CoSAI
Commission on Sustainable Agriculture Intensification

Potential of urban and peri-urban agriculture in the Global South: Priority investments for innovation

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Executive summary

Cities[1] are highly visible centers of mass consumption of food and vast excretion of waste; they are less often associated with the production of food. Yet closer observation of cities in the Global South reveals that they are also locations of food production. This report describes the major challenges affecting crop cultivation and animal raising as well as food consumption in and around cities, where many households are poorly fed, negatively affected by unsustainable urbanization processes, and threatened with a warming and disease-prone world. It asks whether urban agriculture can mitigate these challenges, how it is affected by them, and if, indeed, it may exacerbate them. These questions demand a detailed consideration of the definitions of urban agriculture, especially between agricultural activities within the built-up environment and peri-urban agriculture conducted on the edge of the city and in the surrounding areas. Both of these are included in our analysis of urban and peri-urban agriculture (UPA).

There is mounting evidence about changing urban demand and supply of different food products, the nutrition implications, and the extent to which UPA might satisfy existing and future urban food demand. Across a number of studies there is a convergence in showing that, on the one hand, there are serious imbalances in the existing urban food systems that affect nutritional health; and on the other, that non-trivial areas of land within urban clusters and immediately surrounding them are currently being used for crop production, an important proportion of which produces food which could nourish significant numbers of city dwellers. Out of all the world's irrigated cropland, 11% lies within urban clusters of 50,000 people or more, and a further 30% lies in 10 km buffer zones around these.

Given the size of urban populations, even the amount of food that can be produced on these substantial areas of land may not be sufficient. Among some authors of global assessments there is pessimism about the capacity of urban and peri-urban cropland to feed urban populations, and this pessimism appears to be a response to an extensive literature on the need for localization of food systems for food sovereignty and sustainability. There are grounds to challenge the pessimism: while UPA can only supply a part of urban demand, it has the capacity to produce a range of different nutritious foods, and there is evidence that greater resilience in urban food systems comes with a diversity of food sources. Local production that satisfies, for example, 15-30% of urban food demand is therefore a glass half full, not half empty.

Collecting the evidence from global and national studies

The authors of global assessments all recognize limitations of their approach. Most have tried to identify through their data broad variability between regions, for example in the importance of urban irrigated cropland in Asia compared to Africa. But they also acknowledge considerable variability within regions which they are unable to capture. The same problems exist even where the minimum unit of analysis is the country, which masks variability between cities in each country. Variability between urban areas affecting local food production or the costs of longer value chains may be due

[1] The word city is used throughout this report to indicate an urban settlement (see Introduction).

to geography, demography, local trade networks, infrastructure, storage, processing or policies – factors that can only be captured via a finer-grained analysis. The authors also recognize the way that the kinds of resolution used in global land use assessments tend to exclude small areas of urban food production such as backyard gardens, roadsides and railway embankments, which results in an underestimation of the vegetable and fruit production that are common in these spaces. Furthermore, all of the studies recognize the absence of consideration of urban and peri-urban livestock and aquaculture production and distribution.

As well as the variability across cities, there is also variability in the importance of UPA as an income source within cities, varying from the inner urban core to outer peri-urban areas. The evidence also indicates that agriculture is almost always one of several income sources. Situating UPA within the employment context of the city region food system draws attention to the participation of producers and vendors in different types of short and long food supply chains. Informal food marketing is hugely important as a source of income in the Global South, but also unstable and vulnerable, which was underlined in many countries during the COVID-19 pandemic.

There is a clear recognition that peri-urban food production will be negatively affected by urbanization through land conversion. Another challenge resulting from urbanization is the increasing competition for water between agriculture and urban uses. The dependence of the large areas of irrigated cropland in urban and peri-urban areas on surface water is likely to become more precarious as urban water needs for domestic, commercial and industrial uses expand. Large areas of this irrigated cropland within urban areas also depends on wastewater: an estimated 35.9 million hectares, or 65% of all irrigated urban cropland. An estimated 29.3 million hectares of that is located in countries with low levels of wastewater treatment. Given declining water resources in urban areas, the expanded use of wastewater for food production in urban areas may evolve from being an opportunity for farmers (coming with free nutrients and organic matter) to being a necessity for city region food systems. The main challenges, then, will be to ensure the safety of the food produced in these areas; the occupational health of the producers themselves; and adequate regulation of what is, at present, mostly informal irrigation.

This is just one way that UPA has the potential to contribute to urban resilience – recovery and productive reuse of urban wastewater. As part of a movement away from the unsustainability of the linear energy in/waste out model of city functioning towards a circular bioeconomy, there is increased attention not only to wastewater reuse but also municipal solid waste reduction and recovery. Reduction of waste throughout food value chains is a key response, and beyond this, a wide range of options exist for recovery and reuse of municipal solid waste, including reuse as animal feed, crop nutrients and soil improvers, and municipal composting. Composting has a huge potential, but so far the evidence suggests that only a small amount of municipal solid waste is being recycled as compost, owing to a number of constraints, including challenges involving public–private partnerships.

There is also evidence that UPA contributes to climate change mitigation and adaptation. Mitigation occurs mainly through the provision of a ‘productive’ urban sink through green spaces and especially through urban forestry. The reduction of long food supply chains with corresponding reduced emissions from transport, cooling, packaging and other energy saving on transporting food over long distances is another mitigation effect. These savings can be further increased through synergies in energy use between local industry and agriculture. UPA also contributes to climate adaptation through

several ecosystem services, especially provisioning services that provide food security and poverty reduction while also increasing city resilience through a more diversified food supply. Other ecosystem services provided by UPA that contribute to climate change adaptation include water filtration and flood regulation, acting as buffer zones against building encroachments in vulnerable landscapes and micro-climate modification, especially important for reducing the heat island effect in cities. There is also evidence of a contribution to conserving biodiversity in urban and peri-urban areas. Climate change threatens UPA through higher nighttime temperatures, extreme rainfall and flooding events, soil erosion and droughts.

Innovation investment priorities

In this report we profile numerous opportunities for investment in UPA-related innovations, which we locate within the context of food systems, including the food environment, consumption behavior, supply chains, waste issues, as well as the policy and institutional environment. That environment – which involves municipal governments and their vertical relations with higher levels of government as well as horizontal relations with other local authorities, civil society and the private sector – is a critical area for innovation.

Local governments should be concerned with '3i' innovation: in infrastructure/technology, in incentives, and in incubation. These include both senses of innovation, as new soft and hard infrastructure, technologies and practices, and also as new multistakeholder processes of incubation and scaling. There is a need to invest in both innovative physical and institutional infrastructure – like new kinds of green markets – to increase sustainability, efficiency and equity. There is need to invest in technical innovations along the value chain, including production, marketing, processing and storage. Incentive structures are also a kind of institutional innovation, including capacity building, social inclusion and financial reconfigurations, so as to involve different stakeholders in supporting, investing in and practicing urban food production, processing and marketing. There is also a need to invest in innovation as part of a process, from niche proof-of-concept activities to supporting more widespread uptake through business incubation and scaling activities, recognizing that financial support will be needed over a certain time in different types of food-related enterprises before they become viable and independent.

Some of the key areas of innovation relate to developing institutional infrastructure across city regions through multistakeholder engagement. Examples of good practice, available from several regions, offer lessons on:

- The value and importance of institutional innovation alongside innovative technologies and practices
- The need for both investors and stakeholders to devote sufficient time to build new institutional infrastructure
- The importance of cross-sectoral engagement and partnership
- The importance of participatory approaches to consultation and decision making
- The development of national food policy frameworks
- The identification and facilitation of development brokers
- The need to address information fragmentation – information on food issues located with different agencies or offices – and gaps to improve decision making.

A second area of policy action involves protecting and boosting UPA through innovative policy actions protecting agricultural land and water access and facilitating uptake of specific technologies, including food system mapping, agritourism and innovative approaches to peri-urban zoning and finance.

Investments can contribute to improved access to healthy foods and decent work through two sets of innovations: market repositioning and agro-enterprise. As part of the city region food system, UPA is intimately connected to marketing and consumption of food within the city, as well as the situation of precarious urban employment in the food sector. A high priority for investment should be in food market innovations, which offer double benefits. Through repositioning wet food markets and public procurement processes of institutional markets like schools, hospitals etc to better link with urban and peri-urban producers and to be promoters of healthy food and decent employment, there is a chance for city authorities, in collaboration with the millions of workers in the informal food sector, to reposition the urban food system itself toward healthier food and away from high-sugar, high-fat convenience foods. Market repositioning includes decentralization of large centrally located markets; diversification of types of markets to include, for example, green markets closely tied to producers; and upgrading to improve access and facilities, especially for women.

Meanwhile, UPA can contribute to making city regions more resilient through a safe, climate-responsive, circular bioeconomy. A holistic approach to the circular bioeconomy begins with innovative reduction of losses and waste in the food supply chain through better digital coordination between producers and vendors, better storage and processing, as well as nudging consumer behavior towards accepting blemished but healthy produce and away from over-ordering in restaurants or over-purchasing for the home. Many options have arisen for investing in innovative ways to recover and reuse food wastes that are generated, such as processing as feedstock for insect rearing or swine raising, turning it into compost or bio-fertilizer, or for use in specialist food production such as mushrooms. A high priority for investment must be in testing and scaling the safe use of wastewater for irrigation, given the increasing competition for water in many parts of the Global South. Finally, there is much potential to invest in innovative ways to strengthen and expand the different types of ecosystem services that UPA can provide to cities, for example to maximize the capacity of cultivated plots to filtrate water and reduce flooding threats, or the synergies and increased resilience that can be obtained from higher levels of cultivated and animal biodiversity.

1. Introduction

Food is readily visible on any visit to a large or small city in the Global South. Fresh fruits and vegetables are purchased from vendors at street corners, while pavement customers eat bowls of noodles and stir-fried vegetables from small roadside food stands. On almost every street and alleyway, canteens and small restaurants are serving customers from dawn to late at night. The widespread impression is of the city as a vast consumer of resources, especially food – "a massive food court", as a recent book on urban food systems in Asia puts it (Acharya et al. 2020) – and a huge evacuator of waste.

Less conscious in the urban imagination, and less visible, is the role of the city and its immediate surroundings as a food producer. If one looks carefully in back streets, in vacant lots and near railway tracks, it is possible to see different kinds of vegetables, maize and root crops being cultivated. Mango, papaya and banana trees are dotted around gardens; cows and chickens graze in compounds; goats rummage in garbage. Farther away from the city center there may be larger vegetable fields, piggeries and herds of goats, and in Asia, rice growing on the edge of the city. In other words, food in all its aspects, from planting and animal raising to the plates of food consumed in urban kitchens, is a defining feature of cities. Yet food production and consumption in cities is entwined with at least four existential, global challenges:

1. **A poorly fed world.** More than 800 million people are still hungry[2] and some 300 million of them are in urban areas (Cohen and Garrett 2010). At the same time, changing food cultures in urban areas are also creating an epidemic of obesity and ill health through increasing consumption of processed food with high content of sugars, fats and salt (Popkin et al. 2012). Meanwhile, one-third of all food produced for human consumption is lost, most in urban food supply.
2. **An unsustainably urbanizing world.** Two-thirds of the global population will be urban by 2050, compared with less than a third in 1950. Most of that transformation has occurred in the Global South, which was 15% urban in 1950.[3] As much as 70% of the urban population may now live in small and medium urban centers and surrounding rural areas (Berdegué et al. 2014). There were just over a billion urban slum-dwellers in 2018, 80% in Asia and sub-Saharan Africa; slums account for the major component of urban growth.[4]
3. **A warming world.** Since 1980 there has been 200% increase in urban exposure to extreme heat (Tuholske et al. 2021) and a quadrupling of flooding events increasingly affecting urban areas (EASAC 2018).
4. **A disease-prone world.** Increasing (mainly urban) demand for meat products and high density, mobile urban populations contribute to growing incidence, virulence and rapid spread of zoonotic diseases such as COVID-19.

