this reason, developed a cyclical methodology, named CommunitySensor, to create a common sense for the community itself. He defined 4 macro-level stages: i) mapping the most relevant pieces (seed map), ii) make sense of the collaborative work, iii) implementing the network in terms of aims and priorities, and iv) evaluating the effects of these interventions.

2 Methodology

This study follows an interventionist research model, where interventionist researchers had a direct immersion in the amelioration of a social problem within the context of the University of Turin Green Office (UniToGO). The researcher responds to the need of visualizing the socio-ecological system of the city of Turin that was impossible to obtain, with one-to-one (dyadic) relationships with stakeholders because the results would be partial and not representative of the reality (J. Dumay and Baard, 2017). As any of the traditional methods implemented, such as focus group, interviews, surveys, was inefficiency, with the methodology here presented, researchers have developed a suitable solution (J. C. Dumay, 2010).

In this section, a general methodology to assess the ranking of an organization within the local Sustainability Ecosystem is framed. An overview of the methodology is represented in Figure 1, highlighting the two main phases: 1) the Sustainability *Topics Network*, and 2) the Sustainability *Stakeholders Ecosystem*. In paragraph 2.1, the first phase of the proposed methodology is described, while paragraph 2.2 introduces how to co-design the Sustainability Ecosystem at the local scale. Both phases exploited a Stakeholder Engagement process. The first one was based on the engagement of private citizens, while the second one started from previously identified relevant stakeholders. The Sustainability Topics Network stage aimed at building a semantic map of the most crucial contents and their interconnections, starting from the perception of private citizens. The second one, instead, aimed at assessing a part of the local Sustainability Stakeholders Ecosystem by interviewing relevant stakeholders. During this co-design step, based on a snowball sampling (Conde et al., 2005), each stakeholder had to declare its own network. This approach allows to avoid a company-centred analysis (M. M. Fritz et al., 2018b) in order to minimize any possible bias due to a limited sight focused only on the relationships of the analyzed organization. Both phases follow a participatory mapping process (Moor, 2018) and consist of two steps: 1) *Nodes Identification*, focused on identifying relevant nodes (topics or stakeholders), and 2) *Nodes Prioritization*, based on a Social Network Analysis of the built networks.

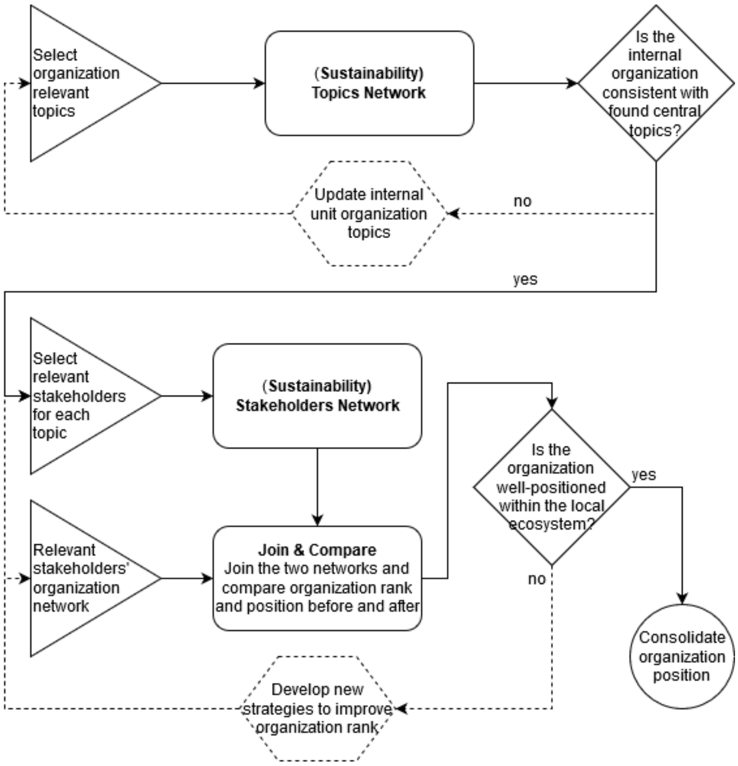


Figure 1: Overview of the methodology.

2.1 Sustainability Topics Network

The aim of this part was to identify concepts, ideas, and keywords related to the five working groups of UniToGO - i.e. Energy, Mobility, Food, Waste and Green Public Procurement - and to explore the semantic and conceptual maps for each single working group. Figure 2 shows the flowchart of this part.

The map construction process consists of two steps. First, the basis of the topics network was created, starting from 6 words: mobility, energy, waste, food, green public procurement, and environment. This first map was simply used to explain to the participants the meaning of the crowdmapping. The following step took advantage of the European Researchers' Night [1]. During the local edition within the City of Turin[2], a crowdsource mapping was performed, involving more than 160 citizens. Each interested people was motivated to add some keywords related to each one of the 6 different basic keywords or to each one of the other words written by other participants. Next to their participation, the reason for the research was explained to them in order to not affect their interaction.

