Food and Agriculture Organization of the United Nations

INTERNATIONAL YEAR OF
FRUITS AND VEGETABLES
2021

PROMOTING SUSTAINABLE AND INCLUSIVE VALUE CHAINS FOR FRUITS AND VEGETABLES
- Policy review -

Background paper for the FAO/WHO international workshop on fruits and vegetables 2020

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Food and Agriculture Organization of the United Nations
Rome, 2021

Required citation: **Santacoloma, P., Telemans, B., Mattioni, D., Puhac, A., Scarpocchi, C., Taguchi, M. and Tartanac, F. 2021.** *Promoting sustainable and inclusive value chains for fruits and vegetables – Policy review. Background paper for the FAO/WHO International Workshop on Fruits and Vegetables 2020.* **Rome, FAO. https://doi.org/10.4060/cb5720en**

ISBN 978-92-5-134718-8

ABSTRACT

The persistence of undernutrition and the increasing levels of overweight and obesity worldwide (with their associated societal costs) are calling for a transformation of food systems towards healthier diets. Fruits and vegetables are key components of a healthy diet; however, their consumption is considerably below the minimal levels recommended by the World Health Organization (WHO). This under consumption is particularly pronounced in low- and middle-income countries and among low-income socio-economic groups in all countries.

This paper uses the value chain approach to analyze the factors that affect the availability and affordability of fruits and vegetables. It examines major challenges across the value chain and identifies opportunities for improvement as seen through a nutrition-sensitive lens. Factors that negatively affect the availability and affordability of fruits and vegetables discussed in this paper include low production and productivity, the loss of agrobiodiversity, inadequate technology, logistics and infrastructure, weak organizational, business and technical skills, and inefficient market linkages across the supply chain.

The paper proposes a number of policy recommendations based on insights from documented cases of good practices and on lessons learnt in domestic and export-oriented value chains. The paper makes a case for reviving native, underutilized and neglected fruit and vegetable varieties to improve nutrition and increase agrobiodiversity. In addition, short value chains delivering to local markets are recommended as a resilience strategy for small-scale producers and low-income consumers in the face of climatic and economic shocks. The paper advocates the reshaping of value chains through policies that boost efficiency, promote the inclusion of poor and vulnerable actors − including consumers − in the chain, and ensure that production is environmentally sustainable.

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ACKNOWLEDGMENTS

This report is one of three background papers discussed during the FAO/WHO International Workshop on Fruits and Vegetables 2020 in preparation of the International Year of Fruits and Vegetables. Twenty international experts from academia, governments, civil society, the private sector and international organizations as well as the Food and Agriculture Organization of the United Nations (FAO) and WHO staff were invited to participate in a series of five online sessions held between August and September 2020. The authors appreciate the thoughtful inputs offered by the workshop participants to the paper.

The authors are very thankful for the insightful comments provided by the peer review committee of the International Workshop: Eve Crowley, Ana Posas, Alberto Ramirez and Ruth Charrondiere (FAO), Fabio Da Silva (Pan American Health Organization [PAHO]) and Pablo Moya (Actuemos).

They are also grateful to the FAO colleagues who contributed with technical comments: Pascal Liu, Fen Beed, Preet Lidder, Ti Kian Seow, Sabine Altendorf, Tomislav Ivansic and Siobhan Kelly. Thanks also go to Ellen Pay for the copyediting, Natalia Geisse and Guido Chiefalo for the graphic design, and Chiara Deligia for coordinating the publishing process.

ABBREVIATIONS AND ACRONYMS

ADB	Asian Development Bank
EBRD	European Bank for Reconstruction and Development
ECLAC	United Nations Economic Commission for Latin America and the Caribbean
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
GAP	good agricultural practices
GFSN	Global Forum on Food and Security Nutrition
GHG	greenhouse gas
GHP	good handling practices
GI	geographical indication
HLPE	High Level Panel of Experts
ICP	World Bank International Comparison Program
ICT	information and communications technology
IYFV	International Year of Fruits and Vegetables
LMIC	low- and middle-income countries
NSVC	nutrition-sensitive value chains
NUS	neglected and underutilized species
OECD	Organisation for Economic Co-operation and Development
PGS	participatory guarantee system
PNAE	National School Meals Programme (Brazil)
SFC	short food circuits
SFVC	short food value chains
SME	small and medium enterprise
WHO	World Health Organization
WTO	World Trade Organization

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1.

INTRODUCTION

BACKGROUND

This paper discusses the critical role played by value chains in efforts to increase the availability and accessibility of fruits and vegetables, and the main challenges and opportunities for the fruit and vegetable sector. It discusses a number of policy implications based on insights from domestic and export-oriented value chains.[1]

This paper uses the definition of fruits and vegetables that was adopted for the International Year of Fruits and Vegetables (IYFV): "edible parts of plants (e.g. seed-bearing structures, flowers, buds, leaves, stems, shoots and roots), either cultivated or harvested wild, in their raw state or in a minimally processed form."[2] The distinction between fruits and vegetables is pragmatic. While fruit is a botanical term (denoting the seed-bearing structure in flowering plants), vegetable is not. The practical distinction is based on culinary taste and use; a fruit is the sweet or sour part of a plant, while a vegetable is the savoury part of a plant. The definition of fruits and vegetables excludes starchy roots and tubers, dry grain legumes, cereals, medicinal plants, stimulants such as tea, coffee and cacao, and ultra-processed food.

It is generally recognized that the exportation of fruits and vegetables has a great potential to reduce poverty levels by generating income for small and medium-scale producers and primary processors and creating employment opportunities. The domestic markets of low- and medium-income countries (LMICs) increasingly offer this potential, too. Fruits and vegetables are of special interest for small-scale farmers as their cultivation has a higher productivity per unit of land than that of other crops (Reardon, Timmer and Minten, 2010), yet many challenges prevent them to participate in and take advantage of formal markets. In addition, due to its highly labour-intensive nature, the growing of fruits and vegetables offers employment opportunities for severely land-constrained farmers and the landless rural poor.

The persistence of undernutrition and increasing levels of overweight and obesity worldwide (and their associated costs) illustrate the need for a transformation of the fruits and vegetables sector that boosts the consumption of fruits and vegetables and thus contributes towards healthier diets (FAO, 2020a). The availability and affordability of fruits and vegetables play an important role in consum-

[1] The 74th Session of the United Nations General Assembly declared 2021 as the International Year of Fruits and Vegetables (IYFV). The initiative aims at raising awareness on the nutritional and health benefits of fruit and vegetable consumption. This paper is part of a series prepared for the FAO/WHO International Workshop on Fruits and Vegetables 2020, held in preparation of the IYFV. Paper #1 discusses the effectiveness of policies and programmes to increase the consumption of fruits and vegetables; Paper #2 discusses the positive health effects of fruit and vegetable consumption.

[2] Minimally processed foods retain most of their inherent physical, chemical, sensory and nutritional properties and are as nutritious as the food in its unprocessed form (Parrish, 2014). Examples include sliced or bagged fruit, vegetable salads, frozen and dried fruits and vegetables, fresh pasteurized juices and fruit juices without added sugar.

ers' decisions but the loss of diversity has prevented exploiting benefits of fruits and vegetables diversity.

Effectively the intensification of fruit and vegetable production towards the growing of only a handful of varieties has led to a nearly 75 percent loss in biodiversity since the 1900s (Padulosi, Thompson and Rudebjer, 2013); it has also hampered the exploitation of the benefits offered by the diversity in fruits and vegetables. This paper makes a case for reviving native, underutilized and neglected fruit and vegetable varieties to improve nutrition and increase agrobiodiversity. In addition, short value chains delivering to local markets are recommended as a resilience strategy for small-scale producers and low-income consumers in the face of climatic and economic shocks.

The value chain (VC) approach helps understand how a sector is organized by examining the structure and dynamics of the interaction between the different actors involved, from production to consumption (Fernandez-Stark, Bamber and Gereffi, 2012).[3] Value chain analysis and interventions traditionally focus on investigating and tackling market failures that affect the income of less advantaged participants; however, the key role played by value chains in determining the availability, affordability, quality and acceptability of nutrient-dense foods (such as fruits and vegetables) is only recently being acknowledged (De Brauw, Gelli and Allen, 2015; FAO, 2020a). Value chain analysis considers not only the economic performance of value chains, but also their environmental and social sustainability (Hawkes and Popkins, 2015; FAO, 2014; De Brauw *et al.*, 2015).

The diversity of value chains for fruits and vegetables worldwide (e.g. the differences in the varieties produced and consumed) poses important challenges to the analysis, as a wide range of alternatives must be considered. Bangladesh alone produces more than 100 types of vegetables and 70 types of fruits, from 60 species (ADB, 2019a). There are also differences in the economic relevance of fruits and vegetables in the overall agriculture sector. In Viet Nam, for example, fruits and vegetables accounted for 22 percent of total cropland in 2017 (ADB, 2019c) − significantly more than in most other countries. The type of policy support that is available to the fruit and vegetables sector also differs considerably from one country to the next. Another variable that calls for differentiation is the market orientation of the sector (export-oriented or focused on the domestic market). Countries like Chile, Peru and Honduras in Latin America, Kenya and Morocco in Africa or Viet Nam in Asia are specialized in export-oriented horticulture, while Chi-

[3] We use the FAO definition of sustainable food value chain: "the full range of farms and firms and their successive coordinated value-adding activities that produce particular raw agricultural materials and transform them into particular food products that are sold to final consumers and disposed of after use, in a manner that is profitable throughout, has broad-based benefits for society and does not permanently deplete natural resources (FAO, 2014)."

na and India, the largest producers of fruits and vegetables in the world, produce mainly for their domestic markets.

The biggest differences are those between global and domestic value chains for fruits and vegetables. Global value chains for fruits and vegetables are highly competitive, with well-coordinated actors offering high-value products at every step of the chain (from the provision of inputs, production, processing, packaging, cold storage, transport, distribution and marketing to export) (Fernandez-Stark, Bamber and Gereffi, 2011). Most of these enabling conditions also apply in the chains supplying domestic markets of middle- to high-income consumers through supermarkets in developing countries. However, in most developing countries the bulk of fruits and vegetables is retailed through channels other than large supermarkets. According to Popkin and Reardon (2018), in Africa only 6 percent of fruits and vegetables are sold through supermarkets; the share varies in Latin America and the Caribbean, from 10 to 15 percent in Mexico to nearly 50 percent in Brazil. Most fruits and vegetables are sold through wholesale markets,[4] fresh (informal) food markets (e.g. wet markets) and specialized grocery stores that follow a different business model than export-oriented or high-value chains. In this type of value chains, coordination between actors is poor, price information is scarce and hardly any measures are taken to ensure food safety (Boza, 2020).

METHODOLOGY

This paper builds on the premise that common efforts of governments and international institutions to boost the consumption of fruits and vegetables to the minimum intake of 400 g/capita/day (as recommended by FAO and WHO) must be underpinned by a sufficient supply of fruits and vegetables on the national level. Section 1 provides an analysis of worldwide production, trade and economic accessibility of fruits and vegetables.[5] It is found that the current supply of fruits and vegetables is, in nearly all countries, insufficient to meet the FAO/WHO recommendations regarding minimum daily intake. This analysis is followed by a review of the evidence-based literature, first to identify drivers, success factors, challenges and opportunities in value chains for fruits and vegetables, from production to consumption, and second to identify public policies that have been successful in improving the functioning of these value chains.

[4] Many wholesale markets in developing countries offer both wholesale and retail services i.e. wholesalers sell both to retailers and other food sellers, and to consumers.

[5] Based on data from the FAOSTAT database.

2.

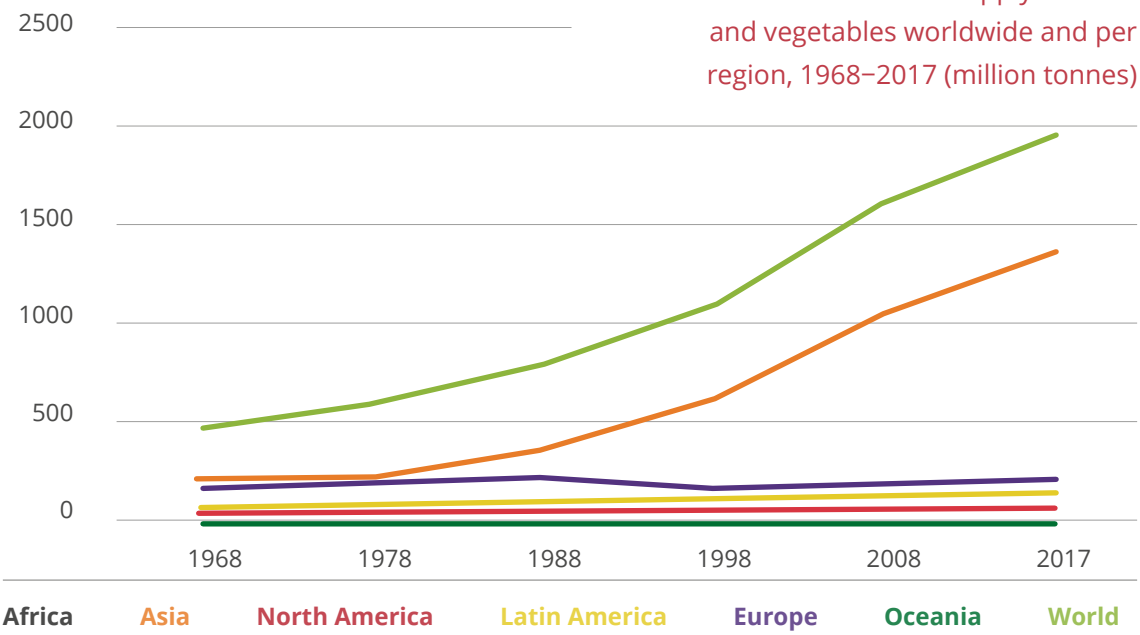
GLOBAL PRODUCTION, AVAILABILITY AND ACCESSIBILITY OF FRUITS AND VEGETABLES

GLOBAL AND REGIONAL PRODUCTION AND NET SUPPLY

The worldwide availability of fruits and vegetables has increased consistently from 1968 to 2017 (see Figure 1). Production in Asia grew by almost 750 percent in volume terms over the period; that in Africa increased fourfold, from 45 to 180 million tonnes per year (although this volume remains low compared to other regions). The production of fruits and vegetables in Central and South America shows an increase of 317 percent over the past 50 years. Meanwhile, production increased by 117 percent in Europe and by 174 percent in North America. Annex 1 and Annex 2 provide more detailed data.