Can agriculture in cities of the Global South mitigate these challenges? Can it survive them? Do agricultural processes exacerbate them? Much of the large literature on urban agriculture and food

[2] https://sustainabledevelopment.un.org/sdg2
[3] https://population.un.org/wup
[4] https://unstats.un.org/sdgs/report/2019/Goal-11

systems ('agri-food systems'[5]) tries to answer these questions, and does not always come to the same conclusions. Part of the reason for this is the variation in types of urban agriculture in each particular location, and part is due to the variable conditions across the geographies, economies and socio-political and physical environments of different cities. So before it is possible to consider how urban agriculture is linked with these different challenges – as victim, as part of the problem or as part of the solution – it is necessary to consider what we mean by urban agriculture.

Much of the meaning of the term is linked to the spatial aspects of cities, the density of construction, the availability of small open spaces, the presence of backyards and rooftops, and where the urban ends and the rural begins. Definitions of urban and the delimitation of a city are notoriously diverse (Weeks 2010; Dijkstra et al. 2019). Across authors and countries, different criteria are used and therefore different estimates are generated. Whilst recognizing this variability, this study cites many of these different estimates in order to build up a picture of the challenges facing urbanization and how investment in urban and peri-urban agricultural innovations can help address those challenges.

Cities are constantly changing, but there has been a long struggle between the desire for planned change by (urban-based) national and local governments and the organic changes 'informally' brought about by the choices and actions of millions of urban actors (Scott 1998). Most modern cities have a built-up urban core and gradually expanding, less densely populated outer urban periphery connected in a multiplicity of ways to the core, and beyond that reduced but still important linkages with the rural hinterland. 'Urban agriculture' has been defined in many ways. A thoughtful, broad definition was provided by Mougeot (2000) that identifies it as 'located within (intraurban) or on the fringe (periurban) of [an urban area] which grows or raises, processes and distributes a diversity of food and non-food products, (re-)using largely human and material resources, products and services found in and around that urban area, and in turn supplying human and material resources, products and services largely to that urban area' (Mougeot 2000: 10). The emphasis of the definition is the integration of agriculture with the urban ecosystem, meaning both ecological and economic processes, including urban land management (informal and formal), urban development and especially urban food systems. Mougeot also notes the connectivity with rural agriculture, although his urban ecosystem-based definition clearly distinguishes it from rural agriculture. What Mougeot calls "intraurban agriculture" includes several sub-types, including backyard and rooftop gardens; community gardens; small-scale animal raising, including fish; small-scale vegetable plots, such as on roadsides or beside railway lines; institutional gardens attached to schools, prisons, "third age" housing, etc.; and larger commercial plots (Lee-Smith et al. 2020). This variation is mostly determined by scale, but also subsumes economic (subsistence or market objectives) and organizational elements (household versus community or institutional production).

The term "periurban" included in Mougeot's (2000) definition can also include various types of agriculture, including many of those mentioned by Lee-Smith et al. (2020), though a combination of larger commercial plots and small- or medium-scale livestock raising predominate. Peri-urban is a complex concept that has received greater definitional attention in recent years. It includes the key elements of the peripheral and the transitional and the gradually reducing set of linkages with the city. As a book on this peripheral zone describes it, the peri-urban is an interface with the urban that

[5] This concept, which is adopted in this report, seeks to highlight a focus on food and people often lacking in ecological literature and a focus on agro-ecosystems, often lacking in food focused literature (Pingali et al. 2005).

experiences the immediate impacts of the city, in terms of land demands, labor demands, pollution and so on, but extends to areas that mainly experience a market-related influence, especially in terms of the handling of agricultural and natural resource products (Simon et al. 2006). This definitional understanding is further elaborated in a recent paper (Simon 2021), which emphasizes the dynamic processes involved by using the idea of "periurbanization". This process leads to the temporary and changing creation of an interface around an urban area that varies in composition and rate of change, as the leading or outer edge of the interface moves outwards into rural areas at a different rate from that of the inner edge, where the intense change pressures rapidly lead to it effectively becoming urban or suburban. Taking together the diversity of urban agricultural and food system practices and the mostly larger-scale crop and animal production and food marketing in peri-urban areas, this study adopts the term and acronym 'urban and peri-urban agriculture' (UPA) to refer to this complex set of practices, and sometimes 'urban and peri-urban agri-food systems' when emphasizing the point made by Mougeot (2000) about integration with the urban ecosystem. At particular points in the paper specific types of agriculture within UPA will be highlighted.

Mougeot's definition also included connectivity with rural agriculture, and this aspect has also received considerable research attention over recent years. The types of linkages that connect the inner edge of the peri-urban as well as the outer edge and more distant rural areas to the urban core have been studied in terms of rural–urban linkages (Satterthwaite and Tacoli 2002). Important elements of those linkages relate to food, whether it is the marketing of food products, the outward flow of inputs for food production, the mobile labor involved in food production and food marketing or the contaminants associated with these processes, which are systemically interrelated. The important set of linkages involving food supply to cities also stimulated the formulation of the concept of the foodshed (Kloppenburg et al. 1996). Modeled on the idea of the watershed, which nourishes whole tracts of downstream territory as water drains into lowland rivers, the foodshed is the agricultural space that feeds the city. Cities are in fact fed by multiple foodsheds of varying sizes and involving different types of food (Karg et al. 2016). Urban and peri-urban agriculture are major tributaries of different types of foodsheds, as will be discussed in later sections.

A distinct elaboration from the idea of rural–urban linkages has been the notion of the city region food system, which is a useful framework to understand urban food security, employment in the informal food sector, generation and recovery of food-related organic wastes, the interconnections with climate change processes and the critical issue of governance arrangements and actions that affect how the city region food system functions (RUAF and FAO 2015; Blay-Palmer et al. 2018). Both foodsheds and the city region food system approaches in the literature will be explored in this study to understand the importance of UPA and opportunities for investment.

After describing methods used for this literature review in Section 2, Section 3 examines some global trends relating to the changing food demands of urban populations and changing food supply, especially in terms of the size of crop foodsheds needed to satisfy demand. This section also looks at global estimates of the prevalence of UPA, at least in terms of cropland in and around urban clusters. For example, how much land would be needed within urban space to satisfy the actual demand or recommended levels of consumption of vegetables? What is the total area of cropland within and immediately around urban clusters currently available, both rainfed and irrigated? These studies provide grounds for optimism, in relation to the extent of cropland available, but also indicate that UPA cannot satisfy even 50% of global urban demand. The conclusion is for modest optimism in terms

of a significant but not predominant contribution to urban food supply, and also an alert about the vulnerability of cropland to urbanization processes.

In Section 4, the paper reviews urban and peri-urban-level assessments in terms of evidence for the contribution of UPA to food supply, food security and employment, both directly in production and via participation in short and long food value chains. To what extent does UPA contribute to individual, household and community food security? Is it a significant livelihood option for women, men and/or youth, either through the production and sale of agricultural products, or through different types of marketing of those products? This involves consideration of literature on the urban informal sector, particularly the very large component of that sector that involves food. This section also considers evidence about the impact of UPA on the resilience of cities in the face of climate change, through the provision of short food supply chains, through resource recovery and reuse as part of the circular bioeconomy, and through the provision of ecosystem services. Relevant to all of these issues is the question of how enabling or disenabling the national and urban policy and institutional environment are within which urban and peri-urban agri-food systems function, and the paper examines different literature on that issue.

In light of the evidence provided by the literature, Section 5 considers high-potential types of innovation that, with investment, can increase the resilience of cities and city regions. Institutional and policy innovation is central to this agenda, and this is the first area of innovation to be considered, in relation to both urban and peri-urban agri-food systems. Section 5 continues with a consideration of innovations in relation to the conservation of peri-urban land and water for agriculture, and the need for specific technological innovation. In relation to agriculture within urban areas, a greater focus is suggested on protecting and expanding urban spaces for cultivation, both as a contribution to food security and to the environmental conditions of cities. Section 5 then considers priority innovation and investment opportunities in markets and marketing and in relation to climate change mitigation and adaptation, especially through solid and liquid waste reduction, recovery and reuse, and through better understanding of the ecosystem services deriving from UPA.

2. Methods

The topic of urban and peri-urban agriculture has become an increasingly popular topic of academic and developmental interest across many fields and regions. A Google Scholar search using the term agriculture AND urban OR peri-urban for their appearance anywhere in the article yielded 3.7 million hits. For occurrences in the title, it yielded 4,800 hits. But as the Introduction made clear, there are other terms – urban and city region food systems, urban organic waste recovery, food systems governance and so on – and there are many other fields that engage with the issue of UPA. The present study does not claim to be an exhaustive review of this very large literature. It is necessarily partial and narrative. It has also benefited from literature recommendations from expert colleagues. It has proceeded primarily using combinations of keywords and snowballing from bibliographies of selected or recommended articles.

Based on this process, 326 articles were identified and reviewed, distributed across 15 categories: global studies; resource recovery; employment and markets; agricultural intensification; policy institutions; food systems/foodsheds; food and nutrition/diets; health risk; climate change; informal sector; urban agriculture and gender; multifunctionality; general practitioner; and multi-thematic studies.

3. Global assessments of changing urban food demand and prevalence of urban and peri-urban food production

To determine the current health, economic and social importance of agriculture within and around cities, the level of its contribution to urban resilience and its potential for the future through strategic investments, it will be helpful to step back from the roadside cultivations, the backyard animal raising and the peri-urban vegetable patches and consider the global picture. What do we know about changing urban demand for food in the global population? How much agricultural land exists within and in close proximity to urban areas and how much of urban demand can it potentially feed now and in the future? How much agricultural land is disappearing to urban development? As a food production and distribution system, UPA is able to help address two interconnected major challenges posed by the existing global food system:

- The global system's delivery of inadequate diets that are leading to both under- and over-nutrition in the global population, and especially the almost 60% of the population now living in urban areas.
- Agriculture's runaway contribution to increasing carbon emissions through industrial production practices, long value chains and linear processes that generate large amounts of waste destined for landfills or to accumulate in the landscape.

If UPA can in principle contribute to reducing these unsustainable processes, how much can it contribute?

There is no lack of advocates for the contribution of UPA to address these challenges, through food sovereignty linked to localization of food systems and presented as antidotes to high-tech solutions offered by industrial agriculture (Whatmore et al. 2003; Chaifetz and Jagger 2014). But this paper recognizes the importance of complementing such studies with large-scale data on cropland and water availability in relation to the food demands from urban populations and also on current global food flows, markets and even dietary preferences. Projecting into the future, increasing urbanization, growing competition for land and water, increasing temperatures and other climate change effects, as well as a changing policy and institutional environment, will all influence the feasibility of, and demand for, urban and peri-urban food supply.