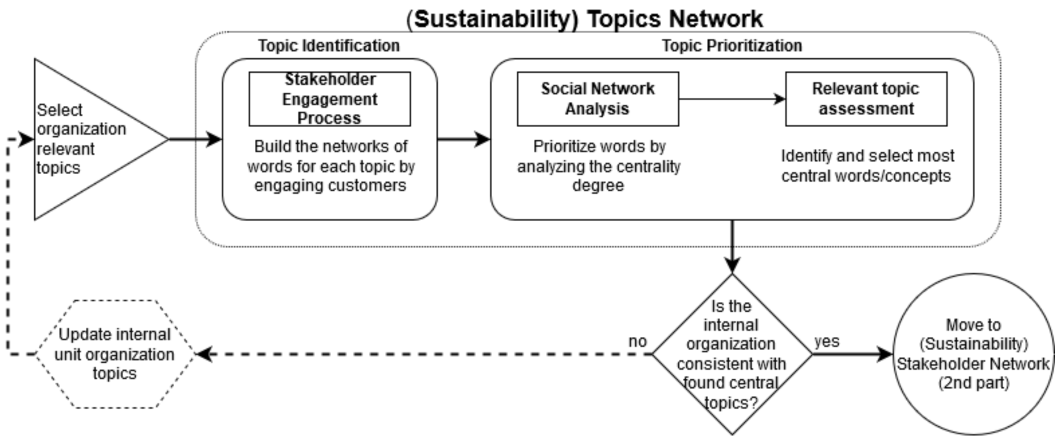


Figure 2: Sustainability Topics phase.

2.2 Sustainability Stakeholders Ecosystem

The second phase flowchart is represented in Figure 4. With respect to the *Stakeholders Identification* block, nearly forty participants were invited to a workshop named "Co-Design of the Sustainability Ecosystem". Participants belonged to local NGOs (e.g. urban garden, recycling, and sustainability fields), to local Public Administrations (PAs) of the City of Turin (e.g. the Innovation and Smart City sector of the City, the Green Team of the Polytechnic of Turin or the Unesco Chair in Sustainable Development and Local Territory Management), to energy providers or to UniToGO itself (the Green Office of the University of Turin), i.e. the organizer of the workshop. Several participants were students from various Departments of the University and the Polytechnic of Turin or private citizens. Figure 3 shows the composition of the participants subdivided into PA members, Private Citizens (or Students), NGO members and Business members to represent the fundamental components of the society (Donaldson and Preston, 1995).

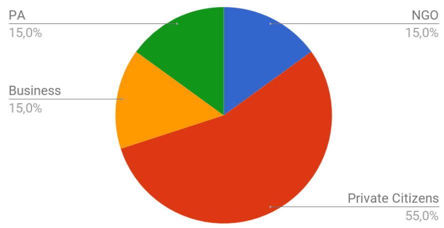


Figure 3: Participants composition.

[1] https://goo.gl/ZXNS8B
[2] https://goo.gl/oyFhxH

The 4-hour workshop, after a small technical introduction about Social Network Analysis, was divided into 3 parts - A) *Relevant Actors of the network*, B) *Relations within the network (1)* and C) *Relations within the network (2)* - as depicted on the top of Figure 4. First, participants were split into 4 different groups - Energy, Food, Mobility, and Waste - depending on their interest, or the relevance of their organization on that particular field. Second, two empty datasheets were provided to each group. The delivered sheets were designed to obtain precise information in order to fill the adjacency matrices A_x (see Equation 1) for each thematic network x. The first part of the workshop, *Relevant Actors of the network*, points to define the total number of the nodes N, subdivided into participants (P) and non-participants (NP), such as $N = P + NP$, for each thematic network; the second session, *Relations within the network (1)*, aims to obtain information to fill the green and blue parts of the adjacency matrix (as shown in Equation 1) related to relations and weights between P and P nodes (the green part) and between P and NP nodes (the blue part); finally, the third session, *Relations within the network (2)*, points to obtain basic information regarding the red part of the matrix, thus, between NP and NP nodes.