The production of vegetables is largely oriented towards domestic markets. Indeed, only 5 percent of all vegetables grown worldwide are traded internationally. Over the past decade, Mexico has expanded its prominent position in the North American vegetable market, while trade within the European Union (dominated by exports from the Netherlands and Mediterranean countries) has grown continuously (Van Rijswick, 2018a). The fruit market is slightly more global, with about 9 percent of all fruits traded internationally. Bananas, apples, citrus fruits and grapes are the most prominent categories in the international fruit trade; Latin America is the dominant global export region and China the largest import market (van Rijswick, 2018b). The international trade in bananas and other tropical fruits (mango, pineapple, avocado

FIGURE 1. Net available supply of fruits and vegetables worldwide and per region, 1968–2017 (million tonnes)



Source: FAOSTAT. FAO, 2020b.

Note: Tonnes refer to domestic production of primary fruit and vegetables plus or minus the balance of import and export.

and papaya) has increased steadily over the past decades; projections confirm that this trend will continue, which is of particular interest to small-scale farmers in producing countries such as India, China, Mexico, Thailand, the Philippines and Central American countries (FAO and OECD, 2020). The impact of international trade on the local availability of fruits and vegetables varies per region. Local availability is reduced in Latin America (by 17.6 percent of the total availability), Oceania (12.4 percent) and Africa (3.5 percent), whereas North America (25 percent) and Europe (10 percent) increased their domestic availability after trading. These changes are driven more by the international trading of fruits than by that of vegetables.[7]

The FAOSTAT database includes data for 22 vegetable and 31 fruit items, labelled as primary fruits and vegetables.[8] Native and underutilized fruits and vegetables, widely consumed in many rural areas of the world, are not part of those. The wide diversity of species and varieties of fruits and vegetables is thus not captured. This lack of statistical data is a challenge, as data are essential to underpin decision-making, identify targets and monitor the impact of public policies and services, and determine targets of research and development efforts (Varshney and Banerjee, 2017). Global trends, for example increasing urbanization, call for a rethinking of food value chains and food systems. Meanwhile, climate change imposes the need for a stronger focus on natural resources management and biodiversity, adding to the complexity of the issue.

A recent study shows that farms smaller than 50 ha produce between 51 and 77 percent of the volume of the major food groups (cereals, fruits, pulses, roots and tubers, and vegetables) for human consumption in the world's various regions (Herrero *et al.*, 2017). Large farms (> 50 ha) account for 75 to 100 percent of total fruit production in North and South America and in Australia and New Zealand. Meanwhile, small farms (≤ 20 ha) produce more than 75 percent of most food commodities (including fruits and vegetables) in sub-Saharan Africa, South East Asia, South Asia and China. Very small farms (≤ 2 ha) are locally significant in sub-Saharan Africa, Asia and Central America, where they account for around 30 percent of the production of most food commodities. In China, very small farms produce 64 percent of fruits and 60 percent of vegetables.

Global patterns of nutrient production by farm size are similar to those of the production of food commodities. Notably, small farms (≤ 20 ha) account for 71 percent of global vitamin A production. Vitamin A is supplied mainly by fruits and vegetables, some livestock products and orange-fleshed roots and tubers. Farms with a higher diversity

[7] See Annex 3 for more details.

[8] See Annex 3 for more details.

and a relative abundance of different species produce most of the world's vegetables (81 percent) and fruits (66 percent).

AVAILABILITY OF FRUIT AND VEGETABLES

According to the FAO publication *The State of Food Security and Nutrition in the World* (SOFI), the average global availability of fruits and vegetables increased from 306 g/capita/day in 2000 to 390 g/capita/day in 2017 (FAO *et al.*, 2020). Only upper-middle-income and high-income countries and Asia as a region have enough fruits and vegetables to meet the FAO/ WHO recommendation of consuming a minimum of 400 g per day. Over the period 2000−2017, the availability of fruits and vegetables increased from 167 to 191 g/capita/day in Africa, and from 121 to 142 g/capita/day in low-income countries. As such, the availability of fruits and vegetables in Africa and in low-income countries falls far short of the consumption target of 400 g/capita/day.

Micha *et al.* (2015) compare the intake of fruits and vegetables to the optimal intake of 300 g/capita/day for fruits and 400 g/capita/day for vegetables (as opposed to the minimal recommended intake by FAO/WHO). These standards were met by only two countries for fruits, and four countries for vegetables, out of a total of 133 countries. Mason-D'Croz *et al.* (2019) conclude that many countries need to increase production to ensure an adequate supply of fruits and vegetables in the future. Particular attention must be paid to the types and varieties of fruits and vegetables that are produced, to respond to the tastes and needs of local populations. There is indeed evidence that some countries, while exporting large volumes of certain fruits or vegetables, produce only a limited, non-diversified amount of domestically appropriate fruits and vegetables because most of their horticultural resources are channelled towards varieties that sell on international markets (Fernandez-Stark, Bamber and Gereffi, 2011; Humphrey, 2009).

Efforts to boost the consumption of sustainably produced fruits and vegetables could have a positive effect on the environment by, for example, reducing fuel consumption in the food system (Canning 2017) or reducing the water footprint of diets (Aleksandrowicz *et al*., 2016; Springmann *et al*., 2018). They would also reduce social costs, e.g. by lowering GHG emissions. The promotion of flexitarian diets (including moderate amounts of animal-sourced foods such as red meat) could help achieve such outcomes (FAO *et al.*, 2020).

ECONOMIC AND PHYSICAL ACCESSIBILITY OF FRUITS AND VEGETABLES FOR CONSUMERS

To promote healthy diets, food systems must improve the relative availability, affordability and desirability of fruits and vegetables. This section will focus on the availability (physical accessibility) and affordability of fruits and vegetables – desirability, related to time, convenience and palatability, will be dealt with in another paper (Gerritsen *et al*., forthcoming)

Economic accessibility (affordability)

A number of studies carried out over the past decade underline the relative unaffordability of healthy diets as compared to current diets, particularly in low- and middle-income countries (Drenowski and Darmon, 2005; Chastre *et al.*, 2007; Alemu *et al*., 2019). This is partly due to the increased affordability of energy-dense and nutrient-poor ultra-processed food (Hawkes *et al.*, 2009). At the same time, the relative prices of fruits and vegetables have increased. A study of four emerging economies (Brazil, China, the Republic of Korea and Mexico) shows that over the period from 1990 to 2012, the prices of fruits and vegetables rose faster than those of most other foods (Keats and Wiggins, 2014). This makes it harder for individuals to increase their intake of fruits and vegetables. A recent article has highlighted how sustainable diets – such as the diet recommended by the EAT-Lancet Commission (Willet *et al.,* 2019) – are out of reach for about 1.58 billion people living on a low income, due to their high cost (Hirvonen *et al*., 2020). Fruits and vegetables account for about 30 percent of the total cost of a healthy diet – more than animal products and legumes. Similarly, the latest SOFI data show that healthy diets are unaffordable for more than 3 billion poor people in every region of the world, but especially in sub-Saharan Africa and South Asia. Healthy diets are estimated to be, on average, five times more expensive than diets that meet only dietary energy needs through starchy staples. Much of this difference is due to the high relative cost of animal proteins and fruits and vegetables (FAO *et al.*, 2020).

The unaffordability of healthy diets, and especially of fruits and vegetables, is particularly pronounced in low- and middle-income countries, and among low-income socio-economic groups in all countries (Miller *et al*., 2016). A study covering 176 countries found that in low-income countries fruits and vegetables were moderately expensive, and dark green leafy vegetables very expensive (Headey and Alderman, 2019). However, the study also found that the affordability of fruits and vegetables varies considerably between regions, with some fruits or vegetables being more expensive in some regions, and less so in others. This points to the need to gain a clear understanding of

national and local prices, as existing price monitoring systems often miss local foods that are important to the nutrition of the poor. In addition, even where prices are available, the nutritional content of the food in question may not have been measured, as in the case of wild foods (Masters *et al*., 2018). These and other limitations will be discussed in Section 3.

In low-income countries, the demand for fruits and vegetables is highly price- and income-elastic as compared with other food items; hence, even small changes in the price of fruits or vegetables may engender large changes in their consumption. Studies have shown that a 10 percent increase in the price of fruits and vegetables may lead to a reduction in their consumption of 7.2 percent (Cornelsen *et al*., 2015); meanwhile, a small increase in income was found to lead to a larger increase in fruit and vegetables consumption compared to other food items (HLPE, 2017). This shows that efforts to reduce the production costs and retail prices of fruits and vegetables may help boost the consumption of fruits and vegetables, if combined with other interventions in the food system (such as income support for low-income consumers through vouchers or other schemes).

A limitation of the studies mentioned above is that many of them are based on the World Bank's International Comparison Program (ICP) data, which provide average prices for selected fruits and vegetables at country level and throughout the year, but underestimate seasonal variations in prices. More importantly, the data do not consider fruits and vegetables sold in local open-air markets, where prices are often lower (Gomez and Ricketts, 2013). For example, there is evidence from a number of Latin American countries (including Chile, Brazil, Costa Rica and the Dominican Republic) that the prices of fruits and vegetables sold in local municipal markets are lower than those of fruits and vegetables sold in supermarkets (Boza, 2020). It is therefore important to carry out national and subnational studies on the cost of a healthy diet, and the role of fruits and vegetables therein, before considering price-related interventions.

Physical accessibility (availability)

The emerging issue of food deserts has led to the proposition that the built environment, i.e. the retail settings that surround people, could have an influence on people's dietary behaviour (Beaulac, Kristjansson and Cummins, 2009).[9] Studies of the retail food environment may analyse the *community* food environment (the density and proximity of different types of food outlets) or the *consumer* food environment (the types, quality and relative prices of various foods offered in stores) (Ni Mhurchu *et al*., 2013). Community food environment studies have shown that the relative density of outlets has a greater impact on dietary patterns than proximity. This

[9] Food deserts are geographic areas where residents' access to affordable, healthy food options (especially fresh fruits and vegetables) is restricted due to the absence of grocery stores or food markets within convenient travelling distance.

means that the higher the density of outlets that sell fruits and vegetables as compared to that of other outlets, the higher the odds that people who live in that area will consume healthier diets (Caspi *et al*., 2012; Bivoltis *et al*., 2018). Although most of these studies have been carried out in urban centres in high-income countries, there is growing evidence that the same holds in LMICs (such as Mexico, Brazil and Ghana) (Bridle-Fitzpatrick, 2015; Dake *et al*., 2016; Duran *et al*., 2015). These findings demonstrate that it is important to increase the density of healthy outlets as compared with that of unhealthy outlets in urban areas (of different sizes), and particularly in low-income neighborhoods; outlets that prevalently sell fruits and vegetables should be spread out homogeneously in such areas.

Emerging evidence on the consumer food environment consistently shows that there is a link between buying in specific stores (e.g. supermarkets vs farmers' markets) and dietary patterns and/or obesity. In LMICs, there is evidence that consumers who buy prevalently in supermarkets have unhealthier diets; this seems to hold especially true for low-income consumers who are more price sensitive and thus prefer the cheaper ultra-processed foods sold in supermarkets (Asfaw, 2008; Demmler *et al*., 2018). Studies carried out in the United States of America into the link between the type of food outlets and diets have shown that consumers who shop at farmers' markets, under community-supported agriculture (CSA) schemes or through other local food initiatives consume more fresh fruits and vegetables and have a more positive attitude towards healthy eating (Pitts *et al*., 2013; Minaker *et al*., 2016; Vicovaro, Puhac and Tartanac, in press).[10]

In conclusion, there is a clear need to ensure that outlets that prevalently sell fruits and vegetables (such as farmers' markets, open-air municipal markets and small fruit and vegetable vendors) are not crowded out by other outlets (e.g. convenience stores and supermarkets), particularly in low-income areas. A recent study carried out in Latin America shows that while open-air markets (including farmers' markets) have declined in importance over the past decades, they are still crucial for the sale of a variety of fruits and vegetables, especially in low-income areas. Indeed, open-air markets ensure the physical availability of diverse and traditional varieties of fruits and vegetables that are not found in supermarkets; they are often the preferred outlets of poorer people due to their proximity and lower prices (Boza, 2020). In most LMICs, farmers' markets do not require an introduction. Here, fresh foods are traditionally sold on farmers' markets, which are thus linked to traditional diets with a greater emphasis on fruits and vegetables. This suggests that local governments should take due account of the importance of food outlets in urban planning, and improve links between local smallholders producing fruits and vegetables and these outlets.