3.1 Changing food consumption patterns and the nutrition transition

Recent assessments of global food consumption suggest that there is sustained growth in overall demand for food in the Global South, based largely on rapid population growth relative to the Global North (EU 2015). The biggest changes have been in consumption of vegetable oils, driven by their increased use in food preparation among even low-income households with increased food expenditures (Popkin 2012), but also linked to their growing use in biofuels. The consumption of meat has been increasing in the Global South too, leading to some writers referring to the "Livestock Revolution" (Delgado 2003). A large part of the overall growth has been driven by high population

increase, for example in Africa. Per capita consumption has been variable between regions, between types of meat and through different time periods. Large increases in meat consumption in the Global South seem to be mainly driven by China and other middle-income countries, with African countries, India and other low-income countries continuing to have low consumption and very gradual growth over recent decades (Godfray et al. 2018). Consumption over time is variable in different periods, for example when economic crises like the Asian economic crisis of 1997-2000 reduce consumption (EU 2015). Growth in consumption of chicken has been consistently greater than other meats and above population growth levels (EU 2015; Godfray et al. 2018).

Although these studies do not differentiate between rural and urban growth, given that the overwhelming proportion of population and income growth over the past 50 years has been in urban populations, increased demand for and consumption of fats and meat is mostly happening in urban areas. The most dramatic shift toward urban settlements as the new 'center of gravity' of food systems has been in Africa, driven by massive urban population growth, the expansion in the numbers of megacities and secondary cities, and evidence of dietary shifts, with meat accounting in 2011 for up to 30% of urban food expenditures (AGRA 2020). The growth in demand for processed food products is more dramatic still. A recent study on urbanization and the food trade identifies these types of foods as disproportionately represented in the growth of food imports into low- and middle-income countries (Vorley and Lançon 2016). A 2014 study indicated that urban demand for processed food across Bangladesh, Indonesia, Nepal and Vietnam averaged a remarkable 73% of food expenditure, with highly processed foods comprising 42% (Reardon et al 2014).

This is also the message in the literature surrounding the nutrition transition (Popkin and Ng 2007; Popkin 2012). The nutrition transition refers to shifts in dietary and physical activity patterns (mostly increased sedentarism), which are reflected in nutritional and health outcomes, such as changes in average stature, body composition, obesity rates and significant increases in nutrition-related non-communicable diseases (Popkin 2012). Popkin emphasizes the fact that these processes are closely associated with urbanization, and he provides a detailed analysis of the "perfect storm" leading to obesity: the body's biological susceptibility for, and vulnerability to, sugars and fats; the rise of a food industry successfully mass-marketing exactly those products in the form of beverages and processed foods; and the mostly sedentary lifestyle of the urban population, exacerbated by the wide availability of mass media entertainment.

The widespread availability of high-fat, high-sugar processed foods and beverages in urban diets can be contrasted with the inadequate supply of vegetables and fruits (Siegel et al. 2014; Mason-D'Croz et al. 2019). The Siegel et al. study found that, on average, the global supply of vegetables and fruits falls 22% short of requirements, based on 2009 data.[6] Supply gaps are worst in low-income countries, with a median supply gap of 58%. When the effects of food waste are considered, the deficit increases to 63%. Projections to 2025 and 2050 indicated a worsening supply gap in low-income countries of 70% and 65% of vegetable and fruit needs respectively. The authors also note that urban populations in low-income countries may be even more threatened with supply gaps in vegetables and fruits than rural populations because of transportation difficulties. Mason-D'Croz et al. (2019) analyze data to

[6] Based on WHO-assessed need on the consumption side, and FAO Food Balance Sheet data on the 'formal' production side. Subsistence production of vegetables and fruits, and vegetables and fruits informally produced and traded – such as occurs in much of the production in urban and peri-urban areas – are not included in the FAO data.

2010 and also make projections between 2010 and 2050. They also identify significant current deficits and draw attention to the projected situation in sub-Saharan Africa. Projections for that region suggest that between 800 million and 1.9 billion people could be living in countries where average availability of fruit and vegetable will be below the World Health Organization (WHO) cut-off level of 400 g/person per day, even on optimistic socio-economic growth scenarios. They also find the situation considerably worse when food waste is considered. These findings clearly underline the importance of increasing diverse sources of fruit and vegetable supply for urban populations.

Growing recognition of the link between urban population growth and the negative consequences of the nutrition transition has stimulated increased research and policy attention to nutrition and food systems in urban settings. The Global Panel on Agriculture and Food Systems for Nutrition (2016) identifies the growth of urban populations, urban diets and vulnerability to food price volatility as one of the six drivers of the global nutrition crisis, noting the challenge of leveraging the potential access of urban populations to fresh, nutrient-dense foods. Dury et al. (2019), in their discussion of nutritional risks, also note the evidence that the benefits of improved access to macro-and micronutrients in urban settings, and thus the decrease in under-nutrition, is currently being outpaced by consumption of high-fat, high-sugar, high-sodium processed foods. Two papers by Tefft et al. (2018; 2020) represent collaborative efforts by the World Bank and Food and Agriculture Organization (FAO) to focus attention on the increasingly important part of the global food system involving urban and peri-urban populations. They note the need to transition from a focus on feeding the world's population to understanding and influencing the quality of food consumed in urban settings and the employment associated with the urban food system. They identify "three overlapping and rapidly evolving segments or channels of the urban food system" with implications for nutrition and health:

- a **traditional channel** focused on urban wholesale markets, open or wet retail markets and small, family-run retail stores
- an **informal channel** providing services to the urban poor through informal food vendors and small restaurants, and including different kinds of informal and formal safety nets
- a **modern channel** involving wholesale, food safety systems, capital-intensive food processing, cold chains, food servicing businesses, high-quality logistics, branding, packaging, modern retail outlets and restaurants.

It is questionable how useful it is to differentiate between 'traditional' and 'informal channels'. A similar issue was debated in the early 1970s, when the idea of the informal sector was being formulated as an alternative understanding of employment in the developing world to the prevailing dichotomy between 'traditional' and 'modern' employment (ILO 1972; Hart 1973). That debate resulted in the abandonment of the 'traditional employment' concept in favor of the concepts of the informal and formal sectors. The issue of the importance of the informal economy in general and the informal sector in particular in relation to food marketing and the urban food system will be discussed in Section 4.2.

3.2 Food production, distribution and the global climate

Through detailed analysis of the value chains that deliver standard household food baskets, it has been possible to calculate the cost of externalities created by 'food miles' – the distance that food travels from the primary producer to the consumer (Lang and Heasman 2004; Pretty et al. 2005). Over a 20-year period from the late 1980 to the early 2000s, the amount of food being transported on British

roads increased by 30% and the distance traveled increased 60%. Combined with production externalities and perverse subsidies, these increased the cost, at a conservative estimate, of the weekly UK food basket by just under 12%, equivalent to GBP 8.045 billion per annum for the average of the years 1999-2001 (Pretty et al. 2005). This significant amount corresponds to the carbon footprint of the intensive production techniques, packaging and predominantly long value chains of the UK food system.

High carbon footprint production systems, especially the energy component, packaging and long value chains, are common characteristics of the global food system (Litskas et al. 2020; Kinnunen et al. 2020). Although a recent study by Crippa et al. (2021) suggests that transport accounts for about 5% of total food system-related anthropogenic greenhouse gas emissions, with the majority coming from agricultural land use and land use change, this still accounts for just under a gigaton of carbon dioxide per year and increases with more bulky agricultural produce. So, understanding and reducing long value chain emissions where possible remain important elements of climate change mitigation.

One way to address that question at a global level is to examine the potential minimum distance that food needs to travel to satisfy food demand. In other words, how much of that demand can be satisfied with more local food resources, thus reducing the environmental costs of long value chains. One study of this type estimated that 22-28% of the global population can satisfy its demand for temperate cereals (wheat, barley, rye), rice, tropical cereals (millets, sorghum) and pulses within a 100 km radius (Kinnunen et al. 2020). For maize and root and tuber crops, the range was found to be 11-16%. The more detailed estimates for the different crop foodsheds for different regions show more variation. The largest foodsheds are for temperate cereals, especially those supplying consumers in Africa, but rice, which is a widely traded food commodity, also showed a large foodshed. Maize and cassava showed a large number of smaller foodsheds, reflecting more dispersed global production patterns and enabling more localized access to supply by consumers. Another issue of importance for emissions from long value chains is transport infrastructure, for example the quality of roads affects road transport emissions.

Although changes in production technologies and consumption preferences can potentially decrease greenhouse gas emissions and waste and increase local food supply, Kinnunen et al. (2020) point to the potential vulnerability of concentrating high levels of production within local areas close to consumers. The vulnerability can result from shocks and stresses in the local environment as well as through threats to urban sustainability from agricultural pollution and competition for water. These authors suggest that the most resilient food systems are those that are the most diverse – sourcing food both within small local foodsheds as well as via bigger foodsheds with long value chains. Diversification of agri-food systems is an issue that will be discussed in later sections.

3.3 Responding to urban nutrition and environmental challenges with urban food production

A body of recent research has concentrated more specifically on urban food systems and on the quantities of nutritious food that can be produced within or close to urban clusters, providing better nutritional access at less environmental cost. The issue can be tackled in different ways, and two studies published in 2014 approach the issue via a focus on actual and recommended nutritional needs (Martellozzo et al. 2014), or via a focus on existing agricultural cropland (Thebo et al. 2014).

Focusing on the estimated global consumption of vegetables, a crop type already associated with UPA production, Martellozzo et al. estimate how much urban land would be needed to satisfy current vegetable consumption levels, or to provide the FAO/WHO recommended minimum daily intake of 300 grams. Using a conservative measure of "urban land area" (contiguous areas with more than 50% of the land built up), they estimate that, on average, 30% of urban land would be needed to satisfy "actual" demand. But widely different population densities across urban clusters in different countries lead to very wide variation in urban area required to satisfy vegetable consumption. Eleven countries cannot satisfy actual vegetable consumption with the available urban land, including Nigeria and Gabon in West/Central Africa and Laos and the Philippines in Southeast Asia, whereas 22 countries would need less than 10% of the urban area to do so, including several countries in South America and Southern Africa. Using the recommended measure of producing 300 grams/person, only nine countries require less than 10% of urban land area to produce sufficient vegetables, all in the Global North, and 51 countries would be unable to meet this recommendation with urban production, especially countries in West, Central, East and Southern Africa and in Southeast Asia.

Given the importance of population density in determining the urban land needs to satisfy vegetable demand, small and medium urban clusters emerge with higher potential. Approximately 50% of the global urban population is now living in urban clusters smaller than 500,000 inhabitants, and these tend to have lower population densities. However, as will be seen when the issues of urban governance are discussed, having sufficient urban land to theoretically satisfy vegetable demand does not mean that the land will be used for that purpose. Urban land use access and practices are complex, and subject to competition for use and to political interventions. This also means that using countries as the minimum unit of analysis is problematic, since land use practices will vary considerably between urban clusters.

An alternative approach is to empirically estimate the available irrigated and rainfed cropland within and immediately surrounding urban clusters which contributes to urban food needs (Thebo et al. 2014).[7] Focusing on crop production means dealing with a range of both food and non-food crops and thus is not exclusively focused on urban nutritional needs.[8] As well as examining the areas of cropland within urban clusters, Thebo et al. also calculate cropland in peri-urban areas of 10 km and 20 km surrounding urban clusters. The study was unable to consider either livestock or aquatic production.