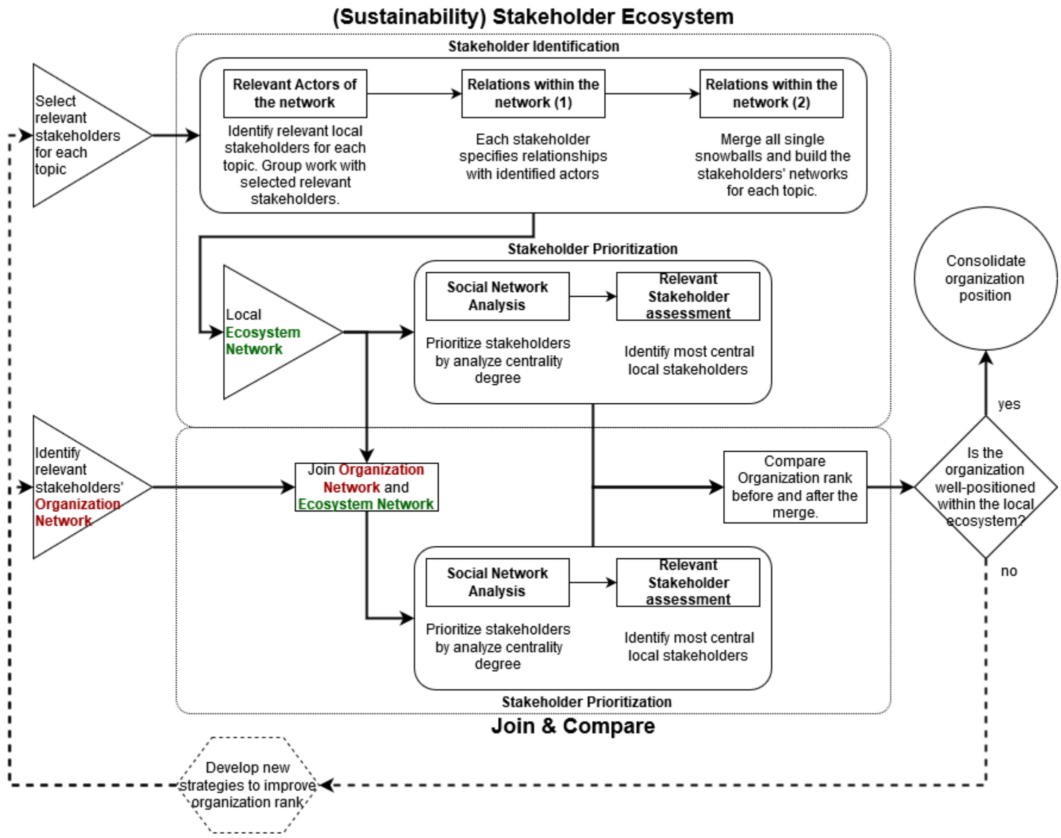


Figure 4: Sustainability Stakeholders phase.

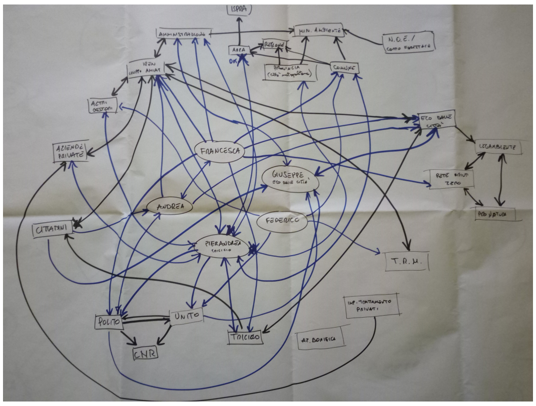
Equation 1 shows how the Adjacency Matrix was split with respect to the three phases of the workshop. A_x represents the Adjacency Matrix for network x, w_{ij} is the weight between node i and node j, p is the number of participants in the table x and N is the total number of the identified relevant nodes.

$$\mathcal{A}_x = \left(\begin{array}{cccc|cccc}
\multicolumn{4}{c|}{\overbrace{\hphantom{w_{1,2}\quad w_{1,2}\quad w_{1,2}}}^{\text{P-P interaction}}} & \multicolumn{4}{c}{\overbrace{\hphantom{w_{1,p+1}\quad w_{1,p+1}\quad w_{1,p+1}}}^{\text{P - NP interaction}}} \\
0 & w_{1,2} & \cdots & w_{1,p} & w_{1,p+1} & w_{1,p+2} & \cdots & w_{1,N} \\
w_{2,1} & 0 & \cdots & w_{2,p} & w_{2,p+1} & \ddots & \ddots & w_{2,N} \\
\vdots & \vdots & 0 & \vdots & \vdots & \ddots & \ddots & \vdots \\
w_{p,1} & w_{p,2} & \cdots & 0 & w_{p,p+1} & \cdots & \cdots & w_{p,N} \\
\hline
w_{p+1,1} & w_{p+1,2} & \cdots & w_{p+1,p} & 0 & w_{p+1,p+2} & \cdots & w_{p+1,N} \\
w_{p+2,1} & \ddots & \ddots & \vdots & w_{p+2,p+1} & 0 & \cdots & \vdots \\
\vdots & \ddots & \ddots & \vdots & \vdots & \ddots & 0 & \vdots \\
w_{N,1} & w_{N,2} & \cdots & w_{N,p} & w_{N,p+1} & \cdots & \cdots & 0
\end{array}\right)
\begin{array}{l}
\left.\vphantom{\begin{array}{c}1\\1\\1\\1\end{array}}\right\}\text{P-NP interaction} \\
\left.\vphantom{\begin{array}{c}1\\1\\1\\1\end{array}}\right\}\text{NP-NP interaction}
\end{array} \tag{1}$$

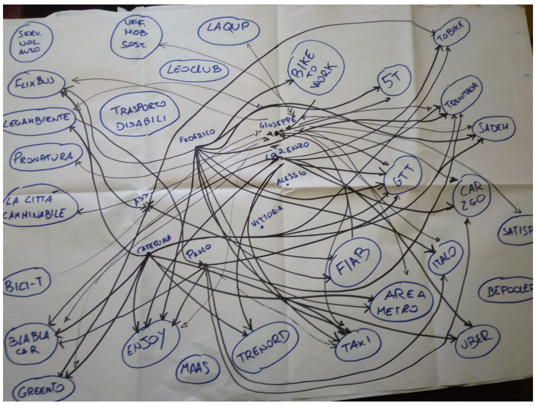
Relevant actors of the network. The first module aims to identify the most noteworthy and important actors (nodes) of the thematic network for each field. For this purpose, a first datasheet was prepared. For each identified relevant actor of the thematic network, participants must specify: name of the organization, type of actor - Public, Private, NGO or project (research project, network, ...), the most relevant field for that particular actor - food, mobility, energy, waste or other, and optionally an URL for the website. Some explanations are needed for the relevant field. For instance, a relevant node within the thematic food network may have a different field as business core: a waste management company (waste field) may be relevant for an urban garden NGO (food field), an energy provider (energy field) is fundamental for an electric car company (mobility field) and so on.