[10] Under a CSA scheme, consumers subscribe to the harvest of a farm or group of farms; in return for subscribing, consumers receive a weekly or bi-weekly box of produce or other farm goods.

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3.

SUSTAINABLE AND INCLUSIVE DOMESTIC VALUE CHAINS FOR FRESH PRODUCE: DRIVERS, OPPORTUNITIES AND CHALLENGES

DRIVERS

The drivers behind the restructuring of value chains for fruits and vegetables must be analysed against the wider background of overall changes in agri-food systems. Agri-food systems have been transforming rapidly over the past decades in response to various trends, including market liberalization, urbanization, income growth, dietary changes, technological advances (e.g. in retailing) and the growing role of foreign investment in the agri-food sector. Local and fragmented food supply chains coexist in parallel with geographically much larger ones.

The main drivers of the transformation of value chains for fruits and vegetables can be categorized as downstream (demand side) or upstream (supply side) drivers. Although there are obvious differences between value chains in industrialized and developing countries, some common overall patterns of change can be observed. On the demand side, consumer demand is one of the core drivers of innovation and value creation at each level of the food chain. Population growth, urbanization and income growth cause changes in food consumption patterns; distance and time constraints make consumers place a premium on food preservation and convenience. Consumers in developed countries and middle-class consumers in developing countries are shifting towards diets that include not only products with a higher nutrient value, but also products that embody more value-adding services (e.g. ready-to-eat products) (Regmi and Gehlhar, 2005). The increase in consumer income in low- and middle-income countries favours healthy dietary patterns, including a higher intake of fruits and vegetables, more dietary diversity and a higher vitamin and mineral intake. Further income growth is expected to boost consumer demand for high-value foods, including fruits and vegetables; this is expected to trigger an increase in the supply of these products, be it with cost constraints (FAO *et al.*, 2020).

On the supply side, agriculture has rapidly diversified beyond staple crops into horticulture, dairy, livestock, fish and pulses. Rural-urban linkages and logistic infrastructure have further facilitated the transportation of these products to urban as well as rural consumers (Zeigler, 2019). Secondary and tertiary cities and towns account for 50 percent of the global urban population. Megacities source food from all around the country, while smaller cities are more reliant on surrounding rural areas for food (Berdegué and Proctor, 2014), especially for perishable, high-value products such as fruits and vegetables. This creates opportunities for rural small-scale producers and service providers to supply fruits and vegetables.

Despite the transformation of the agri-food chain and the expansion of large retailers, there is evidence that in developing countries, fruits and vegetables continue to move primarily along traditional value chains (FAO, 2005; Guarin, 2011). For instance, in Kenya, Zambia and

Nicaragua, over 90 percent of all fruits and vegetables are purchased by consumers in traditional retail outlets. Even in countries with a high penetration of modern supermarkets, the share of traditional outlets in overall sales is high; for example, 63.2 and 72.5 percent of all fruits and vegetables are sold in traditional outlets in Thailand and Mexico, respectively (FAO, 2005).

OPPORTUNITIES

A simulation quantifying the gap between the supply and the demand of fruits and vegetables in more than 150 countries between 1961 to 2050 found that even with zero wastage, many countries will need to increase their production of fruits and vegetables to achieve the WHO's dietary recommendations (Mason-D'Croz *et al*., 2019). This shows that, within supply chains, the production (including the supply of inputs) and post-harvest stages are those most in need of improvement. The projected increase in the demand for high-value foods may present an opportunity for developing countries to exploit their comparative advantage in the production of fruits and vegetables for both export and domestic markets.

The analysis of opportunities in supply chains for fruits and vegetables must distinguish between value chains for export markets on the one hand, and those for domestic markets on the other. The analysis of the structure of these chains and of the distribution of added value, power and influence among their main actors provides a foundation to identify opportunities to upgrade both types of value chain in a gender-sensitive manner.

Export-oriented value chains for fruits and vegetables

Motivated by the growing demand for fruits and vegetables, a number of developing countries have pursued the production and export of these high-value agricultural products and have managed to capture a large share of the international market for fresh produce. The produce industry constitutes an important source of employment, as the production of fruits and vegetables is considerably more labour-intensive than that of cereals (Joshi *et al*., 2004; World Bank, 2009) and provides more post-harvest opportunities for adding value.

Export-oriented value chains consist of several segments: the provision of inputs, production, packing, storage, processing, distribution and marketing. The most important inputs used are seeds, fertilizers, agrochemicals, labour, and farm and irrigation equipment. Logistics is a key supporting segment. Due to the fragile and perishable nature of fruits and vegetables, a high degree of coordination among the different actors along the chain is required to ensure that products reach their destination in good conditions. Cold storage is used throughout the chain to keep produce fresh, while both air and sea freight help ensure time-

ly delivery. Fruits and vegetables can be consumed either fresh or in a processed form. In some cases, produce that fails to meet the requirements for the fresh market are redirected to processing; in other cases (e.g. orange juice or preserved peaches), the processing industry requires different varieties and/or qualities than the fresh market.

Packing and storage are usually carried out by large producers or exporters that consolidate fresh fruits or vegetables. The first activity within the packing segment of the chain is grading. Unacceptable, low-grade produce is redirected to processing plants or to the domestic market. Washing, trimming, chopping, mixing, packing and labelling are other processes that may occur at this stage of the value chain. Once the produce is ready for transport, it is blast chilled and placed in cold storage units. Packing is usually characterized by economies of scale due to the high costs of cold storage and other facilities. Processed fruits and vegetables include dried, frozen and preserved produce, as well as juices and pulps. Many of these processes add value to the raw product by increasing its shelf life; they are often sold under the processor's or retailer's own brands.

Export-oriented fruit and vegetables industries often produce spillovers into other industries in terms of the transfer of skills or technologies or access to innovation; they may create opportunities for the inclusion of small-scale producers and small and medium enterprises (SMEs) in primary processing. These effects are among the main drivers motivating developing countries to put in place support mechanisms and regulations to attract (foreign) investments in the export-oriented produce business. A closer look at the organization of the export value chain may help assess whether spillovers and inclusiveness in developing countries have indeed met expectations.

Export-oriented value chains for fruits and vegetables are organized by interactions and linkages between differently sized firms. At production level, there are small, medium and large farms. Large producers often buy from small and medium farmers (referred to as outgrowers) to supplement their production for export; these large firms are referred to as producer-exporters. In many countries, there are also exporters who do not produce anything themselves, but only buy in from independent outgrowers (Gereffi and Fernandez-Stark, 2011).

The producer-exporters in a country usually consist of a few large multinationals and a large number of medium-sized domestic firms. Strong domestic firms in countries such as Kenya and Chile have expanded abroad and have vertically integrated along the value chain (Fernandez-Stark, Bamber and Gereffi, 2011). Producer-exporters often consolidate vertically through:

- the upstream integration of exporters into production and the growing dominance of large farms;
- contracts with outgrowers whereby farmers may receive inputs, credit and technical assistance, and sales to the exporters are guaranteed; and
- non-contract supplies from independent growers (Jaffee and Masakure, 2005).

Larger farms are better able to supply products that meet strict quality and traceability requirements, as they have the financial resources to make the investments that are needed to meet these requirements. Larger farms may also undertake other important functions such as product development and innovation (Humphrey, 2005).

A review of the literature shows a lack of evidence as to the effectiveness of efforts to improve the participation of smallholders and local SMEs in export-oriented value chains and increase their share in value added (Fernandez-Stark, Bamber and Gereffi (2011) examined the cases of vegetables in Kenya and fruits in Chile). Opportunities for smallholders are mostly limited to domestic or regional markets or to developing countries, where standards are not as rigorous and/or compliance is less expensive (Boselie *et al*., 2003; Neven *et al*., 2009).

The fresh produce industry offers important opportunities for job creation in developing countries. The production of fruits and vegetables is more labour-intensive than that of other crops and provides more opportunities for the post-harvest adding of value (Joshi *et al*., 2004; Lumpkin, Weinberger and Moore, 2005; World Bank, 2009). The labour-intensive nature of the industry makes workforce development a strategic element to facilitate spillovers and ensure a more equitable division of added value. The following areas are key for capacity development:

- training in food safety and quality standards along the value chain;
- incentives for firms to shift from a temporary to a more permanent workforce to maximize the return on investment in training;
- partnerships between educational institutions and private enterprises to tailor education programmes to the needs of the industry; and
- capacity building of all job categories in agricultural production, packing and storage, and agro-processing (Fernandez-Stark, Bamber and Gereffi, 2011).

Women account for at least half of the total employment in both export-oriented and domestic fruit and vegetable industries in developing countries (Lumpkin, Weinberger and Moore, 2005). Thus, efforts to create and upgrade employment in supply chains for fruits and vegetables

must particularly strive to ensure the gender-equitable division of the benefits of such development. This holds especially true for the primary and secondary processing segments of the value chain, where the opportunities for wage employment are greater, and wages higher.

Domestic value chains for fruits and vegetables

Fruits and vegetables are produced all around the world. However, actors oriented towards the domestic market usually are not incentivized to organize efficiently. Production is scattered along a great number of producers cultivating various species and varieties according to specific climatological contexts. Most commercial transactions are informal and largely driven by intermediaries. Hardly any food safety requirements are met. These value chains usually are not supported by public policies. As an exception, policies promoting the fruit and vegetables sector in India prompted a sustained annual 4.3 percent growth in the production of fresh produce between 2001 and 2016 (OECD, 2018).

Most fruits and vegetables are highly perishable and prone to damaging. Losses along the supply chain from the harvest to the markets are therefore high; however, the extent of these losses differs between products, regions and value chains. Several methods have been developed to measure the economic importance of these losses, each focusing on a different aspect of the value chain and on different types of food loss. A systematic analysis of the existing literature was conducted by Kitinoja and Kader (2015), who find that the levels of reported losses of fruits and vegetables worldwide have not changed much from the 1970s (when a first loss estimate of 30 to 40 percent was published by the National Academy of Sciences) until the present time (National Academy of Sciences, 1978). Reported losses vary enormously between crops (from 0 to 80 percent), most likely depending on the nature of the product (the degree of perishability) as well as a range of unreported contributing factors, including production methods, the incidence of diseases, the time lapse between harvesting and marketing, the temperature during handling, weather conditions, the type of packaging, etc. Depending on the adopted criteria, losses in sub-Saharan Africa are estimated to be as high as 55 percent of the total production for fruits, and 43.5 percent for vegetables. Monetary losses resulting from the deterioration in quality of fruits and vegetables are considerable. It is estimated that 4.8 to 81 percent of tomatoes, amaranth leaves, okra, oranges and mangoes undergo damage, spoilage or decay at farm level, 5.4 to 90 percent at wholesale level, and 7 to 79 percent at retail level. Such produce becomes at best sellable only at reduced prices, culminating in losses estimated at 16 to 40 percent of total production (Kitinoja, 2010). In South Asia, postharvest losses for high-value crops have been found to range from 25 to 40 percent, depending mainly

on transport methods (Faqeerzada *et al.,* 2018). Figures for Latin America seem to be similar or slightly lower; however, precise data are scarce (Boza, 2020).

Domestically, fruits and vegetables reach consumers through formal or informal (wholesale) markets (e.g. fairs, wet markets), traditional retail outlets (neighborhood stores), modern retail outlets (supermarkets) or through public procurement.

A recent study has shown that in Latin America and the Caribbean, wholesale markets constitute the most important connection between producers, intermediaries, retailers and consumers (Boza, 2020). Similar findings are reported for South East Asia (ADB, 2019) and China (Ren and An, 2010). Wholesale markets play a crucial role in domestic supply chains in these countries as they agglomerate most of the produce and then supply it to other markets and outlets and consumers. In wholesale markets, consumers can find a great variety of local and traditional fresh produce from small-scale producers. In Latin America and the Caribbean, 70 to 80 percent of all fruits and vegetables sold pass through wholesale markets (Boza, 2020). For example, in Brazil, 16.82 million tonnes of fruits and vegetables moved through wholesale markets in 2018 – equal to nearly 70 percent of the domestic market (Prohor, as cited in Boza, 2020). These transactions are often not subject to any food quality or safety standards, and there are no transparent price setting mechanisms (Boza, 2020). The intermediaries in these markets play an important role since financial and logistical barriers often prevent small-scale producers from transporting their own products. The main advantage of wholesale markets for suppliers is that payment is immediate on sale and demands regarding product origin, food safety or good agricultural or handling practices are very low. Likewise, many retail markets (such as open-air markets where smallholder producers sell directly to consumers) also impose low or no quality or food safety requirements.

According to the Chilean Observatorio de Ferias Libres (Observatory of Open Markets) (Boza, 2020), the main challenges faced by small-scale producers in Chile in the marketing of their produce are a lack of organization, poor infrastructure, inadequate waste management and competition from irregular vendors. Despite the fact that the importance in Latin American and the Caribbean of traditional retail outlets is declining to the benefit of modern retail outlets (Reardon and Popkin, 2018), in countries such as Mexico, open-air fairs still account for half of all retail sales of fruits and vegetables.