Using the GRUMPv1 Settlements points (CIESIN et al. 2011) for identifying urban extents[9] of over 50,000 in population and the MIRCA2000 dataset of global monthly irrigated and rainfed crop areas around the year 2000, Thebo et al. (2014) identify 67.4 million hectares of urban cropland, that is, cropland within those urban extents, making up almost 6% of the global total. Almost 24 million hectares of irrigated cropland were identified within urban extents, which is 11% of the global total of 214 million hectares (Figure 1). Nearly 47 million hectares of rainfed cropland was identified in urban areas, which is 5% of the global total of 932 million hectares. The conclusion is that some type of

[7] Of course, not all of the food produced within and around urban clusters will be consumed there. Some will be reexported to other cities and even other countries. At the global scale, these issues were not examined, but they are discussed in later sections.

[8] These authors analyze 26 crop types produced in urban and peri-urban environments, including staple and 'other' annual food crops, oilseeds and industrial crops.

[9] From a remote sensing perspective, urban extent refers to the built-up area.

cropland is almost always present in urban areas, with 98% of the identified urban areas having some rainfed and 87% having some irrigated cropland.

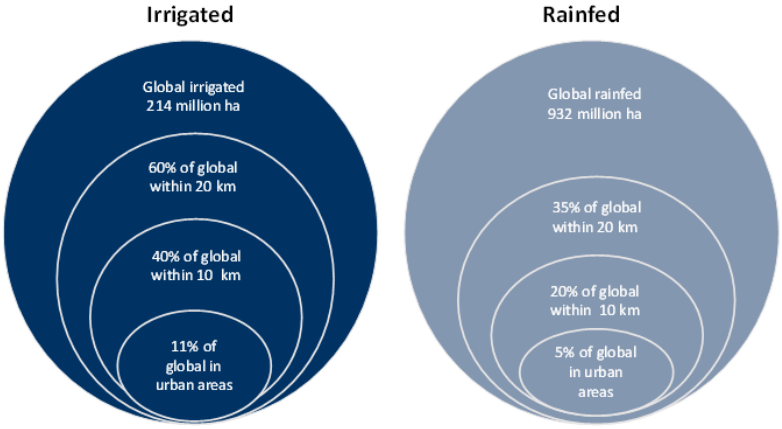

Figure 1. Urban and peri-urban cropland as a proportion of global cropland.
Source: Thebo et al. 2014.

When the peri-urban buffer areas of 10 km and 20 km radius are included in the estimates, it is clear that a very large part of global irrigated cropland is included within and immediately surrounding cities. The 40% of all irrigated land lying within the 10 km radius represents almost 90 million hectares of prime agricultural land on the doorstep of urban centers.

Thebo et al (2014) also identified considerable regional variation, confirming contrasts between Asia and Africa. Particularly striking was the importance of irrigation in urban Asia, accounting for 49% of all urban irrigated land, with rainfed less important (26% of all urban rainfed). Urban irrigated cropland in Asia accounts for 6% of global irrigated land, about 13 million hectares, with 17% or about 36 million hectares within a 10 km radius of Asian cities (Figure 2). There are almost 50 million hectares of irrigated land, almost a quarter of the global total, within a 20 km radius of Asian cities. Rainfed urban cropland is less significant as a proportion of the global total, mainly because rainfed agricultural land is widely distributed in temperate regions as well as in Africa and the Americas. Irrigated urban cropland in Africa accounts for less than 1% of the urban irrigated total and only about 3% of urban rainfed. Latin America accounts for about 10% of global urban irrigated and about 7% of rainfed cropland.

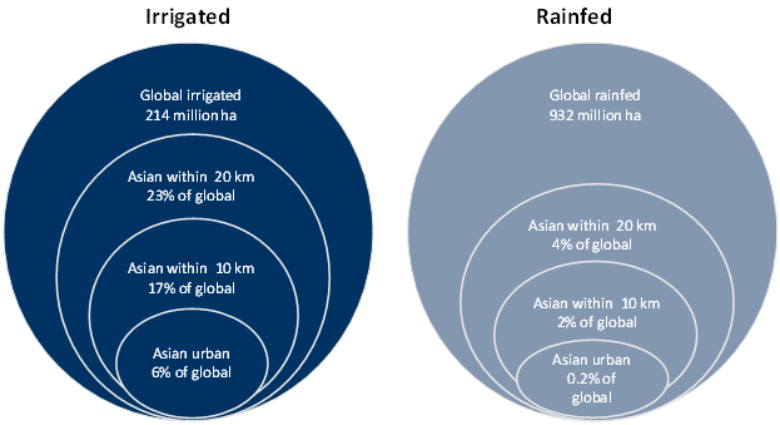

Figure 2. Urban and peri-urban cropland in Asia as a proportion of global cropland.
Source: Thebo et al. 2014.

Overall, rice, wheat and maize were found to be the major crops grown under irrigation in urban extents, accounting for 62% of annual harvested area. Wheat, maize and fodder grasses were the main crops on rainfed urban lands, accounting for 40% of annual harvested area. Higher crop diversity was found in rainfed systems compared to irrigated systems within the urban extents. Despite the predominance of these mostly staple food or feed crops in the proportion of global urban area planted, a category of 'other' annual crops predominated in terms of the number of regions where they were one of the top three crops. This was especially the case in irrigated cropland. This category of 'other' annual crops includes especially vegetables and some root and tuber crops.

Almost certainly the area of both irrigated and rainfed urban cropland described in this study is underestimated. Thebo et al. (2014) acknowledge that because of the spatial resolution adopted, they have not captured small areas of cultivated land such as backyard gardens, roadsides and riverbanks. Since the small plots are known to be often planted with vegetables, root and tuber crops, maize and fruits, it is likely that these crop types are also underestimated in the study. This is important when considering the potential role of these croplands as accessible sources of local nutrients. By identifying the importance of irrigated cropland in urban settings, especially in Asia, they also highlight a looming threat in the future: competition for water between agriculture and the growing urban domestic, commercial and industrial demands.

Whereas the combined use of settlement and cropland databases provides an illuminating understanding of UPA production at the global level, the consumption side is missing. Using the same settlements database with a more recent data source on cropping (ESA 2016), and supplementing these with other agricultural and diet datasets, a recent study has assessed the potential of UPA to make cities more sustainable through nourishing urban populations with a small carbon "foodprint" (Kriewald et al. 2019). The study focuses on peri-urban areas because of their larger potential impact, but also because of the difficulty of identifying and quantifying agricultural production within urban clusters. The authors select urban clusters[10] of 100,000 population or more, yielding 4,100 urban clusters globally, accounting for 71% of the world's urban population in 2010. The study calculated that 63% or 2.15 million km^2 of total peri-urban land areas around urban clusters was farmland, which

[10] The term urban cluster refers to a central core and adjacent densely settled territory with a defined population threshold.

accounted for 8.5% of all arable land in 2010. This is quite close to the figure of 2.72 million km^2 estimated by Thebo et al. (2014) for the urban and peri-urban area with a 10 km radius.

Based on current diets, food production and productivity, Kriewald et al. (2019) estimated that this was sufficient to feed almost a third (30.6%) of all urban residents based on 2010 data. With a maximum yield scenario, this rises to 35.3%. Projecting to 2050, using the maximum yield scenario but modeling the effects of urbanization, climate change and diet change, the authors estimate a reduction to 22% in the proportion of the urban population that could be nourished from peri-urban food production. The paper identifies urban growth as more significant than climate change in the reduced percentage of the urban population theoretically able to be nourished through peri-urban food production, and this is supported by other research. Azadi (2011), for example, confirms the leading role of urbanization in land use conversion and identifies this as most serious in the Global South, where rates of conversion can reach above 800 hectares/day, almost all in peri-urban areas. A more recent assessment, which takes into consideration the existence and expected continuation of "prevailing cropland fractions" within urban areas, estimates that between 27 and 35 million hectares of cropland will be lost through urbanization, mostly at the peri-urban interface, by 2030 (d'Amour et al. 2017: 8940). This highlights the role of urban governance and land use planning in managing urbanization processes to minimize their effect on agriculture.

Considering the pressures on agricultural land created by urbanization and its need for protection, what would be the minimum amount of agricultural land needed to satisfy the entire food demand of global urban clusters? Kriewald et al. (2019) estimate, based on their modeling, that most urban clusters would require a foodshed of 5,000 km^2, which translates to a circle with an 80 km diameter. This is an average estimate for most urban clusters. Geography, the presence of nearby urban centers, the production characteristics of particular foods like fish, and many other factors mean that there is a lot of variability on the ground. The paper also highlights additional potential benefits of local food production, such as the creation of circular food economies involving, for example, the use of city-generated organic wastes as fertilizer or feed. Another benefit can be the reduction of food loss and waste through shortening value chains, with the additional benefit of reducing greenhouse gas emissions. The authors also note potential challenges, especially competition for water from domestic, commercial and industrial users with on-going urbanization. Other authors mentioned above (e.g., Kinnunen et al. 2020) also warn about the potential vulnerability a city would face if it depended primarily on one foodshed.

3.4 Summary and conclusions

This section has considered evidence about changing urban demand and supply of different food products, the nutrition implications, and the extent to which urban and peri-urban agriculture might satisfy existing and future urban food demand. Across a number of studies there is a convergence in showing that, on the one hand, there are serious imbalances in the existing urban food systems that affect nutritional health and, on the other, that non-trivial areas of land within urban clusters and immediately surrounding them are currently being used for crop production, an important proportion of which produces food which could nourish significant numbers of urban dwellers. Irrigated croplands lying within a 10 km buffer zone of urban clusters of 50,000 population or more account for 41% of all irrigated cropland. Even the irrigated area within urban boundaries was found to account for 11% of all irrigated cropland across the world. Yet given the size of urban populations, even the amount of food that can be produced on these substantial areas of land may not be sufficient. One recent macro

study on this topic is entitled 'Local food crop production can fulfil demand for less than one-third of the population' (Kinnunen et al. 2020). This pessimism may be a response to the admirable but idealistic expectations about 'localization' of food systems for food sovereignty and sustainability advocated in some of the literature (Kloppenburg et al. 1996; Hinrichs 2004; Chaifetz and Jagger 2014). Perhaps because of the high expectations for UPA to be found in some of the literature, there may be a tendency for some of the data-intensive assessments discussed above to go in the opposite direction, minimizing the contribution of UPA to urban food security in a glass-half-empty approach.

But the authors of these macro studies all recognize the limitations of their approach. Most have tried to identify through their data broad variability between regions, for example in the importance of urban irrigated cropland in Asia compared to Africa. But they recognize considerable variability within regions which they were unable to capture. The same problems exists where the minimum unit of analysis is the country, which masks variability within countries and between cities, for example in the urban and peri-urban areas needed to satisfy vegetable demand. Variability between urban areas affecting local food production or the costs of longer value chains may be due to geography, demography, local trade networks, infrastructure issues, storage and processing challenges, or policies – factors that can only be captured via a finer-grained analysis.