Relations within the network (1). During the second module, participants had to fill, individually, a second datasheet with information about the relations related to their own organization or their point of view (for private citizens and students). More precisely, they had to identify, for each relevant actor defined in the first module, the Importance ($1-10$) and the typology ($p - d_{in} - d_{out} - none$) of the relation between their own organization and all the other actors/nodes. The importance of the relation was defined on two main subjective parameters: the frequency of the collaboration ($1 \rightarrow$ occasional or $10 \rightarrow$ monthly interactions) and the optionality ($1 \rightarrow$ optional and $10 \rightarrow$ compulsory interaction). The typology, instead, represents the direction of the relation. Let's define $A =$ participant node and $B =$ another relevant node of the network, $p =$ partnership, $d_{in} =$ degree-in and $d_{out} =$ degree-out; p corresponds to a stable and frequent collaboration and it is represented by a double arrow ($A \leftrightarrow B$), while d_{in} and d_{out} have a double meaning and they are represented with a single arrow. For B2B relations (also including PA and NGO) d_{in} means that a relevant node of the network B is a supplier of the node which represents the participant A ($B \rightarrow A$) while d_{out} means that A is a supplier of B ($A \rightarrow B$). The second meaning concerns private citizens/students and public/private companies, so it is related to B2C relations. In this case, the direction of the arrows is reversed. In fact, even if the customer of a public company (e.g. public transportation service) is the private citizen and the public company provides the service, the arrow is from the citizen to the company because of the dependent role of the customer. Finally, $none$ represents no interaction between two nodes. At the end of this second part of the workshop, the first three blocks (green and blue) of the Adjacency Matrix (Equation 1) of the entire thematic network were completely filled.

Relations within the network (2). During the third module, participants had to draw down the whole network obtained within each thematic table. Once drawn all nodes and relations identified during the first two parts, participants had to think about possible interlinkages among all other relevant nodes (NP). This last part of the workshop was conducted in a qualitative way, asking participants to draw only arrows without



(a) Final result of the *waste* working group.



(b) Final result of the *mobility* working group.

Figure 5: Photo from the workshop of "Co-Design of the environmental sustainability ecosystem" for the City of Turin

asking any other parameters as importance or frequency. Figure 5a and Figure 5b show two of the four networks obtained within the thematic groups.

3 Results & Discussion

The *Nodes Prioritization* phase of the proposed methodology, as represented in Figure 2 for the Sustainability Topics Network and in Figure 4 for the Stakeholders Ecosystem, is discussed in the following paragraphs. For both networks, the most central nodes (topics or stakeholders) were identified thanks to three centrality indicators: 1) the closeness, 2) the betweenness, and 3) the eigenvector centrality degrees.

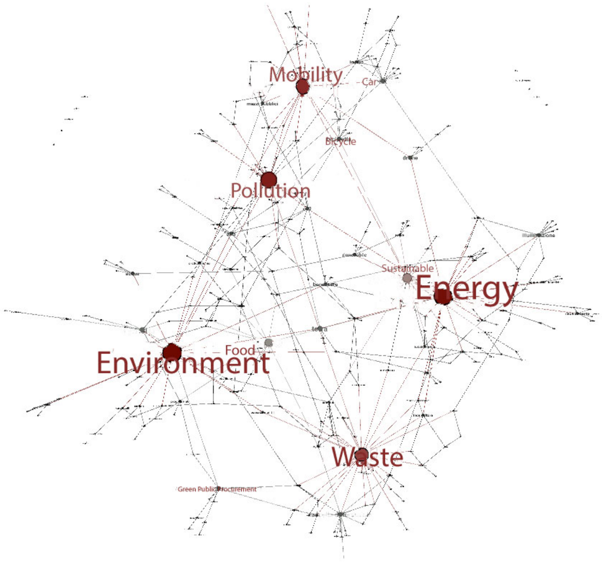
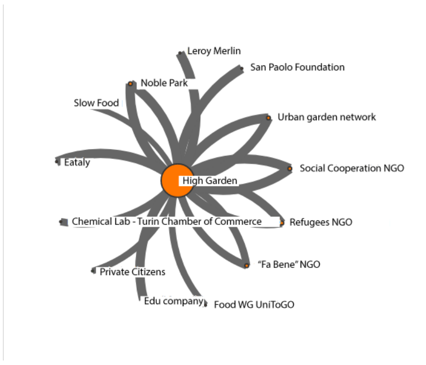


Figure 6: Sustainability Topics network.