Globally, supermarkets are very competitive retail actors (Reardon and Popkin, 2018). They are able to offer produce that meets the demands for food safety and quality of medium- and high-income consumers. Large retailers may participate in purchasing schemes with smallholder groups, if supported by government programmes. Successful examples in Chile and Colombia show that smallholder groups that participate in such schemes

improve product quality, benefit from timely payments, enjoy long-term, stable markets and make higher profits as there is less or no intermediation (Boza, 2020).

Public procurement offers opportunities for smallholder participation, if the scheme is part of a broader support package that includes improving access to finance, providing crop insurance, developing capacity, promoting collective organization, improving the uptake of technology, etc. (Boza, 2020). An example is the case of PNAE, Brazil's national school meals programme, under which the government has committed to purchase 30 percent of all food from smallholders (for a total value of nearly USD 500 million); a range of support programmes is developed to implement this plan (Boza, 2020).

Informal markets are relevant to food systems, despite their volatility, instability and lack of protection for both workers and producers. This sector is a source of employment for the most vulnerable population groups, who often lack access to public services. The participation of women in informal markets is high. In Colombia, half of all street vendors sell fruits as their main product to students and urban workers (Cámara de Comercio de Bogotá, 2018).

The main challenges related to traditional formal and informal markets concern:

- the improvement of managerial capacities to comply with food safety and quality standards through the implementation of good practices and traceability systems along the chain;
- the creation of an enabling policy and institutional framework to facilitate the business of smallholders and SMEs on these markets with clear rules, standards and commercial protocols;
- the provision of public infrastructure such as roads and electricity networks; and
- the fostering of innovation in primary processing, packing and transportation.

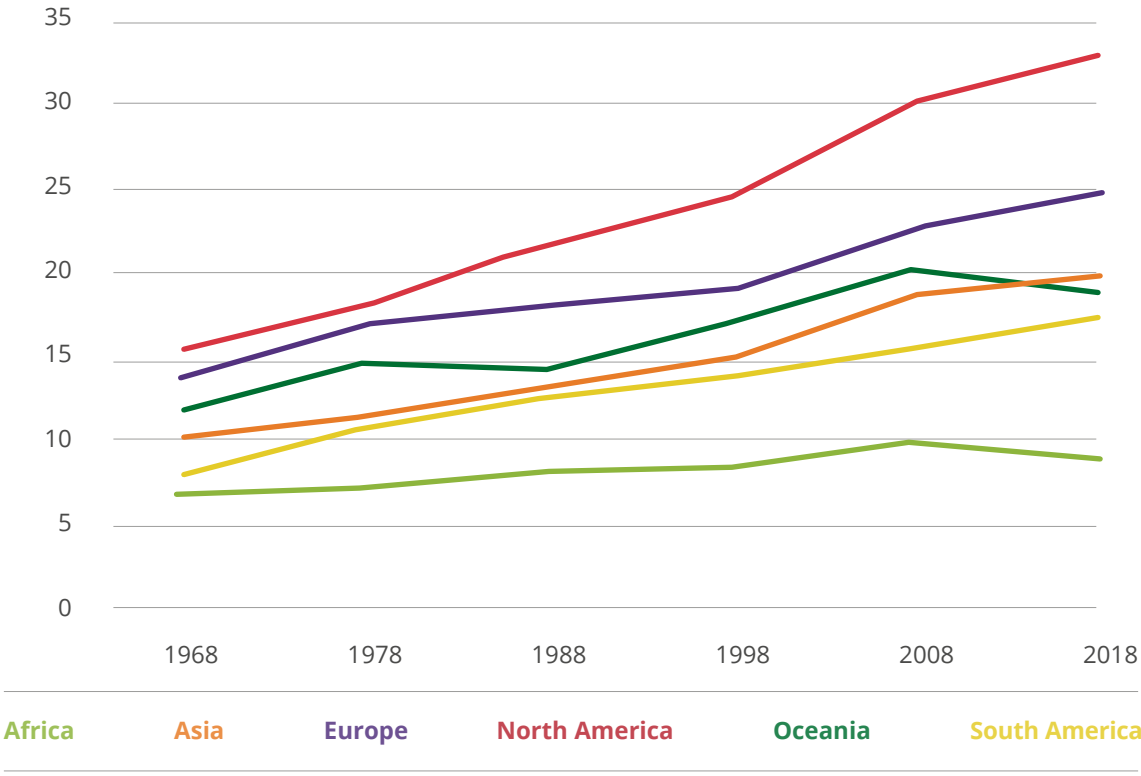
CHALLENGES AT THE PRODUCTION STAGE

Productivity

Low productivity affects countries' capacity to produce sufficient fruits and vegetables to meet recommended consumption levels. Low productivity may be linked to several factors, including the access to inputs, the uptake of technology and innovations in general.

Figure 2 shows the yields for primary vegetables for the world's various regions over the period 1968–2018 (note that differences in the kinds of vegetables produced in the various regions inhibit the

FIGURE 2. Yields of primary vegetables, by region (tonnes/ha), 1968–2018



Source: FAOSTAT. FAO, 2020b.

comparison of the absolute numbers).[11] Over the period, yields in North America and Europe have increased by 216 and 181 percent, respectively. Meanwhile, yields in South America and Africa show increases of 207 and 135 percent, respectively, over the same period of 50 years. Current yields (2018) for vegetables for individual countries range from 31.5 tonnes/ha in Chile to 5.7 tonnes/ha in Uganda. This compares with 17.2 tonnes/ ha and 9.1 tonnes/ha in South America and Africa, respectively, and 18.8 tonnes/ha worldwide (FAO, 2020b).

Among the factors that hinder the sustainable production of fruits and vegetables are:

- the lack of sustainable access to natural resources including land, soil nutrients and water;[12]

[11] See Annex 4 for detailed data; primary vegetables include artichokes, asparagus, cabbages, cantaloupes and melons, carrots, cauliflower, chillies and peppers, cucumbers and gherkins, onions, eggplants, tomatoes, garlic, green beans, green peas, leeks, lettuce, mushrooms, okra, pumpkins, spinach, string beans and watermelons.

[12] Such access may be facilitated or impeded by land tenure systems.

- the lack of quality inputs (due their non-availability or to a lack of financial resources);

- the lack of quality seeds or planting materials for preferred species and varieties;

- the lack of knowledge of good agricultural practices (production and plant protection) in the face of changing environmental and climatic conditions;

- the lack of research and extension services for producers;

- the lack of adequate policies and institutions, and the lack of coordination between them;

- the lack of information on market prices or on the supply and demand of products;

- the imbalance between fruit and vegetable production for household consumption on the one hand, and for sale in the market on the other (FAO and World Vision, 2020).

The lack of investment in general public infrastructure, such as rural roads, consolidation centres or irrigation systems, should be added to this list.

Environmental sustainability of production

There is evidence that the production of foods with positive health effects (such as fruits and vegetables) has a lower negative impact on the environment than that of foods associated with a higher risk of disease (Clark *et al*., 2019). Nevertheless, the intensive use of resources within a limited space and timeframe typical of horticulture carries a risk of negative impacts on the environment. The use of intensive, non-sustainable production practices may negatively affect the availability and quality of land and water resources (e.g. by diminishing soil fertility) (Wainwright, Jordan and Day, 2014). In addition, the level of energy use in supply chains for fruits and vegetables is high (Elia and Farina, 2010).

Sustainable production starts with maintaining healthy soils. The quality of soils is crucial to the production of fruits and vegetables, as plant performance depends on the acquisition of sufficient nutrients and water through the root system. A healthy soil provides the right environment for vigorous root system development, improved water retention and control of pests and diseases, all critical to crop productivity (FAO, 2016a). The efficient use of water resources in horticulture is crucial to enhance natural equilibria and crop competitiveness (Elia and Farina, 2010). Sustainable production practices, taking due account of the growing water scarcity in many parts of the world, must be further developed and promoted.

Practices to protect crops against pests and diseases are potentially harmful to the environment and to people. Jin *et al*. (2016) found that although farmers in the study area of Anqui were aware of some degree of risk when using pesticides, they still overused them. Improper disposal of pesticides was also common. The probability of pesticide overuse significantly decreased with farmers' risk perceptions, their willingness to reduce pesticide use, better social relationships and strict government monitoring. The perception of risk was found to be an important element in education and communication efforts. Climate change may affect the prevalence of pests and diseases in certain regions, and farmers may have to deal with unfamiliar pests; hence, knowledge regarding the correct use of pesticides must be further disseminated.

Appropriate cultivation practices may help mitigate the impact of horticultural production on the environment through soil protection and conservation, the optimal use of fertilizers and integrated pest management (Wainwright, Jordan and Day, 2014). FAO promotes the sustainable intensification of crop production, to enable producers to achieve the highest possible productivity by unit of production input within an ecosystem's carrying capacity. This is achieved by applying conservation agriculture practices, using good seeds of high-yielding, adapted varieties, applying integrated pest management, ensuring adequate plant nutrition based on healthy soils, managing water resources efficiently, and integrating crops, pastures, trees and livestock (FAO, 2011). Meanwhile, numerous examples show that by using the productive landscape approach the production of fruits and vegetables can be integrated within a sustainable and highly biodiverse productive environment (Chavez-Tafur and Zagt, 2014).

Environmental challenges are exacerbated by climate change. Williams, Crespo and Abu (2019) note that farmers in Ghana are taking measures to reduce the vulnerability and improve the resilience of their production activities in the face of increasing temperatures and declining rainfall, two trends of climate change that have been observed over the past two decades. Among the farmer-driven measures that are being implemented are soil, water and crop conservation measures and farm management practices, including adapted fertilization, supplementary irrigation, crop rotation, intercropping and mixed farming.

CHALLENGES AT THE POST-HARVEST AND PROCESSING STAGES

Producers in developing countries face tremendous challenges in the post-harvest and processing stages[13] due to the absence of appropriate infrastructure or technologies, or the incapacity to use them. Examples include the inadequacy of packing materials or the absence of cold storage and packing facilities (ADB, 2020). Those constraints cause a high level of post-harvest losses. For example, post-harvest losses of fruits and vegetables in Viet Nam are estimated to account for 10 to 30 percent of total production, whereas this number rises to 30 to 40 percent in Pakistan (ADB, 2020).

CHALLENGES AT THE MARKETING STAGE

The challenges faced by producers and traders at the marketing stage of the supply chain are associated with market failures, the inadequacy of market infrastructure, the inability to comply with food safety and quality standards and market directors' lack of managerial capacities.

Various forms of market failure work against farmers in fruit and vegetable value chains. First, most developing countries do not have reliable price information systems. Second, wholesalers and other traders often enjoy oligopoly power, and informal purchase agreements are usually tilted to their advantage. Third, fruits and vegetables are highly seasonal; therefore, their prices exhibit substantial fluctuations. As a result of these market failures, farmers capture less than 30 percent of retail prices for fruits and vegetables in Viet Nam, and less than 15 to 20 percent in Pakistan (ADB, 2020).

Many wholesale markets, where most smallholders sell their products, lack permanent stalls that offer shade. Farmers therefore often have to sell their produce from trucks or in open spaces, which makes it impossible to comply with food safety and quality standards. Table 1 presents a number of examples of the challenges faced by sellers in wholesale markets Viet Nam, Pakistan and Nepal.

COMPLIANCE WITH FOOD SAFETY AND QUALITY STANDARDS

Since the 1980s, numerous regulations and voluntary standards related to food safety and quality have been developed; they impact the suppliers of both domestic and international markets, especially for fruits and vegetables. The growth in importance of food safety and quality requirements in international trade is linked

[13] For the purposes of this paper, processing is understood to include minimal procedures such as washing, sorting, trimming, peeling, slicing or chopping, as these do not affect the quality of freshness of produce.

TABLE 1. Overview of challenges faced by sellers in wholesale markets in Viet Nam, Pakistan and Nepal

VIET NAM	PAKISTAN	NEPAL
· **Market infrastructure:** lack of permanent stalls with shades, produce sold from trucks, inability to comply with food safety and quality standards, inadequate logistics infrastructure (e.g. parking).	· **Market infrastructure:** lack of space forces traders to operate in open spaces under unhygienic conditions, inability to comply with food safety and quality standards, insufficient water supply.	· **Market infrastructure:** inadequate transportation and cold storage facilities, lack of quality measures, lack of space for expansion.
· **Management:** inadequate waste management, lack of hygiene and food safety measures. Lack of market transparency, poor coordination among actors. Lack of reliable data on volumes traded and prices, and on consumers' purchasing habits.	· **Management:** excessively interventionist. Revenues from the licensing fees are not used for waste management or maintenance. Poor coordination and lack of market transparency, no actions on food safety.	· **Management:** government-nominated management boards discourage private investments, poor services, lack of managerial training and skills.
· **Peripheral infrastructure:** small parking areas, insecurity, poor waste management, lack of cold storage, poor roads, buildings and utilities.	· **Peripheral infrastructure:** small parking areas, no waste management, lack of cold storage, bad exterior lighting, poor telecommunication systems.	· **Peripheral infrastructure:** small and insecure parking areas, poor design of unloading docks, unfenced areas, lack of refrigerated storage and transport.

Source: ADB, 2019a, 2019b, 2019c.