The authors discussed above also recognize the way that the kinds of resolution used in global land use assessments tend to exclude small areas of urban food production such as backyard gardens, roadsides and railway embankments, resulting in an underestimation of vegetable and fruit production, which are common in these spaces. All the studies recognize the absence of consideration of urban and peri-urban livestock and aquaculture production and distribution. There is clear recognition that peri-urban food production will be negatively affected by urbanization through land conversion (d'Amour et al. 2017; Kriewald et al. 2019). Another challenge resulting from urbanization is the increasing competition for water between agriculture and urban uses. The dependence of the large areas of irrigated cropland in urban and peri-urban areas on surface water is likely to become more precarious as urban water needs for domestic, commercial and industrial uses expand. A study by Flörke et al. (2018) estimates that there will be a 1-6 million m^3 deficit in urban surface water by 2050.

A large amount of existing irrigated cropland within urban areas actually depends on wastewater. A recent study estimated that a total downstream urban cropland of 35.9 million hectares was likely to be irrigated with wastewater (65% of total irrigated urban cropland), and that 29.3 million hectares of this area, home to 885 million urban residents, are located in countries with low levels of wastewater treatment (Thebo et al. 2017). Given declining water resources in urban areas, the expanded use of wastewater for food production in urban areas evolves from being an opportunity for farmers (because of the free nutrients and organic matter it contains) to being a necessity for city region food systems. As will be seen below, the main challenge will be to ensure the safety of the food produced in these areas, the occupational health of the producers themselves and adequate regulation of what is, at present, mostly informal irrigation.

Finally, there are grounds to challenge the pessimism about the extent to which urban food production can satisfy urban food demand. Urban production has the capacity to grow a range of different nutritious foods but can only supply a part of urban demand. But there is also evidence that a diversity of food source increases the resilience of urban food systems, so that if 15-30% of urban food demand can be satisfied from local production, this becomes a glass half full, not half empty.

4. The national and city-level picture: Limitations and opportunities of urban and peri-urban agriculture for food, jobs and urban resilience

To identify more clearly the extent to which different socio-economic groups, women and men and different age groups are currently involved in UPA and what challenges and opportunities they face, it is necessary to move to a more granular level to contextualize the large-scale findings about land area for agricultural production and urban food supplies.

4.1 Urban food security, nutrition and diets: How important is local and regional food production?

Food is the most basic human necessity and our way of securing it has grown steadily more remote over the millennia. From direct provisioning in the Paleolithic period of gathering and hunting a wide diversity of flora and fauna, we mostly passed into a Neolithic period of farming a small number of species of plants and animals. From the "original affluent society" (Sahlins 1974), humans passed to a state of gluts and famines, seasonally and socially, which intensified with the establishment of the first urban settlements (Scott 2017). While the earliest cities established areas of agriculture in their immediate periphery at a time when transport routes from further afield were unstable and easily closed (Mumford 1961), modern cities have depended on a mixture of supply chains stretching farther and farther from the core, even to the extent of banning agriculture within cities altogether (Prain and Lee-Smith 2010).

So, to understand the current and potential future contribution of UPA to urban food security and diets, it is first necessary to recognize that food security is one product of the urban food system which goes beyond UPA. As a critical review of writings on urban food security and agriculture has observed, there is a tendency in some writings on urban agriculture to conflate it with urban food security, as though having access to own food production is a guarantee of food security (Battersby 2013). But Battersby and other writers note that "food security is far broader than urban agriculture … and … urban agriculture is far broader than food security" (Battersby 2013: 456). While agreeing with this point, and recognizing in later sections the multifunctional benefits of UPA which go beyond a contribution to urban food security, it is important to understand the extent to which it contributes nutritionally rich supplementary food to households and what factors limit that contribution, since this is a major incentive for urban and national governments to support and help expand UPA. A first step is to locate UPA within an understanding of urban food systems, often characterized as comprising four key elements (HLPE 2020) (Figure 3):

- **Consumer behavior and diets**, including food preferences, options, preparation and nutritive value and diversity
- **The food environment**, which is the interface between people and the wider food system (Turner et al. 2018) and which includes food availability and physical access to markets or

other food outlets, economic access, how food is promoted or advertised and its quality and safety

- **Supply chains**, meaning the delivery of food from points of production to different kinds of urban outlets
- **The political and policy environment** governing or influencing availability, access and utilization of food.

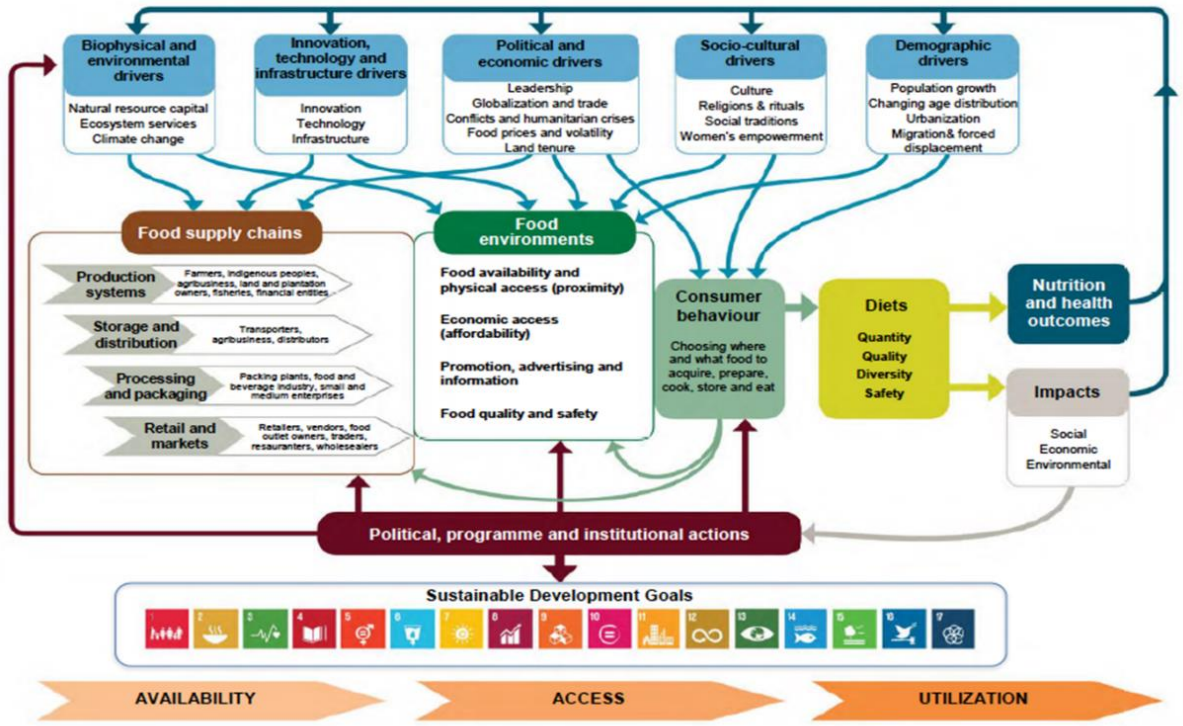

Figure 3. Conceptual framework of food systems for diets and nutrition.
Source: HLPE 2020.

Almost all of the initial thinking about food security and food systems and the poverty conditions that lead to food insecurity in the Global South has been based on the rural context (Amis 2002; Battersby 2013). It was no accident that during the first decade of the twenty-first century, the World Bank organized its major development investments into two vice-presidencies: one for 'Environmentally and Socially Sustainable Development', including rural development, agriculture and food, and the other on 'Infrastructure', with a major focus on urban development. Nevertheless, an important literature – including from within the World Bank – has sought to understand poverty and food security in the urban context. Writers on urban poverty have discussed the way that global poverty is rapidly being urbanized and that levels of poverty in urban areas have been underestimated, primarily because measures of poverty developed in rural areas are not fully applicable in the urban context (Ravaillon et al. 2007).

Cities in the Global South have been described by a UN-Habitat Executive Director as "two cities within one city – one part of the urban population that has all the benefits of urban living, and the other part, the slums and squatter settlements, where the poor often live under worse conditions than their rural

relatives" (UN-Habitat 2006a). This is one reason why mean poverty measures for urban areas often suggest a situation considerably better than rural conditions.

Factors associated with this 'other city' which trap people in poverty and create food and nutrition insecurity include: unstable access to income and employment made worse by spatial factors making mobility difficult and expensive; short-term, low-quality and insecure living conditions; poor or non-existent infrastructure and services such as piped water and sanitation; vulnerability to risks such as flooding, exposure to environmental hazards and health risks particularly associated with living in slums; and finally, the issue of social exclusion and inequality, especially experienced by women, minorities and migrants (Baker 2008). Given these factors, the poverty threshold is much higher in urban areas, and more difficult to escape.

Similarly, writers on urban food security (cf. Crush and Frayne 2010; Battersby 2011; Haysom and Tawodzera 2018) point out that many of the methods developed over several decades to characterize and offer solutions for food and nutrition insecurity in the Global South have been based on research in rural areas, leading to what a number of writers have identified as a food security 'rural bias' (Crush and Frayne 2010). This bias, which appeared even in the FAO Committee on World Food Security in 2006 through the promotion of agriculture-based rural development as the main response to global food insecurity, also consists in focusing strongly on the household as the unit of production and consumption and assuming that improved availability of food from more productive agriculture would reduce household food insecurity (Battersby 2011).[11] The situation is clearly very different in cities and urban settlements, which are characterized by a diversification of income sources in which agriculture may or may not play a part (Rakodi 2002; Kantor 2008; Prain and Lee-Smith 2010) as well as other types of food entitlements, including social safety nets. Furthermore, the unit of production and consumption may not always be the nuclear household. There is a significant presence of transient migrant women and men in urban areas who are among the most vulnerable of the urban population (Frayne 2005). The proportion varies by region and country. From a large sample of migrants recently moved to Shenzhen, China, almost half (47%) were young, single women and men (Wang et al. 2010). There are also multi-generational extended families, including adolescent relatives from natal villages whose rural families seek educational or work opportunities for their offspring through relatives in the city (Gu 2021). For this group, access to food is often through street food vendors and low-cost restaurants. Among those living in nuclear households, men, in particular, frequently eat main meals outside the household (Haysom and Tawodzera 2018).

As well as changes in where people eat under urban conditions, with their implications for food security and nutritional status, there are also changes in food preferences related to greater exposure to processed convenience foods with high sugar and/or fat content. These foods are convenient because of their easier and shorter cooking compared to fresh foods, and can be especially attractive to working women with caring responsibilities and less time for food preparation (Hawkes et al. 2017). These kinds of changes can lead to over-nutrition, obesity and other diseases. So, in considering urban food and nutrition security, these writers argue that there needs to be much greater attention paid to consumption as well as production, and to individual consumption patterns as well as household consumption (Crush and Frayne 2010).

[11] Even in rural contexts, agriculture is not necessarily the primary source of income for food access and now rarely the only source (Ellis 2000; Bryceson 2002; 2019).