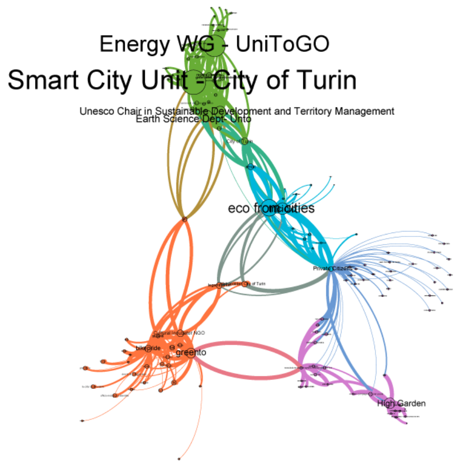
3.1 Sustainability Topics Network

Thanks to the crowdsource mapping during the European Researchers' Night, more than 400 keywords (nodes) and 550 interconnections (links) were obtained thanks to the contribution of 160 private citizens. Data are publicly available at `https://goo.gl/RVcZ5D`. Figure 6 shows the final graph obtained where the size of texts and of the nodes represents the betweenness centrality.

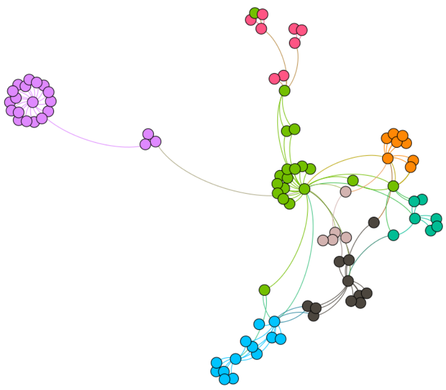
The network shows how several words and concepts act as a bridge between the five different thematic groups of UniToGO (i.e. Food, Mobility, Waste, Energy, and GPP). In particular, in a qualitative way, observers may notice that the following secondary words gained fundamental importance in terms of high degree (n. of inbound and outbound links) and in terms of betweenness centrality: pollution, water, sustainable, separate collection, car, bicycle, earth. This first graph was used to introduce to the participants of the second module a general framework of noteworthy concepts and to stimulate a general and systemic sight for the subsequent co-design of the ecosystem.



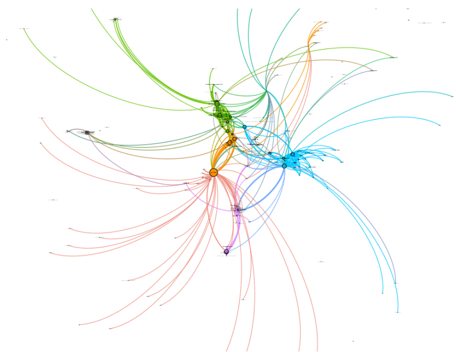
(a) Network of a single participant. This graph corresponds to a single line of the Adjacency Matrix 1.



(b) Results of the *stakeholder identification* block. The obtained stakeholders' map is the union of each single participant centered maps (Figure 7a).



(c) UniToGO Stakeholders' map.



(d) Union of the previous two stakeholders' maps (Figure 7c and 7b).

Figure 7: Results of the *Stakeholder Identification* phase.

3.2 Sustainability Stakeholders Ecosystem

Stakeholder Identification. The result of the Stakeholder Identification phase developed during the workshop "Co-Design of the Sustainability Ecosystem" is shown in Figure 7b and was built as illustrated in Figure 4. The four different colors represent the four tables - Food, Mobility, Energy, and Waste. During the first module of the workshop, more than 200 relevant actors were identified, 88 for the Food network, 65 for Energy, 30 for Mobility and 25 for Waste, and, at the end of the workshop, within the 4 thematic tables more than 300 links were highlighted. As described in Section 2, during the first part of the workshop (*Relevant actors of the network*) participants had to identify the most relevant nodes for each thematic table, while during the second part (*Relations within the network (1)*) each participant had to identify the relations (links) among his/her own organization and all other actors. An example of a partial result, focused only on one organization (e.g. *high garden* NGO), is shown in Figure 7a. The links' thickness represents the importance (1-10) of the relations identified by the participants. A double link appears when a participant defined a partnership with another actor in the network. This methodology, as shown in Figure 7a, is based on a user/participant centered point of view. In fact, each participant must work only on information related to his/her own organization, or his/her own point of view (for private citizens). In this way, no one had to answer about unknown information and the whole network (Figure 7b) rose up and emerged just linking the single user-centered networks. The bottom graph in Figure 7, instead, shows the UniToGO stakeholders' map (Figure 7c) and the Union (Figure 7d) between the UniToGO map (Figure 7c) and the output of the workshop (Figure 7b), as described in the *Stakeholder Prioritization* block in Figure 4. The UniToGO map was directly obtained from detailed information on the 5 different working groups, analyzing the *"Environmental Sustainability Action Plan"* of the University of Turin. The different colors represent the different working groups of the UniTo Green Office - Energy, Food, Mobility, GPP, and Waste. It was used to assess the impact of UniToGO within the local ecosystem by comparing the network obtained from the workshop, with (Fig. 7d) and without (Fig. 7b) the UniToGO graph (Fig. 7c).