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to the occurrence of food safety scares, growing consumer interest in social and environmental sustainability and the growing control exerted by supermarkets over global value chains (Santacoloma, 2014). Some voluntary standards may improve market access and profitability for smallholder farmers (e.g. organic or fair-trade standards) more than others (e.g. GlobalGAP) (Loconto, 2014). The main challenges for compliance by small-scale producers are a lack of institutional infrastructure and managerial capacities (e.g. a lack of laboratories, inspection and certification bodies and capacity development for good practices along the supply chain) and certification costs. These challenges may hamper efforts by smaller producers to access to high-value markets, which offer possibilities to increase incomes.

CHALLENGES RELATED TO GENDER

Strong gender bias as to the distribution of roles between men and women span geographic and cultural dimensions. They affect women's access to land, training, infrastructure, finance, education, information and markets. The constraints faced by women differ according to their position in the supply chain: wage labour in post-harvest operations, unpaid family labour in smallholder operations, and self-employment (e.g. in the cultivation of crops). In post-harvest operations, contract conditions (including wages or flexible employment conditions) often discriminate against women. Women may also have less access to training, which affects their productivity and may prevent their progress into more sophisticated segments of the chain. Meanwhile, labour in smallholder production is not only unrecognized as work, but also unremunerated; due to their higher participation in unpaid family labour, this affects women more than men (Barrientos, Dolan and Tallontire, 2003). The exclusion from networks and restricted access to information may also limit women entrepreneurs' knowledge of new products or market requirements. Case studies show that buyers may exploit these weaknesses to negotiate lower prices with female suppliers, which is detrimental to women's ability to capture a fair share of the benefits along the value chain (Bamber and Fernandez-Stark, 2013).

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4.

POLICY RECOMMENDATIONS TO PROMOTE INCLUSIVE AND SUSTAINABLE VALUE CHAINS FOR FRESH PRODUCE

UNDERLYING CONSIDERATIONS

This section presents a number of policy recommendations to tackle the challenges and exploit the opportunities listed in Section 3, and thus work towards the overall objective of ensuring the sustainability of value chains for fruits and vegetables and their inclusion of smallholders. The motives underlying this objective include:

- Improving farmers' access to quality inputs and natural resources not only increases productivity, but also contributes to agrobiodiversity and boosts producers' resilience to environmental and climatic change.

- Successful strategies for the inclusion of smallholders may transform the structure of the value chain by creating new business opportunities and market linkages; this may increase productivity, boost incomes, create employment and promote food security.

- Sustainable, inclusive value chains may improve consumers' diets in terms of food quality and nutritiousness, for example by shortening the supply chain from producers to consumers. They may also promote biodiversity.

- Cross-sectoral policy coherence and collaboration between the health and economic sectors is crucial to build nutrition-sensitive, sustainable value chains for fruits and vegetables (Thow and Priyadarshi, 2013).

- Increasing and diversifying the production of fruits and vegetables may help meet the growing demand for these products in domestic and local markets.

POLICIES RELATED TO SUSTAINABLE PRODUCTION

Policies must be designed to lift constraints hindering the development of sustainable production and create an enabling environment that allows the sector to fulfil its potentials.

Promote horticulture in rural, urban and peri-urban settings

Fresh produce should be easily available to consumers, on a year-round basis. Since fruits and vegetables are often highly perishable, it is advisable to produce them close to consumers in rural, urban and peri-urban areas and improve the links between producers and consumers (e.g. between rural zones and cities). An important share of all produce is grown

on small-scale family farms, for their own consumption and for marketing. This production is crucial to ensure the year-round diversity of the food supply and has a potential to generate additional income. This holds especially for urban and peri-urban areas, where policies must focus on urban planning, market access, organic waste recycling, and pest and disease management (Sumangla, Malahotra and Chowdappa, 2013). FAO has developed a five-pronged strategic framework to help policymakers in cities promote the sustainable development of urban and peri-urban horticulture. The strategy consists of the following five pillars:

- ensure political and institutional commitment;
- secure land and water for horticulture;
- ensure product quality while protecting the environment;
- ensure the participation of all stakeholders;
- secure new markets for fruits and vegetables.

This framework can adapted to rural areas.

The recent COVID-19 pandemic has highlighted the importance of shorter supply chains, especially for nutrient-rich fresh fruit and vegetables. Indeed, restrictions on movements in the framework of the fight against COVID-19 not only affected consumers' ability to access food, but also impacted production (e.g. labour shortages for harvesting, or impeded access to inputs). Against this background, urban and peri-urban agriculture was promoted by multiple municipalities to improve the availability of food for their citizens and safeguard farmers' livelihoods (FAO, 2020c).

Facilitate farmers' access to quality seeds of performing varieties

Agricultural policies aimed at achieving food security must emphasize strategies that ensure the availability of affordable, high-quality seeds and planting materials of locally suited varieties (including to local tastes) (FAO, 2001). In many countries, a lack of efficient policies and institutions leads farmers to produce and use their own, inferior seeds, which results in low productivity rates (Tata *et al*., 2016).

The production and distribution of vegetable seed is heavily dominated by a limited number of large multinationals, with the top five vegetable seed companies accounting for around 70 percent of the total market. The emphasis is on crops with the highest profit margins and the largest markets. Nevertheless, in the Philippines, Thailand and Taiwan, Province of China, regional seed companies have emerged. They initially concentrated on regionally important crops for which western companies do not provide seeds, but now supply seeds for a full range of crops. This indicates that niche players are likely to continue to emerge

and grow. However, some of these will be taken over by the multinationals as soon as they obtain a strategic market position (Louwaars, 2011)

Promote the production of indigenous fruits and vegetables

Of an estimated 350 000 plant species in the world, about 80 000 are edible for humans. However, at present only about 150 species are actively cultivated as human food or animal feed. Of these 150 species, 30 account for 95 percent of the total production of calories and proteins for human consumption. While over 1 000 varieties of bananas are reportedly produced and consumed locally in the world, only one variety (Cavendish) accounts for almost half of the global production of bananas. In Africa, the third largest production region of bananas globally, some 70 to 80 percent of all bananas produced are local varieties − mostly cooking bananas, which are crucial to food security in the region (FAO and OECD, 2020).

Local, traditional fruits and vegetables often have nutritional properties that are superior to those of their internationally traded counterparts (Schreinemachers, Simmons and Wopereis, 2018). Awareness is rising that these crops boost the resilience of the livelihoods of rural populations in many parts of the world. Traditional fruit and vegetable varieties are well-adapted to the local climate; they contribute to poverty reduction and improve household food security in disaster-prone areas (Rahim, 2009). The leaves of certain crops, while generally considered a by-product, may be consumed as leafy vegetables; examples are cassava, taro, quinoa, yam and sweet potato. However, these leaves are not subject to extensive research or breeding, and often (but not always) have a limited market interest. They can be considered orphan crops (Olabode *et al*., 2016; Sogbohossou *et al.*, 2018).

BOX 1. Traditional vegetable crops

A study into the use of traditional crops in Benin recorded 187 different species belonging to 141 genera and 52 families. About a quarter of these species were cultivated, while the rest was gathered from the wild. Most of these species (65 percent) were herbs, followed by shrubs (20 percent) and trees (15 percent) (Dansi *et al*., 2008). In Lubumbashi, in the Democratic Republic of Congo, cassava leaves are the main vegetable in people's diets (Tollens, 2003). The nutritional composition of cassava leaves is very interesting, as they contain a high level of crude protein (29.3 to 32.4 percent of the dry weight). By way of comparison, amaranth leaves, another interesting but neglected vegetable, contain 19.6 percent dry weight crude protein (Awoyinka *et al.*, 1995).

Promoting the biodiversity of horticultural crops may help achieve food and nutrition security. Indeed, indigenous crops may contribute to food security, nutrition, health and economic development; thus, strategies to promote the production of such crops should be implemented (Kahane *et al*., 2013). This requires the creation of a favourable policy environment and increased investment (Jaenicke, 2013), the promotion of research and the dissemination of information (Pichop *et al*., 2016), and knowledge management and capacity building. The production of indigenous vegetables should begin with the development of good seed or planting materials, and be accompanied by appropriate agronomic packages that consider health and environmental sustainability (Nono-Womdim *et al*., 2012).

Promote good agricultural practices, including access to modern technologies

To ensure the sustainable management of natural resources, fruits and vegetables must be produced through good agricultural practices, combining traditional knowledge with the use of modern technology and methods. Ultimately, production systems should be economically profitable, socially acceptable and environmentally sustainable. In other words, they should benefit the health of consumers by supplying healthy, safe and high-quality fruits and vegetables while at the same time respecting the environment and provide decent working conditions (related, for example, to the exposure to the health hazards of agrochemicals) for farmers and labourers (FAO, 2012). The fruits and vegetables produced by such systems must meet a number of criteria, including the absence of pathogenic bacteria, the limitation of pesticide residues, acceptable concentrations of minerals, good nutritional values (vitamins, minerals, proteins and carbohydrates), and compliance with the expectations of the market (in terms of organoleptic characteristics such as shape, size, colour and taste, shelf life, etc.). The stringency of retailers' quality requirements may impact upon the sustainability of production; farmers have been found to discard between 20 and 40 percent of their fresh produce because it failed to meet retailers' cosmetic specifications (FAO, 2019).

In many countries, children are still widely employed in agriculture, and especially horticulture, which is often a family business. Children may be involved, for example, in the preparation of land, the planting of seedlings, weeding, the application of fertilizers or pesticides, harvesting and primary processing (ILO, 2017). The elimination of child labour in agriculture therefore remains a priority.

The sustainable production approach of FAO is based on principles that help farmers preserve soil health and use water efficiently. It uses eco-friendly technologies and techniques (e.g. for pest management) that make efficient use of inputs, protect the environment, build resilience to climate change and contribute to rural development (FAO, 2011; FAO, 2016).

Under certain circumstances, the adoption of sophisticated technologies such as greenhouses, precision irrigation, wireless controlled tools and machines, drones or biotechnology (e.g. in-vitro plant breeding), as well as mechanization may be feasible options that may contribute to the sustainability of horticultural production by small-scale producers. Meanwhile, the protected cultivation of horticultural crops (e.g. in greenhouses) may be a valid technical option for producers facing climate or pest pressures. It may considerably improve water use efficiency and productivity per hectare. Whatever the technologies used, care must be taken to adapt the technologies to the conditions of the small-scale producers involved and to facilitate access to them, specifically for women.

Mixed cropping systems (such as agroforestry) enhance the interaction between different species (Lauri *et al.*, 2016; Cerdan *et al*., 2012; Deheuvels *et al*., 2012; Gidoin *et al*., 2014). Besides promoting biodiversity, mixed cropping systems enable a more efficient use of space and water and soil nutrients. These diversified systems – which may use windbreakers or shade trees − improve soil fertility and enhance the resilience of production to climate and other types of shocks (FAO, 1996).

UPGRADE THE POST-HARVEST AND MINIMAL PROCESSING STAGES

Developing countries wishing to upgrade their horticultural activities into primary processing and packing and packaging for high-value export markets face three main challenges. The first challenge is understanding buyers' expectations; this requires open lines of communication regarding preferences regarding product quality and packaging. Chilean and Kenyan producer associations have organized trips to key markets for their members to observe purchasing behaviour first-hand (Fernandez-Stark, Bamber and Gereffi, 2011). The second challenge is investing in technologies that prolong the shelf life of the produce. For example, the Kenyan horticultural industry upgraded its packing through private investments in equipment that helped reach high standards of hygiene and in on-site laboratories for product and staff health tests. The third challenge is the existence of a local (in-country) packing and packaging industry capable of reliably providing services such as sorting, washing, chopping, mixing, packaging (in appropriate containers) and labelling (branding and applying barcodes). Exporting produce in bulk for packaging elsewhere represents a missed opportunity for value creation and holds back the development of a country's horticultural industry, Jordan being a case in point (Fernandez-Stark, Bamber and Gereffi, 2011).

Adequate technologies may prolong the shelf life of produce, reduce post-harvest losses and improve food safety and quality along the chain (ADB, 2019). Among the myriad of development projects carried out between 1990s and the present day, only about 1 percent have focused on horticulture; of these horticultural projects, only one third included any kind of post-harvest component (Kitinoja, 2011).

Comprehensive and systematic research by Kitinoja *et al*. (2010 and 2013) assessed 12 past international horticultural projects and identified the causes of post-harvest losses of 18 horticultural crops in four countries. The researchers aimed to identify small-scale innovations that could reduce post-harvest losses and were easy to implement on a trial basis. These innovations had to add value and increase returns from horticultural crops by at least 30 percent. Four major categories of post-harvest innovations were found to meet the evaluation criteria: using improved containers, providing shade for produce during post-harvest activities, using improved field packing methods, and using low- or zero-energy cold storage technologies. The study showed that many of these innovations could easily be scaled up by increasing the number of units (i.e. shade covers, plastic crates, field packing stations, cold chambers). The large-scale application of these post-harvest methods and technologies requires proactive extension efforts targeting small-scale farmers and women groups. In this respect, the researchers recommend the following strategies (Kitinoja, 2011):

- Integrate knowledge regarding post-harvest losses into general agricultural curricula and government extension services.

- Establish post-harvest training and services centres (PTSC) to test innovations to reduce losses under local conditions, identify the most promising and cost-effective techniques and practices, provide demonstrations of those innovations that are deemed technically and financially feasible, and provide hands-on training and capacity building opportunities to farmers.