The food environment for the poor in urban contexts presents a complex picture. It includes both a personal dimension, including accessibility, affordability, convenience and desirability; and an external dimension, including different kinds of food outlets and direct access to food through UPA (Turner et al. 2018). A major component of the external food environment are wholesale markets and the mostly informal retail wet markets which are very important sources – often the only accessible source – of fresh food, as well as local social spaces (Smit 2020). Such markets also have challenges, in terms of congestion, food safety issues and sometimes insecurity, especially for women vendors and consumers. The urban food environment also consists of very large numbers of street vendors, small kiosks, curbside restaurants and food stalls. Other retail food channels include supermarkets, which are of growing importance in the Global South, especially for processed foods (Ruel et al. 2017), and different kinds of fast-food outlets. These may be international franchises or local brands, often provide high-fat, high-sugar processed foods of different types, and are often supported by widespread advertising (Battersby 2011). This aspect of the food environment has been identified as a particular problem in Asia and the Pacific, where the prices of processed foods and beverages are lower than of fresh foods (Farrell et al. 2021). These can to some extent be categorized into an informal food sector, with more sales of fresh plant and animal products and greater diversity, and a modern sector especially associated with supermarket outlets and processed foods (Ruel et al. 2017; Tefft et al. 2018).[12] Access to these different sources of supply is determined by many factors, including access to land for own production, the physical location of outlets, levels of income for food purchases, as well as taste preferences and susceptibility to advertising and promotions.

Urban food systems are also composed of a wide range of food supply chains. These range from own production in different types of urban and peri-urban plots[13] to the supply of internationally imported foodstuffs, though it is estimated that in the Global South most countries are heavily dependent – up to 90-95% – on domestic supply chains (Reardon 2015). As has been seen, these domestic supply chains can be short, involving food coming from urban or contiguous peri-urban production areas, or long, from the surrounding region or other parts of the country. From the point of view of local food security and nutrition it is important to understand these different supply chains and how they contribute to urban food and nutrition security. This geographical dimension of urban food systems has been characterized in different ways, which is the subject of the next section.

Urban food security in the context of rural-urban linkages and a city region landscape

A solid body of research has demonstrated that the lived reality of low-income, often migrant city dwellers involves a wide range of linkages with peri-urban and rural areas (Satterthwaite and Tacoli 2002; McGregor et al. 2006; Simon et al. 2006; Berdegué et al. 2014). These writers identify three key points on this continuum. It starts at the built-up urban core, which includes the millions living within megacities, but also the approximately 2 billion – according to Berdegué et al. – living in small and medium cities and urban settlements. At the other end of the continuum are the 3.4 billion living in rural settlements according to these authors, the vast majority of whom maintain linkages of different kinds with nearby small urban settlements, small cities or metropolises. Between these two points is an ‘interface’, a dynamic area that is neither urban nor rural. At the inner face of this area urbanizing

[12] Tefft et al. 2018 also propose a ‘traditional’ sector, but following the arguments made by Benanav 2019 on the characteristics of the informal economy, that term is not used here.

[13] UPA is uniquely both part of the food environment (for subsistence producer households and neighbor recipients of produce) and a distinct food supply chain within the urban food system.

processes such as changes in land use and resource extraction are intense, and at the outer face, market linkages gradually change the structure of rural existence (Simon 2021). These linkages embrace flows of people involved in commuting, seasonal and long-term migration; cash and income in the form of remittances and earnings in multiple locations; agricultural inputs and food and other produce between producers and remote households and between producers and markets; information about technologies, markets, neighbors, businesses and politics; natural resource flows; and waste and pollution. In relation to food, it is known that food transfers from rural to urban locations along family networks are widespread (Frayne 2005; 2010; Prain and Lee-Smith 2010; Crush and Caesar 2017).

Important as these food transfers are, bigger flows occur though market channels linking the peri-urban and rural hinterlands with urban consumers. Although the concept of the foodshed was used in some of the global studies discussed in the previous section, at that scale it remains a somewhat abstract concept. On the other hand, at the micro-scale, there are claims about the advantages of short supply chains involving UPA which can better supply urban food needs, resulting in more sustainable urban food systems. But there has been a lack of empirical evidence about how cities actually feed themselves.

An early attempt to address that research gap and to try and understand the differentiated food flows feeding specific urban populations and their nutritional significance documented and analyzed two city regions in West Africa: one around the regional capital of Tamale in northern Ghana and the second around Ouagadougou, the capital of Burkina Faso (Karg et al. 2016). The methodology was based on checkpoint surveys of the road systems bringing food shipments to each case city and official documentation of rail transport into Ouagadougou. In Ouagadougou, not all the short supply chains of urban and peri-urban production were captured because of positioning of the checkpoints. The study found that foodsheds are variable by crop and across seasons, with some foodsheds specific to a single crop, while others supplied multiple crops. For vegetables, a high proportion came from close-by peri-urban areas during the peak season, but from further afield during the lean season. The picture is complicated by the re-export of some vegetables like tomatoes to other destinations, including across borders. This also happens with livestock. The study found that the only food commodities that were exclusively supplied from urban production were traditional vegetables. Apart from a few food commodities with very large foodsheds, like fish for Ouagadougou and onions for both locations, large amounts of food supplies were found to originate within the immediate region, the size of which varied between the peak and lean seasons. The authors identified a 30 km radius cut-off point for Tamale and a 50 km radius for Ouagadougou where there was a steep increase of up to 30% of all food supplies coming from that area (respectively up to 28% and 20% of major food items), and thereafter a steady decline in supplies. A second cut-off point was identified at around 100 km, where between 50 and 58% of food was supplied. The data on food supplies led the authors to posit two city region scales: a “30% city region” which accounts for around 30% of food inflows in the lean season, and a “50% city region” where 50% of all food supplied in the lean season comes from. The data presented in this paper emphasize the complexities of foodsheds within space and over time for a particular region and point to the importance of this information for understanding when the supply of some food items may be vulnerable and which food supplies are highly resilient. Echoing some of the conclusions of the global studies, these authors conclude that there is need for cities to balance multiple priorities between food security, food sovereignty and the city’s carbon footprint, but there

may be increased city resilience in diversifying food sources rather than trying to move to near-exclusive dependence on local supply.

A review paper of foodshed studies which considers both those that assess the capacities of local production systems to provide local food self-sufficiency, as well as those (like Karg et al. 2016) which examine food flows wherever they come from, concludes that there are tradeoffs to be made between the various food sovereignty and environmental benefits of local production compared to the sustainability risks of having food supplies in quite similar local ecologies, compared to the diversification of sources across a region (Schreiber et al. 2021).

Another significance of the food flow papers has been to provide empirical evidence for an important part of the reality and coherence of the city region food system concept (RUAF and FAO 2015; Blay-Palmer et al. 2018). City region food systems have been defined as "the complex network of actors, processes and relationships to do with food production, processing, marketing, and consumption that exist in a given geographical region that includes a more or less concentrated urban center and its surrounding peri-urban and rural hinterland" (Forster et al. 2015: 8). These authors also emphasize the dynamic character of the actors, processes and relationships creating flows between different points in the city region. Those dynamic processes also include ecosystem services within the landscape. They underline the fact that the term refers not only to megacities and their agricultural hinterland, but also to small- and medium-sized urban centers linking more remote small-scale producers to urban centers and markets.

It is clear from the definition that city region food systems involve different types of flows beside food, but those other flows impact on the food system (Rodríguez-Pose 2008). Contaminants from the city may affect the quality and quantity of agricultural production in downstream areas; urban laborers may leave the city to work on the harvest; inputs may flow outwards from urban-based suppliers to peri-urban and rural producers; and crucially, different types of institutions and governance arrangements may affect both production and marketing chains. As these writers argue, the term captures a spatial reality on the ground with multiple processes and structural arrangements affecting the food system. It supersedes the artificial designation of 'urban' and 'rural' which in many cases were artifacts of colonial processes (Lee-Smith and Lamba 2000); these artifacts "are conceptual lenses that distort our view of the reality of social processes and can only lead to sub-optimal policies and investments" (Berdegué et al. 2014: 5). The issue of the policy and institutional dimensions of city region food systems, the need to improve rural–urban connectivity to achieve sustainable food systems, and what might be optimal investment opportunities to contribute to that connectivity are discussed in the last part of this section and in Section 5. First, we will consider in more detail food production for own consumption, referred to, but not a focus of, the foodshed paper by Karg et al. (2016).

Contributing to the urban food system through own food production

Several multi-country studies have sought to understand how often urban populations are engaged in the production of food and thus contribute to the urban food system, either directly through own consumption or via short food supply chains. Based on the analysis of national household survey data in 13 countries in Africa, Asia and Latin America, Zezza and Tasciotti (2010) found that on average 39% of urban households were engaged in agriculture, with a higher percentage practicing crop production (34%) compared to livestock raising (19%) (Table 1). Because these surveys only capture urban

households involved in agriculture, without being able to distinguish where the crop production or animal raising is located, it is possible that there is some overestimation of the numbers cultivating crops or raising animals in the urban core or nearby peri-urban areas. The data also do not provide information on the location of the households themselves, whether in urban centers or on the periphery, in capital cities or in small and medium cities and urban settlements. Nevertheless, the scale of involvement in UPA indicated in these figures does align quite well with the extent of cropland areas identified in the geospatial studies in the previous section.

Table 1. Participation in urban and peri-urban agriculture (UPA) based on country-level household data.

Country and year of data	Urban households participating in crop raising	Urban households participating in livestock raising	Total participation of urban households in UPA	Proportion of income from agriculture (urban population)	Proportion of income from agriculture (rural population)
Africa					
Ghana 1998	38%	14%	41%	44%	61%
Madagascar 2001	30%	13%	33%	63%	68%
Malawi 2004	45%	14%	46%	26%	77%
Nigeria 2004	29%	12%	32%	71%	80%
Asia					
Bangladesh 2000	26%	14%	30%	9%	37%
Indonesia 2000	10%	3%	11%	27%	35%
Nepal 2003	52%	36%	57%	19%	51%
Pakistan 2001	4%	13%	14%	22%	41%
Vietnam 1998	65%	35%	69%	13%	62%
Latin America					
Ecuador 1995	17%	28%	35%	4%	23%
Guatemala 2000	35%	21%	42%	11%	50%
Nicaragua 2001	65%	29%	68%	8%	57%
Panama 2003	31%	12%	34%	3%	35%
Means	34%	19%	39%	25%	52%
Maximum values	65%	36%	69%	63%	80%
Minimum values	4%	3%	11%	3%	23%

Source: Zezza and Tasciotti 2010.

Though there is possible overestimation of these figures because of the inclusion of rural agriculture practiced by urban residents, they nevertheless are largely supported by surveys in selected urban locations in sub-Saharan Africa conducted within the past 20 years (Table 2).[14] The mean percentage

[14] For two urban clusters, Table 2 includes two separate studies to show the degree of consistency in the findings. Only one of the two cases have been used in the extrapolated population involved in farming. A widely cited publication on urban agriculture published in the 1990s (Smit et al. 1996) made various estimations of city populations involved in farming in sub-Saharan Africa. These were estimates based on experiences in those cities but were not based on survey findings. For that reason they were not included in Table 2.

involved in farming is 28%, with a median of 26.5%. However the proportion of the population involved in farming is very variable across the sample, with the highest proportion reported for Blantyre, Malawi (64%) and the lowest proportion in Windhoek, Namibia (3%). Extrapolating the estimations made at the time of these studies to current population levels, almost 13 million people in these 19 urban clusters or combined clusters could be engaged in some form of agricultural production. This kind of extrapolation is made with extreme caution, of course, given known fluidity in participation in UPA and urbanization processes that may have affected agricultural opportunities, but nevertheless it gives a sense of the scale of involvement in this practice.

Table 2. Estimates of populations involved in agriculture in selected sub-Saharan African cities.