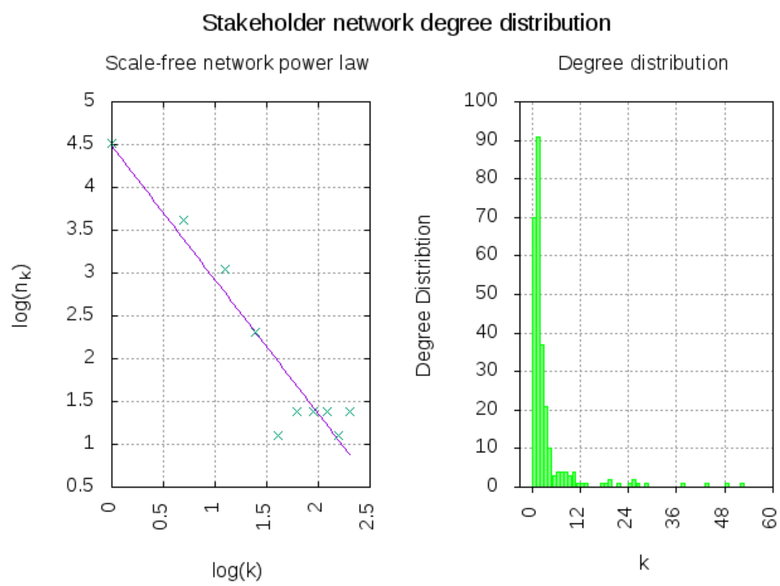


Figure 8: Degree Distribution of the graph 7d. On the left, the power law is represented while the degree distribution histogram is plotted on the right.

Stakeholder Prioritization. In this section, results on centrality measures of the final network obtained by the union of Figure 7c and Figure 7b are reported. First of all, the degree distribution was analyzed for the obtained stakeholders' map and it is represented in Figure 8. On the left, empirical data related to nodes degree and the linear interpolation of the power law, $\ln(n_k) = a + b\ln(k)$, are plotted. The two obtained parameters ($a = 4.48, b = 1.5$) are consistent with the scale-free property as proof of the consistency of the emergent network. On the right, instead, the related degree distribution is plotted.

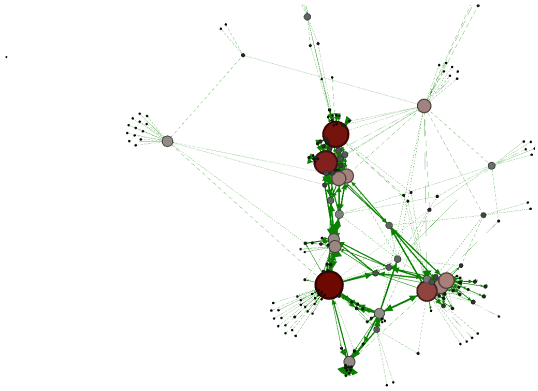
With respect to the closeness, betweenness, and eigenvector centralities, a comparison between the top actors/nodes of the two networks represented in Figure 7b and 7d is reported. This comparison, as described in the bottom-right part of the Figure 4, could be used to identify the impact of an organization (in this case UniToGO) within a local network. Moreover, the centrality degree analysis reveals if the internal organization is well-positioned and if the internal thematic structure (e.g. the UniToGO working groups) is well-designed with robust interconnections within the local territory network. Results are summarized in Table 1 and in Figure 9 and highlight how UniToGO and the UniToGO Energy Working groups are well-positioned within the local Ecosystem. Indeed, with respect to the closeness, betweenness, and eigenvector centralities, both nodes (UnitoGO and UniToGO Energy WG) have a good ranking.

Table 1: Stakeholder Prioritization results: top five actors for each centrality degree measure

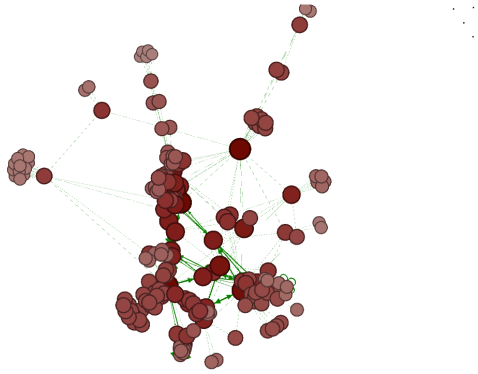
	Organization + Ecosystem Networks (Fig 7d)		Ecosystem Network (Fig 7b)	
Ranking	Name	Centrality	Name	Centrality
Closeness centrality				
1	UniToGO	0.418	Private Citizens	0.510
2	Private Citizens	0.416	Unesco Chair	0.441
3	Unesco Chair	0.415	Eco from Cities	0.416
4	greenTo	0.398	Triciclo	0.414
5	City of Turin	0.385	City of Turin	0.409
Betweenness centrality				
1	Private Citizens	0.197	Private Citizens	0.245
2	UniToGO	0.159	UniToGO Energy	0.072
3	GreenTo	0.117	Smart City Unit	0.064
4	UniToGO Energy	0.108	Unesco Chair	0.063
5	GPP network	0.073	High Garden	0.058
Eigenvector centrality				
1	Private Citizens	1.0	Private Citizens	1.0
2	greenTO	0.82	BikePride	0.66
3	UniToGO Energy	0.77	Students	0.61
4	Unesco Chair	0.73	Unesco Chair	0.594
5	BikePride	0.72	Smart City Unit	0.591