- Establish post-harvest working groups at country level to bring together researchers, extension agents, farmers and other actors in the value chain on the issue of reducing post-harvest losses.

UPGRADE MARKET INFRASTRUCTURE AND LOGISTICS

Fresh fruits and vegetables are highly fragile and perishable. Hence, adequate logistics infrastructure for storage and transportation is crucial to the avoidance of losses and thus to the reduction of costs and environmental impacts along the supply chain. Examples of efforts to improve logistics infrastructure include:

- the building of consolidation centres equipped with facilities for sorting, grading, packing, sanitation and storage in remote production areas;
- the building or upgrading of roads connecting farms to consolidation centres, storage facilities and markets (rural roads, rural-urban highways, border crossings and ports);
- equipping processing factories with suitable processing, packaging and sanitation technologies, and ensuring their capacity to meet food safety and quality standards;
- the building of market structures equipped with good storage and sanitation facilities (FAO, 2015b).

The reliable supply of electricity is a basic prerequisite for the production and post-harvest storing and processing of high-value commodities; it is also essential to the use of information technologies to obtain information on production or post-harvest management practices, and on markets and prices. The uninterrupted supply of electricity is therefore essential to improve competitiveness in production, processing and marketing.

BOX 2. Upgrading horticultural value chains

Dysfunctional horticultural value chains can be improved by upgrading wholesale market infrastructure, as was done in Dhaka, Bangladesh (ADB, 2019a). Dhaka's inner-city wholesale markets are located in restricted locations; among the problems they face are a lack of space and poor peripheral infrastructure (inadequate parking areas, unsanitary facilities, absence of on-site cold storage). Recommendations to solve these infrastructural issues in the long term highlight the need to relocate the wholesale markets to the outskirts of the city and upgrade them with services related to phytosanitary inspection and certification, traceability, laboratory analysis, e-auction, banking, catering and restaurants, and price information (ADB, 2019a).

BOOST MANAGEMENT SKILLS AND PROMOTE COST-EFFECTIVE INFORMATION AND COMMUNICATIONS TECHNOLOGIES

The ability of SMEs to innovate or upgrade depends on the characteristics of the linkages between the various actors in the value chain. These linkages may facilitate or inhibit the formation of collaborative relationships between enterprises, both vertically (between firms at

different levels of the value chain) and horizontally (among firms at the same level of the value chain, for example in the form of cooperatives or associations). Strong horizontal and vertical relationships promote the development of SMEs and enhance the competitiveness of value chains. Research into high-value horticultural chains in Guatemala found that effective group governance and the dissemination of market information can strengthen horizontal relationships. The use of cost-effective information and communication technology can facilitate and promote the participation of farmers in producer groups; the use of such technology reduces the costs of managing producer groups and decreases the likelihood that group leaders engage in fraudulent behavior (Dunn, 2014). Specific recommendations include:

- build databases to provide technical information relating to production and marketing to all players in the supply chain;
- develop low-cost, innovative methods to share information (using mobile phones, radios and computers);
- design innovative mechanisms to encourage farmers and SMEs' participation in value chains and innovation; and
- foster innovative partnerships between the public sector and private actors, including producers, to provide effective training in business management and organization.

PROMOTE COMPLIANCE WITH FOOD SAFETY AND QUALITY STANDARDS

Many developing countries are increasingly shifting their policy objectives towards improving food safety and quality. This shift is likely to have adverse side effects. For consumers, increasingly stringent food safety and quality standards may increase the relative prices and therefore impact the affordability of produce, while smallholders may be excluded from the food system due to their inability to meet the new standards. It is crucial to develop instruments that protect the population against food safety hazards without affecting income generation and employment opportunities. Viet Nam is one of the countries currently facing this challenge. More than 80 percent of the food in the country is retailed on traditional wet markets (IFPRI, 2020), where food safety is particularly problematic. In 2011, a new Food Safety Law entered into force. This law provides a modern framework for food safety management; it sets a single standard for both exported and domestically sold food to replace the low standards prevailing in wet markets. The new requirements create both challenges (as reflected by the occurrence of food scandals, miscommunication and public mistrust) and advances (the improved quality and safety of food). The successful implementation of the new regulations requires capacity building across government levels to ensure the adoption of a risk-based approach

to implementation, along with a carrot-and-stick approach that includes rewards and penalties for (non)compliance.

Geographical Indications (GI) are an interesting example of voluntary quality standards based on the geographical origin of food. The registration of a GI helps preserve local varieties of fruits and vegetables by protecting the name and reputation of the product; success in this respect crucially depends on the guarantee system established by the association of growers that manages the GI (FAO and EBRD, 2018). Examples of GIs for fruits or vegetables are Futog cabbages in Serbia, Violet de Galmi onions in Niger (FAO, 2012b), Devanahalli pomelos in India (Marie-Vivien, 2010), Limon de Pica lemons in Peru (FAO and IICA, 2008) and mandarins of the Neretva Valley in Croatia (Vandecandelaere, 2014), to mention a few.

BOX 3. Participatory guarantee systems

Participatory guarantee systems (PGSs) are an alternative to third-party certification that is gaining relevance in developing countries, where it helps differentiate organic products from conventional ones. PGSs are attractive because of their local nature and their reduced costs compared to third party certification. They serve as a basis for the development and dissemination of knowledge and experience on organic production. In Namibia, fraudulent claims were made about the organic quality of food as a result of weak institutions. Producers and consumers therefore proposed to establish a PGS; consumers wanted to be able to make informed purchasing decisions on the basis of product labels, while producers wanted to differentiate their products from conventional ones. A widespread community including retailers, farmers' markets and consumers was involved in the overall strategy. Vegetables, fruits and spices are the most prominent products in the scheme. For PGSs to work, it is important to have a strong demand from the market for healthy products, a great deal of commitment from pioneer farmers and long-term institutional support (FAO and INRA, 2017).

INTRODUCE PROGRAMMES FOR GENDER-INCLUSIVE UPGRADING

Studies of global value chains in horticulture show that upgrading often creates job opportunities in preparation and packaging, where female employment is most concentrated (Barrientos, Dolan and Tallontire, 2003). Such jobs allow women to enter the workforce without the need to

own land or financial assets. The fact that agricultural production does require such assets constitutes a significant challenge in developing countries – hence the need for innovative approaches to boost the participation of women in the workforce without requiring assets.

A study into the production of vegetables in Honduras showed that the increased participation of female producers lowered exporters' financing costs, as the women's late credit repayments were virtually zero, compared to the much higher rates of men (World Bank, 2013; Chan, 2010). This finding offers an argument in favour of investing in female-led SMEs as part of gender-sensitive efforts to upgrade value chains.

Although these examples are drawn from export-oriented industries, efforts to upgrade (post-harvest) industries oriented towards the domestic market in an inclusive manner may explore the same opportunities. The gap in the access to education, training and employment opportunities between men and women may be tackled by introducing internship programmes in universities and enterprises, setting up research and development centres and creating financial support mechanisms for female entrepreneurs.

BOX 4 . Female participation in horticultural production systems

The cultivation of fruit and vegetables may provide more opportunities for employment creation and income generation for both farmers and landless rural labourers (and especially female labourers) than the cultivation of staple crops. Indeed, the low levels of mechanization and the high level of care required by fruit and vegetable production as compared to staple crop production result in a higher demand for female labour (Schreinemachers, Simmons and Wopereis, 2018). Furthermore, in Niger, Cambodia, and Viet Nam, profits per hectare of vegetables were found to be 3 to 14 times higher than those per hectare of rice (Joosten et al., 2015). Given that increased incomes for women may impact positively upon the nutrition outcome of their children, boosting women's participation in the vegetable production system may offer an indirect pathway to improve nutrition, especially for children.

Specific policy recommendations to boost the gender inclusiveness of horticultural production systems include:

- document regional variations in the constraints and opportunities for women in the horticultural sector;

- emphasize research on women's participation in small-scale production; and

- prioritize comparative research into the gender dimensions of horticultural production and marketing for domestic and export markets.

PROMOTE SHORT FOOD VALUE CHAINS OR SHORT FOOD CIRCUITS (SFVC/SFC)

Smallholders operate mostly in domestic markets; they are often less competitive than their larger-scale counterparts. Short food value chains or short food circuits (SFVC/SFCs) are an alternative type of food system that offers new options as regards the link between producers and consumers and distribution channels (ECLAC, FAO and IICA, 2015). The dynamics of SFVC/SFCs vary depending on the specific socio-cultural and economic conditions of the location. They can stem from producers' initiatives (such as farmers' markets and open-air food fairs, which build on consumers' desire to engage directly with producers), or they can be promoted by government programmes (e.g. public food procurement).

According to Parker (2005), proximity – either geographical or organizational – is a defining characteristic of these short circuits; it constitutes a basis for a collective construction towards a new vision and identity for food production and consumption. The proximity implies conscious relationships wherein both types of actors assume active roles in decision-making related to the production and provision of food (Renting, Marsden and Banks, 2003).

The second most important characteristic of these innovative food chains is the renewed definition of food quality, whereby conventional attributes (physical characteristics such as freshness, size and colour) are expanded to integrate features such as tradition, identity, culture, sustainability or localness. As a result, the locally specific identity of food is reinforced (Renting, Schermer and Rossi, 2012). Smallholders benefit from the increased diversity of the productive system; they capture a larger share of added value and enjoy more stable incomes as a result of the long-term links with consumers. Meanwhile, local communities benefit from the conservation of non-material assets such as cultural identity and heritage. Consumers benefit from the typically lower prices in SFVC/SFCs; these are also the outlets – together with wholesale markets – where most of the traditional, local varieties are offered, with positive health effects. According to ECLAC, FAO and WHO (2015), all markets channels that fall under domestic value chains for fruits and vegetables can be considered forms of SFVC/SFC. Innovative channels such as e-commerce or home delivery by producers or on-site consumption (agro-tourism) are also categorized as SFVC/SFC.

Evidence suggests that traditional retail outlets, including open-air markets, local grocery stores and neighbourhood stores encourage a greater consumption of fruits and vegetables among consumers. Hence, promoting these traditional outlets – whose share in overall food sales is declining worldwide − is key to improve diets.

Wholesale markets are highly important in domestic supply chains for fruits and vegetables. They could therefore serve as vehicles of transformation − if organizational and governance issues can be tackled, and additional services can be provided. Cunha (2014) proposes three ways to upgrade wholesale markets:

- implement projects to improve logistics capacities and infrastructure (e.g. cold chain infrastructure);
- turn markets into hubs of information about production, product origins and prices, both for producers and consumers; and
- dedicate space on markets to promote produce grown using organic or agroecological production methods.

Whatever the type of retail outlet, there is a need to improve production practices, strengthen logistics infrastructure and capacities, boost marketing skills and foster the creation of collaborative networks of actors; as such, new institutions, based on consumers' confidence, can be built. SFVC/SFCs do not compete with global value chains, but are rather complementary marketing channels that help build resilience of local food systems.

BOX 5. The Mexican Network of Organic Markets

An example of a short food value chain is the Mexican Network of Organic Markets (Red Mexicana de Tianguis y Mercados Orgánicos), created by 26 farmers' markets from 15 states to strengthen the organic movement. These markets are more than just spaces for commercial exchanges; they are places where consumers can support producers who apply sound environmental and social practices to preserve local resources, knowledge and traditions. To attract consumers, the markets organize free cultural or social activities that promote the exchange of experiences on food, health, the environment and mobility. These activities provide an opportunity for communication and learning between producers and consumers. Most of the products offered on these markets are fresh fruits and vegetables, followed by prepared food (Santacoloma, 2016).

DEVELOP NATION-WIDE POLICY INSTRUMENTS AND PROGRAMMES

In many countries, there is a lack of both national and regional coordination between policies affecting the horticultural industry; this lack hampers the development of the sector. Governmental and other policymaking bodies must proactively develop a coordinated multisectoral approach to ensure coherence between sector-specific and general interventions. Attention should be paid to ensure that the strengthening of economic activities goes hand in hand with a greater inclusion of smallholders and improved environmental sustainability.

The previous paragraphs addressed policy implications that are specific to different stages of the value chain. The overarching challenge is how to balance the different goals and entry points to ensure inclusiveness and sustainability across the chain – in other words, to boost the supply and demand of fruits and vegetables whilst ensuring equal access to these products for consumers, and an equitable division of income between suppliers.

Solutions must be found for net-exporting countries that suffer from a deficit in the availability and affordability of fruits and vegetables on the domestic market. One policy option is to require retailers and institutional buyers to source a minimum percentage of their fruits and vegetables locally. Other measures could aim to improve the proximity of fresh fruits and vegetable outlets, for example by introducing street markets or street food vendors, especially in low-income areas. Such measures would need to be accompanied by adequate (nutrition-sensitive) social protection measures to ensure that fruits and vegetables not only become more physically available, but also more affordable (FAO, 2020c). This would ultimately help ensure the inclusion of poorer consumers in value chains. Examples of measures include cash transfers (the most common type of measure), as well as in-kind food transfers, voucher schemes and school meals programmes. Multiple studies have shown that cost reductions through coupons, vouchers, discounts or loans can positively affect consumer demand and consumption of healthy foods (Glanz and Yaroch, 2004) Comprehensive economic pilot research in the United States of America examined the use of price incentives to promote the consumption of fruits, vegetables and other healthy foods among food stamp recipients. The study found mean price elasticities of 0.70 for the demand for fruits, and 0.58 for the demand for vegetables; hence, a 10 percent reduction in the price of these foods can be expected to increase purchases by 7 percent on average for fruits, and by 5.8 percent on average for vegetables (Andreyeva *et al.*, 2010). In the United States, changes in prices alone would probably not increase the consumption of fruits and vegetables to the levels recommended by FAO/WHO (Hood, Martinez-Donate and Meinen,

2012). Nevertheless, the impact of small price changes accumulates across the entire population; their impact on the actors in the supply chain should therefore not be underestimated. In addition to these measures, governments may use economic policies, including taxation, to promote healthy living and, as a part of that, the consumption of fruits and vegetables (FAO and C-POND, 2017).