Country	City	Population producing some food	Cases where women are mainly responsible	Urban population	Population source	Study references	Extrapolated farming population
Botswana	Gaborone	5%		208,411	2019 UN	Crush et al. 2011	10,421
Cameroon	Yaoundé	20%	87%	4,164,167	2018 UN	Bopda & Awono 2010	832,833
Ethiopia	Addis Ababa	50%	45%	5,005,524	2018 UN	Yilma 2003; Tegegne 2004	2,502,762
Ghana	Accra	15%	10%	2,556,972	2018 UN	Obuobie et al. 2004	383,546
Kenya	Nairobi	30%	70-85%	4,922,192	2018 UN	Mwangi & Foeken 1996; Lee-Smith 2001	1,476,658
Kenya	Nakuru	35%	80%	395,141	2018 UN	Foeken & Owuor 2008	138,299
Lesotho	Maseru	47%		118,355	2019 UN	Crush et al. 2011	55,627
Malawi	Blantyre	64%		1,068,681	2017[b]	Crush et al. 2011	683,956
Mozambique	Maputo	22%	70%	1,121,697	2018 UN	Paganini et al. 2018	246,773
Mozambique	Maputo	23%		1,121,697	2018 UN	Crush et al. 2011*	257,990
Namibia	Windhoek	3%		445,745	2018 UN	Crush et al. 2011	13,372
South Africa	Atteridgeville (Pretoria)	54%		64,425	2011 Census	Maswikanen g 2003; van Averbeke 2007	34,790
South Africa	Orange Farm (Johannes-burg)	16%		150,000	2013 Govt. statistics	Rudolph et al. 2009	24,000
South Africa	Msunduzi (Pietermati tz-burg)	30%		910,668		Crush et al. 2011	273,200

South Africa	Johannesburg	9%		4,985,000	2018 UN	Crush et al. 2011	448,650
South Africa	Cape Town	5%		4,100,000	2018 UN	Crush et al. 2011	205,000
Swaziland	Manzini	10%		355,945	2017 Census	Crush et al. 2011	35,595
Tanzania	Dar es Salaam	37%		7,046,892	2018 UN	Sawio 1998	2,607,350
Uganda	Kampala	35%	64%	3,469,510	2018 UN	Nabulo et al. 2004; 2006	1,214,328
Zambia	Lusaka	4%		2,871,098	2018 UN	Crush et al. 2011*	114,844
Zambia	Lusaka & Kitwe	23%		3,579,609	2019 UN	Mupeta et al. 2020	823,310
Zimbabwe	Harare	60%		1,541,824	2018 UN	Crush et al. 2011	925,094
Mean % involved in farming		28%					
Median % involved in farming		26.5%					
Total extrapolated population involved in farming							**12,935,564**

Notes: * To avoid double counting, these numbers are not included in the extrapolated total.

The clusters themselves are very variable. Some are estimates of whole primary cities, like Maputo, Johannesburg or Nairobi. Some are small districts in urban South Africa, where estimates may be expected to be more accurate. Some of the studies were able to assess the gender dimensions of cultivation or livestock raising, at least to the extent of whether women or men were mainly responsible for agricultural activities. In the seven studies where these assessments were done, women were most commonly responsible. Some of these studies provide detailed understanding of the gender implications, for example between responsibility for small backyard gardens and for commercial peri-urban farms. The food security or income implications of women's responsibility for urban agriculture has also been examined in specific studies (Hovorka 2006; Hovorka et al. 2009).

Eleven of the estimates in Table 2 were made in a multi-city study of the contribution of urban agriculture to food security in Southern Africa (Crush et al. 2011). The study is skeptical of the "advocacy-driven enthusiasm" for urban agriculture in the 1980s and 1990s and quotes with approval the observation of Ellis and Sumberg that "the term urban agriculture both claims too much and offers too little in the policy context of urban poverty and family food security" (Ellis and Sumberg 1998:221). Crush et al. (2011) consider that many urban agriculture studies underestimate the importance of rural–urban food flows for urban consumers. The study found that across the 11 Southern Africa urban clusters, 22% on average grew some of their food, a lower average than the 19 cases covering all sub-regions of sub-Saharan Africa. Own production was less important than the informal sector, supermarkets and fast-food outlets as a food source. According to the findings, 12% of surveyed households source food from their own production at least once a month. There is considerable variability across the case locations. In Harare 41% source food at least once a week, whereas in five urban locations 1% or less source food once a week, and the large majority source food less than once a year or never.

The study is important in indicating not only great variability in the presence of UPA in different countries – the highest and lowest percentages of urban populations involved in UPA in Table 2 come from this study – but also the variability that exists within countries and even within cities. In South Africa, findings indicate very low levels of UPA in Johannesburg (9%) and Cape Town (5%), whereas the national Household Surveys conducted in 2002 and 2007 indicated 77% of the urban population "having participation in urban farming" (Crush et al. 2001: 291). Even within Johannesburg and Cape Town there are big variations, for example between the poor, inner city location of the Johannesburg study with 9% involved in UPA, and the poor informal settlement of Orange Farm on the outskirts of Johannesburg, where 89% of the population were engaged in urban farming and a large percentage depended on home-produced food. According to the authors, those locations with above-average levels of involvement in UPA had high levels of poverty combined with newly supportive official attitudes, but poverty alone was not necessarily an indicator of UPA. In fact, they recognize that their focus on poor districts or neighborhoods may have underrepresented the somewhat better-off households in other neighborhoods engaged in agriculture. This is further underlined by the strong correlation found between home-ownership and UPA. Writers on urban poverty emphasize the insecurity of shelter in the poorest urban locations, with individuals and households frequently needing to move (UN-Habitat 2006b; Baker 2008). Under these conditions cultivation may be a challenging option. The situation in the medium-sized Kenyan city of Nakuru in the early 2000s also suggests that the urban poor are not the ones benefiting most from agriculture (Foeken and Owuor 2008). In relation to the importance of rural-urban linkages and city regions, this paper notes that rural farming by urban households is even more important than urban farming, and this is probably a common characteristic in small and medium-sized urban settlements. But in both cases, the Nakuru study found that the non-poor were more engaged and performed better than the poor, so that in years of drought, poor urban farming households faced food shortages.

In a comparative assessment of UPA in cities in sub-Saharan Africa and Asia, local production of vegetables, eggs and dairy were found to make a bigger impact on diets in African cities compared to the cities in Asia (Padgham et al. 2015). Drawing on secondary sources, this study shows that in Addis Ababa, 30% of vegetables (60-70% of leafy greens), 60-70% of milk and 40-60% of eggs are produced through UPA (2007 estimates); whereas in Dhaka, 9.5% of rice and 7-10% of fish are produced within the metropolitan area; and the peri-urban Kathmandu Valley produces 8% of that city's perishable vegetables. However, the three cities selected represent a very small sample of the Asian situation. Older studies from China and Vietnam estimated that as much as 60% of Shanghai's vegetables and 90% of eggs were being produced in the peri-urban areas surrounding the city (Yi-Zhang and Zhangen 2000); and in Hanoi, that 50% of the demand for meat (mostly pork) was being met from the municipality (Peters 2000).

The evidence concerning own food production in Latin America is sparser than in sub-Saharan Africa, with very few multi-city studies looking at the proportion of the urban population involved in farming. Many city case studies have demonstrated the key role of urban agriculture for the food security of households, from Havana in the Caribbean (Cruz and Medina 2003) to Rosario in Argentina (Lattuca 2012), but many of these city studies provide detailed discussion of the organizations and groups involved in urban agriculture as part of mainly public interventions, but do not provide overall estimates of the urban population involved in food production. A multi-city study carried out on behalf of UN-Habitat to explore the impacts of the 2008 financial crisis on the food security of poor urban households (Prain 2010a) found that in Rosario, about 20% of households from a middle-income

neighborhood were involved in agriculture, with poultry raising and fruit trees the most common activities. But these were not reported as important coping mechanisms because of the small returns they provided, compared to social support programs. In Peru, based on extrapolations from several different surveys, it is estimated that about 28% of the population of metropolitan Lima are involved in different types of agriculture, from irrigated plots in the peri-urban areas of the city to inner city use of wastewater and domestic water supplies on small vegetable gardens (Arce et al. 2007).

Food and nutrition security through urban and peri-urban agriculture

What is the relationship between having access to own food production in urban and peri-urban areas[15] and improved food and nutrition security? Padgham et al. (2015) found that animal and fish raising were more associated with better-off households, which is a concern, given the density of nutrients in animal source foods, especially important for young children. The authors did find that vegetable production, which is also important for nutrient intake, was common in poorer households across the sub-Saharan African and Asian case cities they examined. A systematic review of the literature on the impacts of urban agriculture on food security in low-income countries reviewed 35 peer-reviewed papers (Poulsen et al. 2015).[16] The papers that met the selection criteria for the review were mostly of cities in sub-Saharan Africa, including the assessment of 11 Southern Africa cities discussed above (Crush et al. 2011). A few papers that dealt with Asian and Latin American countries were included, mainly the national datasets analyzed by Zezza and Tasciotti (2010). As with many studies of the contribution of urban agriculture to food security, two-thirds of the reviewed papers did not compare producers with non-producers or did not address the issue of the representativeness of their samples. Poulsen et al. (2015) underline a key methodological factor possibly explaining the variation in results. The contribution of UPA to household diets varies by season, so the timing of surveys is very important. Only three of the 35 papers selected conducted multiple interview rounds to try to capture this kind of variability. The foodshed study conducted in Ghana and Burkina Faso (Karg et al. 2016) found that the production of vegetables and other crops within urban and peri-urban areas varied between the lean season and the peak season. Supply of important vegetables to Ouagadougou varied from urban/peri-urban supply in the peak season to more distant rural supply in the lean season.

The most cited motivation for engaging in UPA identified in the review by Poulsen et al. (2015) was the production of food for household consumption, and the second was to earn extra income. Only one case identified income as the main motivation. The review examined the selected papers in terms of four main indicators relating to the amount and quality of food consumed: food and calorie availability; dietary diversity; coping strategies; and nutritional status. Of the few studies that examined food and calorie availability between farming and non-farming groups, some statistically significant differences were found, mainly in the increased calorie consumption mostly from staples and vegetables in the farming groups. However, it is unwise to assume that those involved in UPA will necessarily have higher vegetable consumption. In a separate study conducted in Accra as one of four case cities, urban farming households were found to sell some of the higher value crops like vegetables

[15] The potential contribution of own food production to household nutrition and food security can come from different types of UPA. However, in the multi-country studies and reviews of the literature examined here, there was limited focus on understanding differences between types of UPA in their contribution to food security and nutrition.

[16] Out of a list of 587 relevant articles the 35 papers met the criteria of location, topic, use of primary data and a publication timeframe between 1980 and 2013.

and livestock products to purchase staple foods (Prain and Dubbeling 2011; World Bank 2013). Where papers reviewed by Poulsen et al. (2015) did not compare farming and non-farming populations, several found that an important proportion of the households' food came from own production, though this could vary significantly by season. In relation to dietary diversity, a positive association between UPA and diet diversity was found in 10 out of 15 countries in a multi-country study, which used samples including farming and non-farming populations (Zezza and Tasciotti 2010). In other cases there was significant association in terms of particular food groups, specifically fruits and leafy vegetables and among animal-raising households who also grew crops.