First, looking at the graph without UniToGO (Figure 7b) the top 5 nodes, with respect to closeness centrality, are: Private Citizens, Unesco Chair in Sustainable Development and Territory Management, Eco from cities (a local newspaper), Triciclo (a NGO focused on Circular Economy), and the City of Turin. In this case, the closeness centrality measures are respectively 0.510, 0.441, 0.416, 0.414 and 0.409. By inserting the UniToGO stakeholders' map, the structure changes and the five top nodes are: UniToGO ($C(i) = 0.418$), Private Citizens ($C(i) = 0.416$), Unesco Chair in Sustainable Development and Territory Management ($C(i) = 0.415$), GreenTo, a students' NGO ($C(i) = 0.398$), and the City of Turin ($C(i) = 0.385$). The same approach can be used to analyze the betweenness and eigenvector centrality indices.

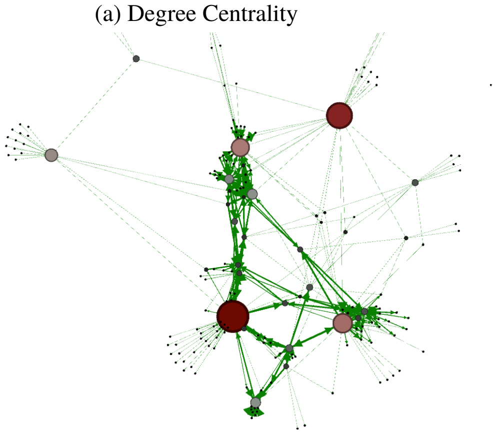
The closeness centrality slightly varies from the Ecosystem Network and the joint network. This feature is a consequence of the closeness degree itself. Indeed, the closeness centrality simply measures the average distance from a node and all the other nodes belonging to the network. Since, in this case, the analyzed network is composed of a few hundreds of nodes, the closeness centrality is not so representative of the importance of a node.



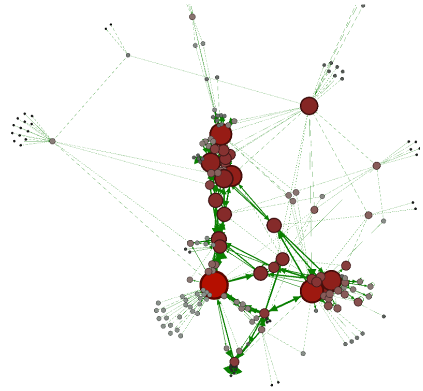
(a) Degree Centrality



(b) Closeness Centrality



(c) Betweenness Centrality



(d) Eigenvector centrality

Figure 9: Different centrality measures on stakeholders' map (Fig. 7d

On the contrary, the betweenness centrality ranking and values noteworthy change, although the top node is always represented by private citizens. UniTogo emerged as the second most central node while the Energy group of UniToGO lost importance. As the betweenness centrality represents the importance of a node in terms of connectivity, i.e. a node is more central if the shortest path between any couple of nodes in the network passes through that node, it is a much more meaningful indicator.

Finally, concerning the eigenvector centrality, UniToGO doesn't belong to the top-five nodes, while the Energy group of UniToGO gained the third position. Again private citizens represent the most central node. The eigenvector centrality highglights another important feature in centrality analysis. Indeed, it is a measure similar to the simplest degree centrality, i.e. the number of inbound and outbound links, but taking into account 2nd nearest neighbours. Thus, it is affected by, first, the number of direct interactions of a node (1st order neighbors), and, second, by their importance within the network. Thus, an high value for the eigenvector centrality means that a node has an high number of links and it is connected with worthwhile nodes.

Table 2: Limitations and advantages

Phase		Limitations	Advantages
Topics Network	Identification	- difficult to engage a statistically significant group	- Highlight behaviour from the stakeholder Monitor Group
	Prioritization	- bias from initial keywords; - not very accurated; - difficult to explain the meaning of centrality degrees for topics	- new urgent topics emerge - reveal sub-topics (e.g. bicycle)
Stakeholders Network	Identification	- difficulties in properly weight relationships - need of a large time effort to map many stakeholders	- not organization-centered - crowdsourcing allows to easily identify a large amount of stakeholders - reveal local stakeholders ecosystems
	Prioritization	- not all centralities have a useful meaning	-allow to easily assess priorities for a large amount of stakeholders - point out emergent features from the identified networks - once the ecosystem is built up, many organizations can be evaluated