Aid for Trade is a WTO-led initiative that seeks to mobilize funds for investments that upgrade developing countries' supply and trade capacities. Aid for Trade is an appropriate instrument for investing in fruit and vegetable industries because of the programme's broad remit: it deals not only with the development of agricultural production, but also with internal and cross-border transportation, storage, technology and infrastructure (Thow and Priyadarshi, 2012).

Efforts to upgrade fruit and vegetable value chains, improve their sustainability and boost the availability and accessibility of fresh produce must be developed in a country-specific manner; indeed, each country's food system is unique, and countries face different challenges for inclusiveness at different stages.

In order to obtain the necessary information for policymaking, the following actions should be considered:

- Identifying and analyzing the challenges faced by the (urban and rural) horticultural industry, including compliance with food safety regulations, product certification, access to credit, the inadequacy of infrastructure, etc.;

- Analysing selected indigenous horticultural crops and varieties for their nutritional properties;

- Examining the impacts of soil type, the use of fertilizers, post-harvest operations and food processing on the mineral content of foods;

- Identifying public policies that may promote the development of efficient and competitive markets, and assessing how the access of especially small farmers and women to those markets can be improved;

- Analysing the impacts of subsidies, tariffs, quotas and trade agreements on both developed and developing nations;

- Developing and implementing intellectual property rights frameworks that protect a nation's rights to equitable profits from the use of their genetic resources, and encouraging research and development of those resources.

5.

CONCLUSIONS AND RECOMMENDATIONS

Only 5 percent of all vegetables produced worldwide, and 9 percent of fruits, are traded internationally. Hence, most of the fruits and vegetables that are needed to meet recommended consumption levels must be sourced domestically. The analysis of the trends in the net availability of fresh produce over the past 50 years shows that current production levels do not meet the recommended consumption requirements (except in certain countries). Low productivity, food losses, poor post-harvest management, inadequate logistics and marketing infrastructure and climate change are among the factors that hinder the development of the potential of the horticultural sector. Meanwhile, low-income consumers worldwide face challenges related to the affordability of fruits and vegetables (FAO, 2020c). The prices of fresh produce are comparatively higher than those of processed foods, and food environments are usually not conducive to the consumption of fruits and vegetables by poor consumers. At the same time, rapid urbanization and the emergence of a middle class with growing disposable incomes in LMICs boosts the demand for healthy foods, thus offering an opportunity for the sustainable development of the fruit and vegetable sector. Policies reshaping value chains should aim at improving efficiency while at the same time ensuring the inclusion of poor and vulnerable actors (including consumers) into the chain, as well as the environmental sustainability of production.

Examples of the successful development of export-oriented value chains, such as in Chile and Kenya, provide interesting lessons for the development of both international and domestic supply systems. First, governments prioritized and actively supported the horticultural sector. They created institutional frameworks to foster public-private collaboration, provided funds for investment (for example, to upgrade ports, highways or laboratories), supported research into innovative post-harvest technology or practices (e.g. packaging or cold storage) and undertook extensive skill- and competence-building of producers, labourers and managers (Fernandez Stark, Bamber and Gereffi, 2011). In Chile, this support allowed the fruit and vegetable industry to upgrade based on three main strategies: understanding market needs (as the value chain is buyer-driven), investing in technologies to increase the shelf life of fresh produce, and developing support services (e.g. the provision of packaging or cold chain technology). By 2010, the Chilean fresh produce sector employed more than 450 000 people in production, packaging and processing − equivalent to 5 percent of the country's total labour force (Lopez, 2009).

Developing countries striving to upgrade their horticultural industry face tremendous challenges, including the inadequacy of logistics infrastructure (e.g. roads) to market perishable products efficiently, the lack of regulatory systems for food

safety and quality, and the absence of consistent training programmes to improve labour skills and competences.

In many developing countries, wholesale markets are the main retail outlet for fruits and vegetables. They could therefore serve as vehicles of transformation − if organizational and governance issues can be tackled. They can play a role in logistics systems, be an information hub about production, product origin and prices for both producers and consumers, and promote produce grown using organic or agroecological production methods.

Evidence suggests that short value chains − where fruits and vegetables are sold, for example, on open-air or farmers' markets − encourage a greater consumption of fruits and vegetables among consumers. Together with innovative marketing channels (such as online selling), such outlets strengthen relationships between producers and consumers, thus contributing to more sustainable value chain linkages and healthier diets.

Capacities must be strengthened at all stages of the value chain: the capacity for good agricultural practices and the sustainable management of resources at the production stage, capacities for packing, packaging and primary processing at the post-harvest stage, capacities related to food safety and quality of private and public actors, and commercial and managerial skills at all stages. The improvement of literacy rates would facilitate training efforts.

In short, there are multiple pathways to leverage fruit and vegetable value chains for healthier diets, social inclusion and environmental sustainability. Various forms of collaboration between private and public actors will be required; trade-offs between the objectives are likely.

This paper identifies key areas where interventions would have the largest impact (see Annex 5). It is likely that combinations of interventions are needed to create the necessary enabling environment for market actors to invest and innovate, and thus build sustainable, inclusive value chains that provide healthy food to consumers. There are two overarching recommendations. First, strategic policies for the horticultural sector should include the provision of technical support; they should improve actors' access to inputs, infrastructure and technologies. Second, the development of public-private partnerships is essential to avoid the pitfalls stemming from unilateral solutions whereby either the public or the private sector carries most or all of the burden. Indeed, evidence shows that approaches whereby the private sector and the public sector take the lead in different but complementary functions yield greater results. The private sector should be the driving force in value creation (meeting demand, creating jobs, increasing stakeholder value and minimizing environmental impacts). Meanwhile,

the public sector (including donors and civil society) should be the promoter and regulator of the business-enabling environment (through legislation, the provision of public infrastructure, policymaking, and research and development).

Further detailed research is required in several areas including:

- statistics related to the nutritional value of underused/neglected species, and best practices for their cultivation;
- the gender dimensions of horticultural production for export and domestic markets (e.g. in relation to land rights, access to finance, capacity development or labour conditions), and the impact of women's inclusion on the nutrition of their children;
- the gap between the issuing and the enforcement of food safety regulations;
- policy options to increase the demand for fruits and vegetables through digital solutions and social and technical innovations; and
- the creation of employment along the chain.

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ANNEXES

ANNEX 1. Main production countries for primary fruits and vegetables, in million tonnes, 2018[14]

COUNTRY	PRIMARY VEGETABLE PRODUCTION (MILLION TONNES)	COUNTRY	PRIMARY FRUIT PRODUCTION (MILLION TONNES)
China	551.56	China	243.59
India	128.24	India	98.72
USA	31.74	Brazil	40.05
Turkey	24.18	USA	26.02
Nigeria	16.39	Turkey	23.6
Viet Nam	16.32	Mexico	22.77
Mexico	16.17	Indonesia	20.44
Egypt	15.57	Spain	19.33
Iran (Islamic Republic of)	15.07	Iran (Islamic Republic of)	18.9
Russian Federation	13.71	Italy	18.01
Spain	12.63	Philippines	16.77
Italy	12.3	Egypt	15.15
Indonesia	11.51	Nigeria	11.99
Republic of Korea	9.8	Colombia	11.94
Japan	9.7	Thailand	11.33

Source: FAOSTAT (FAO, 2020b).

[14] Primary fruits include bananas, plantains, oranges, tangerines and mandarins and clementines and satsumas, lemons and limes, grapefruit and pomelo, apples, pears, quinces, other pome fruits, apricots, sour cherries, cherries, peaches and nectarines, plums, strawberries, raspberries, gooseberries, currants, blueberries, cranberries, other berries, grapes, figs, persimmons, kiwi fruit, mangoes, avocados, pineapples, dates, cashewapple, papayas, and nowhere else specified fresh fruits.
Primary vegetables include cabbages, artichokes, asparagus, lettuce, spinach, cassava leaves, fresh tomatoes, cauliflower, pumpkins, cucumbers and gherkins, eggplants, chillies and peppers, green onions, dry onions, garlic, leeks and other alliaceous vegetables, green beans, green peas, green broad beans, string beans, carrots, okra, green corn, mushrooms, watermelons, cantaloupes melons, and nowhere else specified fresh vegetables.

ANNEX 2. Main production countries for major species of fruits and vegetables, in million tonnes, 2018

VEGETABLE SPECIES	GLOBAL PRODUCTION (MILLION TONNES) TOP PRODUCING COUNTRIES	FRUIT SPECIES	GLOBAL PRODUCTION (MILLION TONNES) TOP PRODUCING COUNTRIES
TOMATOES	**182.256**	BANANAS	**115.737**
China, India, USA, Turkey, Egypt		India, China, Indonesia, Brazil, Ecuador	
ONIONS, DRY	**96.773**	WATERMELONS	**103.931**
China, India, USA, Egypt, Iran (I.R.)		China, Iran (I.R.), Turkey, India, Brazil	
CUCUMBERS, GHERKINS	**75.219**	APPLES	**86.142**
China, Iran (I.R.), Turkey, Russian Fed., Mexico		China, USA, Poland, Turkey, Iran (I.R.)	
CABBAGES, BRASSICAS	**69.381**	GRAPES	**79.125**
China, India, Rep. of Korea, Russian Fed., Ukraine		China, Italy, USA, Spain, France	
EGGPLANTS (AUBERGINES)	**54.077**	ORANGES	**75.413**
China, India, Egypt, Turkey, Iran (I.R.)		Brazil, China, India, USA, Mexico	
CARROTS AND TURNIPS	**39.996**	MANGOES[15]	**55.383**
China, Uzbekistan, USA, Russian Fed., Ukraine		India, China, Thailand, Indonesia, Pakistan	
CHILLIES AND PEPPERS	**36.771**	PLANTAINS AND OTHERS	**39.482**
China, Mexico, Turkey, Indonesia, Spain		D.R. Congo, Ghana, Cameroon, Uganda, Colombia	
GARLIC	**28.494**	MANDARINS[16]	**34.393**
China, India, Bangladesh, Rep. of Korea, Egypt		China, Spain, Turkey, Morocco, Egypt	
PUMPKINS[17]	**27.643**	PINEAPPLES	**27.924**
China, India, Ukraine, Russian Fed., Mexico		Costa Rica, Philippines, Brazil, Thailand, China	
LETTUCE AND CHICORY	**27.256**	MELONS, OTHER[18]	**27.349**
China, USA, India, Spain, Italy		China, Turkey, Iran (I.R.), India, Kazakhstan	

Source: FAOSTAT (FAO, 2020b).

[15] Includes mangosteens and guavas.

[16] Includes tangerines, mandarins, clementines and satsumas.

[17] Includes squash and gourds.

[18] Includes cantaloupes.

ANNEX 3. Indicators related to population, production and trade of fruits and vegetables, and availability of fruits and vegetables, per region, 1968–2017

AFRICA	1968	1978	1988	1998	2008	2017
Population (million)	345.280	450.404	596.849	772.437	987.623	1244.222
Rural population	272.305	335.781	417.293	511.006	617.657	727.897
Urban population	75.745	118.054	183.664	267.786	379.488	528.371
Primary veg production (million tonnes)	14.881	19.696	27.965	41.658	61.734	79.552
Primary fruit prod (million tonnes)	31.968	41.788	48.978	65.681	83.304	108.511
Total primary f&v production (million tonnes)	46.849	61.484	76.943	107.339	145.037	188.063
Vegetable exports (million tonnes)	0.287	0.272	0.277	0.687	1.328	2.623956
Fruit exports (million tonnes)	1.790	2.233	1.857	2.938	4.525	6.730506
Vegetable imports (million tonnes)	0.072	0.097	0.158	0.200	0.583	1.514566
Fruit imports (million tonnes)	0.143	0.152	0.129	0.250	0.942	1.330753
Balance imports-exports of f&v (million tonnes)	-1.862	-2.257	-1.848	-3.174	-4.328	-6.509
Total available supply (million tonnes)	44.988	59.227	75.095	104.165	140.709	181.554
Daily available supply of f&v per person per day (kg)	0.357	0.360	0.345	0.369	0.390	0.400
ASIA	**1968**	**1978**	**1988**	**1998**	**2008**	**2017**
Population	1 995.769	2 496.097	3 040.940	3 643.663	4 117.572	4 519.040
Rural	1 535.578	1 852.898	2 097.312	2 311.250	2 325.437	2 286.705
Urban	456.060	635.754	938.438	1 324.508	1 777.207	2 217.724
Primary veg production	105.717	139.878	224.119	382.889	649.475	826.458
Primary fruit production	72.269	94.302	141.312	248.426	389.421	489.516
Total primary f&v production (million tonnes)	177.986	234.180	365.431	631.315	1 038.896	1 315.974
Vegetable exports (million tonnes)	0.774	1.133	2.220	4.276	11.312	14.136
Fruit exports (million tonnes)	2.498	3.674	3.793	5.013	11.951	18.376
Vegetable imports (million tonnes)	0.678	1.225	2.470	4.187	8.212	12.449
Fruit imports (million tonnes)	1.704	3.225	4.210	6.786	11.817	20.876
Balance imports-exports of f&v (million tonnes)	-0.890	-0.357	0.667	1.684	-3.233	0.812
Total available supply (million tonnes)	177.097	233.824	366.098	632.999	1035.663	1316.786
Daily available supply of f&v per person per day (kg)	0.243	0.257	0.330	0.476	0.689	0.798

NORTH AMERICA	1968	1978	1988	1998	2008	2017
Population (million)	226.581	249.238	274.300	305.324	336.953	361.942
Rural population	60.913	65.209	68.413	66.011	65.843	65.054
Urban population	165.819	184.367	206.396	239.835	271.064	296.153
Primary veg production (million tonnes)	22.276	25.361	27.004	34.441	36.855	34.421
Primary fruit prod (million tonnes)	20.132	27.338	29.056	35.245	31.434	27.483
Total primary f&v production (million tonnes)	42.409	52.700	56.060	69.685	68.289	61.905
Vegetable exports (million tonnes)	0.572	0.826	0.809	2.159	2.838	3.224
Fruit exports (million tonnes)	0.730	1.521	1.938	3.002	3.599	3.682
Vegetable imports (million tonnes)	0.962	1.935	2.575	4.721	6.693	10.235
Fruit imports (million tonnes)	2.495	3.520	4.779	7.134	9.340	12.327
Balance imports-exports of f&v (million tonnes)	2.154	3.107	4.608	6.694	9.595	15.656
Total available supply (million tonnes)	44.563	55.807	60.668	76.380	77.885	77.561
Daily available supply of f&v per person per day (kg)	0.539	0.613	0.606	0.685	0.633	0.587
LATIN AMERICA	**1968**	**1978**	**1988**	**1998**	**2008**	**2017**
Population (million)	248.468	345.548	393.450	506.621	577.963	636.233
Rural population	89.763	128.433	130.661	129.626	128.183	113.580
Urban population	152.785	220.012	298.890	114.713	455.039	519.250
Primary veg production (million tonnes)	9.899	14.476	20.295	29.836	37.630	45.803
Primary fruit prod (million tonnes)	41.468	55.177	74.790	95.053	117.707	132.910
Total primary f&v production (million tonnes)	51.367	69.653	95.085	124.888	155.337	178.712
Vegetable exports (million tonnes)	0.524	1.225	1.906	4.483	6.944	9.365
Fruit exports (million tonnes)	5.068	6.385	8.652	14.474	20.793	26.548
Vegetable imports (million tonnes)	0.096	0.194	0.159	0.891	1.378	1.358
Fruit imports (million tonnes)	0.544	0.696	0.578	1.711	2.357	3.019
Balance imports-exports of f&v (million tonnes)	-4.952	-6.719	-9.821	-16.355	-24.002	-31.535
Total available supply (million tonnes)	46.415	62.933	85.264	108.533	131.335	147.178
Daily available supply of f&v per person per day (kg)	0.512	0.499	0.594	0.587	0.623	0.634

EUROPE	1968	1978	1988	1998	2008	2017
Population	692.137	740.654	780.336	726.142	733.417	745.415
Rural	270.274	256.246	250.990	212.245	201.623	191.115
Urban	422.411	485.234	530.294	515.405	532.852	550.959
Primary veg production	69.102	86.317	92.626	83.098	89.387	93.915
Primary fruit production	84.868	89.480	95.108	74.069	78.700	76.001
Total primary f&v production (million tonnes)	153.970	175.797	187.734	157.167	168.087	169.916
Vegetable exports (million tonnes)	3.030298	4.22974	6.288616	9.538427	13.67568	18.467753
Fruit exports (million tonnes)	4.553341	6.081227	7.352112	12.445669	16.685358	22.120534
Vegetable imports (million tonnes)	3.233225	4.433222	6.848948	11.131523	17.392296	20.267926
Fruit imports (million tonnes)	9.790325	12.608927	14.937024	20.883609	32.06706	38.347659
Balance imports-exports of f&v (million tonnes)	5.440	6.731	8.145	10.031	19.098	18.027
Total available supply (million tonnes)	159.410	182.528	195.879	167.198	187.186	187.943
Daily available supply of f&v per person per day (kg)	0.631	0.675	0.688	0.631	0.699	0.691
OCEANIA	**1968**	**1978**	**1988**	**1998**	**2008**	**2017**
Population	19.503	22.592	26.435	30.607	35.561	41.007
Rural	5.748	6.503	7.762	9.494	11.311	12.960
Urban	13.114	15.885	18.445	20.908	24.069	27.731
Primary veg production	1.272	1.765	2.250	3.011	3.283	3.315
Primary fruit production	3.060	3.338	4.481	5.653	7.053	8.141
Total primary f&v production (million tonnes)	4.331	5.103	6.730	8.665	10.336	11.456
Vegetable exports (million tonnes)	0.017276	0.043941	0.238947	0.478665	0.42495	0.520267
Fruit exports (million tonnes)	0.255522	0.182992	0.455142	0.781633	0.860423	1.255719
Vegetable imports million tonnes)	0.013628	0.015186	0.023253	0.041935	0.071567	0.087917
Fruit imports (million tonnes)	0.054263	0.075872	0.104276	0.163089	0.226347	0.269029
Balance imports-exports of f&v (million tonnes)	-0.205	-0.136	-0.567	-1.055	-0.987	-1.419
Total available supply (million tonnes)	4.126	4.968	6.164	7.609	9.349	10.037
Daily available supply of f&v per person per day (kg)	0.580	0.602	0.639	0.681	0.720	0.671

WORLD	1968	1978	1988	1998	2008	2017
Population	3 551.599	4 304.534	5 145.426	5 984.794	6 789.089	7 547.859
Rural	2 265.947	2 645.071	2 972.430	3 239.633	3 350.052	3 410.074
Urban	1 285.933	1 659.306	2 176.127	2 749.214	3 439.719	4 140.189
Primary veg production	223.148	287.493	394.258	574.932	878.364	1083.464
Primary fruit production	253.766	311.423	393.724	524.126	707.619	842.562
Total primary f&v production (million tonnes)	476.913	598.916	787.983	1 099.058	1 585.983	1 926.026
Vegetable exports (million tonnes)	5.204432	7.72961	11.739313	21.621797	36.522144	48.336954
Fruit exports (million tonnes)	14.89576	20.077658	24.047461	38.654079	58.413575	78.712757
Vegetable imports (million tonnes)	5.054599	7.898342	12.23515	21.172668	34.329958	45.912979
Fruit imports (million tonnes)	14.731112	20.278654	24.73686	36.9275	56.749331	76.663864
Balance imports-exports of f&v (million tonnes)	-0.314	0.370	1.185	-2.176	-3.856	-4.473
Total available supply (million tonnes)	476.599	599.286	789.168	1 096.883	1 582.127	1 921.553
Daily available supply of f&v per person per day (kg)	0.368	0.381	0.420	0.502	0.638	0.697

ANNEX 4. Comparison of yields of primary vegetables, per region, tonnes per hectare, 1968–2018

	1968	1978	1988	1998	2008	2018
AFRICA	6.76	7.48	8.40	8.62	9.64	9.10
ASIA	9.97	11.44	13.47	15.24	18.82	20.04
EUROPE	13.95	16.87	18.18	19.19	22.67	25.20
NORTH AMERICA	15.36	17.97	21.67	24.79	30.26	33.12
OCEANIA	11.56	14.50	14.50	17.18	20.27	19.11
SOUTH AMERICA	8.28	10.88	12.70	14.02	15.52	17.18
CARIBBEAN	6.39	7.35	7.91	7.65	9.59	11.98
CENTRAL AMERICA	8.49	12.03	13.11	14.74	17.15	21.69

ANNEX 5. Key recommendations

PRIORITY AREAS FOR POLICY AND PROGRAMME DEVELOPMENT	
SUSTAINABLE PRODUCTION SYSTEMS	
Increase the domestic production of fruits and vegetables in rural, urban and peri-urban settings.	Due to the perishable nature of fruits and vegetables, horticultural production should preferably occur near consumers. This implies a focus on domestic production (including in urban areas) for domestic consumption.
Enable farmers' access to high quality varieties and seeds.	Ensure farmers' access to high quality seeds of species and varieties that are adapted to local conditions and to consumers' tastes.
Develop programmes to support the production of traditional fruits and vegetables, including neglected and underutilized species (NUPs).	Develop research programmes and provide institutional support to guide and provide inputs for the production of traditional and neglected and underutilized fruits and vegetables.
Promote good agricultural practices.	Promote the uptake of modern techniques and technologies to increase production and ensure the optimal use of resources and inputs, including greenhouses, precision irrigation and fertigation, wireless control of tools and machines, drones (e.g. to monitor crop damage), biotechnology, propagation of planting material through in-vitro techniques, automation and robotics, etc. Promote alternative production systems (e.g. agroforestry) to move away from monocropping and increase biodiversity, and thus take advantage of the interactions between different species.
POST-HARVEST OPERATIONS	
Develop and disseminate appropriate post-harvest technologies, and develop capacity related to post-harvest practices.	Help small-scale farmers improve basic infrastructure and technology (e.g. packing houses, cold storage, etc.). Improve on-farm hygiene and packing practices. Build capacities related to cold chain management. Develop platforms for post-harvest innovation.
Develop food safety protocols and quality standards for fruits and vegetables.	Improve extension services providers' understanding of exposure to pesticides, agrochemical residues in and (phyto)sanitary conditions of marketed produce, and help them determine high-risk areas for potential intervention. Develop participatory training programmes to help farmer groups implement good agricultural practices (GAP) and good handling practice (GHP) to meet the standards of domestic and export markets. Develop simple low-cost rapid assays and monitoring methods for pesticide levels and microbial contamination at the wholesale level.
Strengthen research and development institutions.	Research and recommend inputs for the production of high-quality produce. Research the processing of fresh fruits and vegetables, and their market potential. Ensure that agricultural extension and rural health services research and collaborate on the main constraints to the production, processing and marketing of indigenous, neglected/underutilized species and varieties. Develop farmer-friendly maturity indexes and other harvesting tools and methods. Establish grading, sorting and packing protocols for different commodities.

MARKET LINKAGES	
Invest in infrastructure.	Invest in electricity as the basic prerequisite for production, post-harvest storage and processing of high-value commodities. Build collection centers near or at production areas, equipped with sorting, grading, packaging, sanitation and storage facilities. Build or upgrade roads from farms to consolidation/storage/market centers. Invest in processing facilities with suitable processing and packaging technology and sanitation systems, allowing them to meet food safety and quality standards. Invest in equipment and training for minimal processing, to provide consumers with produce that is easy to prepare and consume. Equip markets with good storage and sanitation facilities.
Improve access to information to enable market access, process upgrading and coordination between actors.	Develop low-cost and innovative methods to share information (e.g. using mobile phones and radios). Build databases to provide technical information on production and marketing to all players in the supply chain. Establish regional information networks on post-harvest management and loss reduction. Build knowledge centres providing reliable data on trade and prices and on consumers' purchasing habits.
Strengthen producer organizations (POs).	Increase smallholders' bargaining power in food value chains and control over their economic environment by improving regulations related to POs, involving POs in policy consultations and research programmes, and co-financing operational funds.
Develop and improve compliance with standards.	Help smallholders produce products with specific qualities that can generate income and respond to consumer expectations, while at the same time preserving traditional practices and knowledge and promoting biodiversity.
Promote short food value chains/short food circuits (SFVC/SFC).	Study and upgrade local and regional (in)formal markets both in rural and urban areas. Improve smallholders' access to agro-services, infrastructure and price information. Ensure a stable demand for smallholders' output, for example through public procurement programmes for public institutions, food assistance and school feeding. Upgrade and foster linkages between producers and wholesalers.
Build skills and competences.	Boost the productive, managerial and commercial capacities of smallholders, SMEs and their organizations, with a special focus on women and youth. Provide education and training (particularly to youth) and use mentorship programmes to improve smallholders' practices and knowledge, strengthen entrepreneurship, innovation and marketing in value chains, and make agriculture more attractive.
FOOD ENVIRONMENT	
Improve the community food environment.	Boost the number of outlets that prevalently sell fruits and vegetables (e.g. open-air traditional markets, farmers' markets, small produce stalls and informal vendors), especially in low-income areas.
Improve the consumer food environment.	Make fruits and vegetables more available, affordable and desirable in outlets where people buy or consume food.
GENDER	
Analyse regional variations in the constraints and opportunities for women in the horticultural sector; Analyse opportunity gaps in education and employment for women, and develop programmes that enable women to enter into traditionally male-dominated segments of value chains. Prioritize comparative research into the gender dimensions of horticultural production and marketing. Invest in financial mechanisms to support female entrepreneurs.	

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ISBN 978-92-5-134718-8
CB5720EN/1/07.21