3.3 Limitations and further improvements

The case herein discussed presents a methodology to help managers of a public university to understand which shapes a local ecosystem assumes, who is in, and to forecast which are the most powerful players in the field now, and in the future. This type of investigation allows temporal comparison and through the analysis of its dynamics, it is possible to study strategies to help public managers identify networks and partnerships with whom the university should collaborate. This activity of stakeholder mapping involves citizens, students, and the community in co-creating the whole mapping process. Throughout the entire process, the university breaks down the walls with the community and accept to be part of a system, where actors are all democratically represented as nodes of an ecosystem. In addition, the traditional perspective of managerial prioritization of stakeholders is turned into a conceptualization of who is important, not for the organization itself, but for the perception of the community regarding the commitment that such actor has for that issue (Roloff, 2008). In respect of the traditional stakeholder mapping and prioritization framework (Mitchell, Agle, and Wood, 1997), this new methodology is a first attempt of merging Social Network Analysis with multi-stakeholder environment and it goes more in the direction hoped by Myllykangas, Kujala, and Lehtimäki (2010) and Kujala, Heikkinen, and Lehtimäki (2012) of stakeholder dynamism. Consequently, the output of the new methodology is not a representation of dyadic ties, but it is the depiction of a dynamic network.

However, the proposed methodology revealed some criticalities. The main limitations and advantages of the entire process are summarized in Table 2. Regarding the Stakeholder Network activity, participants, especially private citizens and/or small NGOs' members, faced up difficulties to give a precise weight to each relationship. Generally, they over-evaluate their dependency from the public services, as in Italy, there is a cultural emphasis on the role of public institutions to deal with sustainability issues as a sort of public value (Benington and Moore, 2010). A second critique should be made about the duration of the process. To extend a map over a certain limit requires time, and it requires to engage citizens with an in-depth knowledge of the issue to cover a higher number of nodes. On the other side, the map requires how to interpret its results, especially in terms of how to read it and how to translate it into a good managerial tool. A solution can be to guarantee the presence of a certain number of participants in the process representing the important nodes and to involve them in reviewing the map generated.

Regarding the Topics Network, the interpretation of centralities, in other words, the importance associated with a node, is a critical point. Indeed, for topics, there is no straightforward meaning for closeness and eigenvector centralities, while the betweenness centrality is a good indicator to point out emergent topics from a network. However, our starting keywords - i.e. energy, food, waste, mobility, green public procurement, and environment - have influenced the selection of the topics. Nevertheless, those specific starting keywords are the material sustainability issue identified by the Italian Association of Universities for sustainable development (RUS).

On the other hand, the proposed methodology, although in its pilot project, may be extremely helpful for researchers and practitioners to evaluate the main stakeholders of an organization with a quantitative approach. For instance, the Topics Network allows to easily explore the perception of stakeholders in the Monitor Group (Mitchell, Agle, and Wood, 1997) - i.e. low power and low interest - as well as to identify urgent topics in a local territory, which can be pointed out as emergent nodes from the Topics Network. This methodology can be slightly generalized and improved by adopting a real-time mapping; the Sustainability Ecosystem, as well as the Sustainability Topics mapping, should be used to create a uniform and well-designed online tool in order to identify a multi-stakeholder ecosystem in real-time in a collaborative way. Finally, two considerations can be made for the research side. First, further investigations are needed in evaluating the role that other centrality degrees explored in Social Network Analysis studies such as the PageRank (Brin and L. Page, 1998) or the Authority (Kleinberg, 1999). For stakeholder literature indeed, a possible further evolution of the model should be to explore its need creating a merge between stakes and nodes.

4 Conclusion

Participatory community network mapping is a fundamental approach for innovative, effective, and precise stakeholder analysis. Social Network Analysis could be used to analyze obtained network in a quantitative way in order to obtain useful insights for managers, policy- and decision-makers of large, public or private, organizations. In the present work, an innovative methodology to assess the impact of an internal unit (i.e. the Green Office of the University of Turin) of a large organization (i.e. the University of Turin) was presented. The described methodology consists of two main mapping processes: 1) the Sustainability *Topics Network*, and 2) the *Stakeholders Network*. Both processes consist in two main phases, the *Nodes Identification* and the *Nodes Prioritization*.

The *Topics Network* was obtained, with more than 400 words and 550 interconnections identified, by engaging private citizens and by asking them to add words related to six words representing the working groups of the Green Office of the University of Turin. Second, the Sustainability *Stakeholders Ecosystem* of the City of Turin was built in a collaborative way by engaging nearly forty relevant stakeholders of the local ecosystem, identifying more than 200 actors and 300 relationships.

In the Nodes Prioritization phase, the built networks were analyzed through three main centrality degrees - i.e. closeness, betweenness, and eigenvector - discussing the limitations and advantages of each indicator. Betweenness centrality results to be the best indicator to identify most central and important nodes with respect to the whole network, while eigenvector centrality depends on the importance of 1st order neighbors (i.e. already engaged stakeholders of an organization). On the contrary, closeness centrality, for a few hundred nodes network, seems to be not very appropriate to assess stakeholders' centrality, since the small distance from node to node.

Although further investigations are needed to develop a robust interconnection between Social Network Analysis and the Stakeholder Theory, the proposed methodology showed how, by adopting a participatory community network mapping approach is possible, with a limited effort by the organization itself, quantifying precisely the importance of its own network of stakeholders avoiding bias due to a company-centered analysis.

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