In the Poulsen et al. (2015) review, only one study, undertaken in Kampala, examined the relationship between UPA and nutritional status of children and individual and household food security, comparing farming and non-farming households. There were no directly significant associations between nutritional status and UPA, but there was a non-significant trend toward improved growth and body composition of children from livestock-rearing households and a significant positive relationship between household food security and subsequent consumption of animal source foods (Yeudall et al. 2007). This finding and patterns found in other studies (e.g., Padgham et al. 2015), that livestock raising is more common among better-off households, is a definite cause for concern. Multisectoral strategies are needed to increase access to UPA animal raising, given the nutritional and food security benefits.

In contrast to the rather pessimistic conclusions about the role of UPA in food security based on findings in Southern Africa (Crush et al. 2011), the review by Poulson et al. (2015) of research on UPA and food and nutrition security, including the multi-city assessments by Crush et al. and Zezza and Tasciotti (2010), was more cautiously positive about the contribution of UPA to greater household food and calorie availability and consumption. But they also note the variability in findings across different settings, without clear explanations for that variability. They suggest that own food production may have a key role in household food security under specific conditions where other income sources can't cover food needs and suggest the need to examine its contribution to household food during the entire year. It is also important to consider the quality of the food being produced. As Berti et al. (2004) noted, increased food availability does not necessarily improve nutritional health. Much depends on its quality as well as other factors in the household such as feeding practices, hygiene practices and exposure to disease.

Summary and conclusions

The data generated from these country and city studies show significant levels of current involvement of urban and peri-urban populations in food production. Food is central to the lives of citizens and is a major component of household expenditure, so it is not surprising that many individuals and households seek opportunities to reduce food expenditures and supplement household food supplies through their own production. Yet the recourse to this livelihood strategy is uneven across the urban settings that have been studied. It seems that the biggest concerns about the limited contribution of urban agriculture to urban food security were reported from poor inner city areas in large cities where access to on- or off-plot sites for cultivation was limited.

Part of the explanation for contrasting findings, for example between the multi-country studies that drew on national household surveys compared to city assessments, can be accounted for by variability between primary and secondary cities or small urban settlements. Most of the locations selected in

the Southern Africa multi-city study were poor inner city locations in quite large cities like Johannesburg and Cape Town. The country-level data examined by Zezza and Tasciotti (2010) will have included urban populations living in many different types of cities and in different parts of those cities. In smaller, less dense secondary cities, access to land within the city, at the peri-urban interface and in the rural hinterland is easier (cf. Foeken and Owuor 2008).

Another reason for the variability in the reported contribution of UPA to food security is the seasonality of production in many rainfed locations – the vast majority of cases in sub-Saharan Africa – and the sensitivity of single-visit surveys to these effects. Since food supply is such a daily concern, recall questions about food supply in the main season conducted during the off season may not elicit reliable information on main-season supplies. These possible distortion effects would be less in the substantial areas of irrigated cropland in urban and peri-urban areas, but even in these circumstances, irrigation water supply and demand can be seasonably variable. (Biemans et al. 2016).

A third factor that limits the likelihood of those in poor inner city areas practicing agriculture as a means of securing their food needs concerns the precariousness of access to land used for cultivation or livestock in inner city areas. These are mostly marginal public lands like roadsides, land under powerlines, dykes, edges of railways, etc., all exposed to theft and to ambiguous treatment and sometimes harassment by city authorities (Foeken 2004).

For poor inner city individuals and households living in informal settlements, perhaps even more serious than insecure access to land for food production is the insecurity of housing and the frequent need to move at short notice, possibly to an alternative settlement (De Soto 1989; Weinstein 2021). Cultivation of even a 30-day vegetable crop under these circumstances is a long-term commitment that may seem unrealistic.

There are technical, governance and policy issues surrounding the contribution of UPA to urban food security. Are there ways that a combination of alternative water sources and better-adapted crops and varieties can expand the seasonality of production in urban areas? Are urban governments able to improve the security of access to areas for cultivation to offer a more stable contribution by residents to urban agri-food systems? These issues will be tackled in Section 5.

4.2 What is the contribution of agriculture to the urban economy and livelihoods?

Evidence of income from urban and peri-urban agriculture

Enquiries into the contribution of UPA to the urban economy and livelihoods have mainly involved exploring how much income is generated from sales of food produced within urban and peri-urban areas. Other dimensions of livelihoods, such as strengthening social capital or contributing to human capital through improvements in psycho-social health, have received much less attention, even though it is clear that innovation and productivity are closely linked to individual and communal capabilities, equality and health (Sen 1999; UNDP 2019). A few studies have identified non-monetary psycho-social and health benefits of UPA in the Global South (Slater 2001; Cole et al. 2008) and many more discuss this in relation to home gardens and allotments in the Global North (e.g., Soga et al. 2017). This section will concentrate on evidence for the contribution of UPA to individual and household income, but the relevance of non-material benefits will be revisited both in the section

examining the health effects of UPA and also in the discussion about the approach to UPA within urban governance and policy.

Many case studies of urban agriculture producers identify a strong focus on income generation among certain populations and with certain crops and livestock. Many recent case studies are well summarized in Graefe et al. (2019), for example, cases in Mekelle, Ethiopia, where almost all farmers are market-oriented with up to 93% of production marketed; and in Lilongwe and Blantyre, Malawi, where female-headed households sold 90% of their harvest. Graefe et al. report other literature identifying "entrepreneur" farmers with strong market orientation. But what is the picture when the urban population is sampled, without targeting producer households?

The multi-country studies referenced in the previous section in relation to food security also examined the share of total income coming from agriculture for randomly sampled urban populations using national household survey data (Zezza and Tasciotti 2010), or examined whether any income was derived from agriculture for a randomly sampled urban population in the month preceding the survey (Crush et al. 2011). As was the case with food security, these snapshot assessments are likely to have been affected by the seasonality of production and may underestimate income streams from UPA. The national data show that across the 13 countries, on average 25% of income was generated from agriculture, but that there is a large variation between countries and regions (Table 1). Sub-Saharan Africa has the highest figures, with Nigeria in 2004 indicating that 71% of the income of the urban population was derived from agriculture. The Latin American sample indicated that agriculture provided very little income for urban households. For comparison, Zezza and Tasciotti (2010) also provided the share of income from agriculture for the rural population, offering two lessons. First, that agriculture in the twenty-first century is not the dominant form of rural employment it once was. On average just over 50% of rural income derives from agriculture across these countries. Second, that agriculture is more important for both rural and urban populations in Africa than it is in either Asia or Latin America, at least based on the country selections made.

The findings about income in the study of 11 urban populations in Southern Africa by Crush et al. (2011) indicate a modest contribution from UPA, with an average of 3% of respondents deriving income from this source in the preceding month, though with considerable variation, from 51% in Blantyre, Malawi and 14% in Maputo, Mozambique to 0% in Johannesburg. Although they recognize that the averages within specific urban areas as well as overall do not take account of seasonal variability, the authors still conclude that urban agriculture is more of a survival strategy than a business.

These surveys purposely targeted populations in poor urban neighborhoods selected by local partners, from which households were randomly sampled. In many of these neighborhoods there were relatively low numbers practicing agriculture, as reported in the previous section, and most of those did so as a direct source of food rather than for sale. One factor that may explain low levels of sales by producers is the inadequacy of urban markets to channel local produce to consumers, but the small scale and survival objective are thought to be more significant explanations. Crush et al. (2011) recognized that targeting poor, usually inner city neighborhoods may have underestimated the significance of UPA for income generation, especially among better-off households and perhaps in other part of these urban areas. The Lusaka, Zambia neighborhood they surveyed had only 3% of the sample deriving any income from urban agriculture. Yet Lusaka was considered the 'urban agriculture

capital' of Africa in the 1980s and 1990s, and was shown even in 2008 to have thriving urban food production in open plots and in many other marginal spaces (Simatele and Binns 2008). In the Cape Town sample of Crush et al. (2011), only 4% obtained any income over the previous month. Yet a more recent study, while also confirming the generally low levels of urban agriculture practiced in the city, also noted that one large farming area produced about 50% of the city's vegetable supply, presumably generating good income for farmers and climate-friendly vegetables for the city (Paganini et al. 2018). High levels of variability in the practice of UPA between different neighborhoods is clearly very important, driven by space availability, presence of markets and no doubt other factors.

A four-city comparison published in 2013, though not covering Southern Africa, provides evidence of a greater contribution to income from UPA than was generally the case in the Southern Africa cities. The World Bank-commissioned study comprised the four cities of Nairobi, Kenya; Accra, Ghana; Bangalore, India; and Lima, Peru, chosen for their representation of different geographic locations and a diversity of urban agriculture systems (Prain and Dubbeling 2011; World Bank 2013). In the selected districts of each city, randomized samples of farming populations were compared with non-farming populations. For some dimensions of UPA, the study also considered variability along the urban to rural transect, but this was not done for the income data. Crop cultivation was found to be the primary source of income on average for 28% of the sampled population who were involved in farming across the four cities (Table 3). Animal raising was less important as a main income source, except in Bangalore, where 31% considered it the most important source. In responses about secondary income, agriculture was the most important in Nairobi, Accra and Lima. The World Bank study concluded that "agriculture seems to combine well with other occupations and offers the chance to retain multiple employments for household heads to a much greater degree than for those not involved in agriculture", and emphasizes the importance for women and women-headed households (World Bank 2013: 16). The flexibility of agriculture as a secondary source of income offers important opportunities for investment and promotion, both for poverty alleviation measures and for improvements in food security.

Table 3. Major sources of income for agricultural producer and non-producer households in four cities.

	Accra		Bangalore		Nairobi		Lima	
	Producer	Non-producer	Producer	Non-producer	Producer	Non-producer	Producer	Non-producer
Farming (crops)	32%	0%	34%	0%	34%	0%	11%*	0%
Farming (animal raising)	12%	0%	31%	0%	17%	0%	N/A	0%
Petty trading	29%	49%	5%	22%	17%	37%	17%	22%
Small and medium-sized enterprises	5%	16%	2%	9%	1%	1%	6%	6%
Casual laboring	6%	7%	12%	26%	23%	49%	13%	17%
Formal employment	7%	12%	13%	33%	7%	12%	37%	38%
Other	9%	16%	0%	0%	2%	1%	15%	18%
Households surveyed	*1,240*	*448*	*1,315*	*389*	*1,215*	*345*	*1,105*	*477*

Note: * Includes both crops and livestock.

Source: Prain and Dubbeling 2011.

Informal employment in urban agri-food value chains

Just as it was necessary to consider the contribution of UPA to urban consumption and diets in the context of the urban food system to identify challenges and opportunities, so a broad view of employment among urban residents helps to contextualize the importance of income from agri-food systems. The defining characteristic of urban employment in the Global South is informality, a term that has generated a whole literature and multiple points of controversy (Benanav 2019). The most recent effort to define the term by the International Labour Organization (ILO) distinguishes between the informal sector, which is an enterprise-based concept defined in terms of the characteristics of the place of work of the worker, and informal employment, which is a job-based concept defined in terms of an employment relationship and the conditions and levels of protection associated with the job (ILO 2018). To determine whether enterprises are in the informal sector or not, criteria are sequentially applied to narrow down the definition, excluding, for example, enterprises which are in the formal sector such as public sector corporations, NGOs etc., and those where production is for own use, such as the case with subsistence-agricultural producing households. As the ILO and others recognize, employment circumstances are dynamic. A household may consume all of its production one year, but the next season sell part of the produce, making it part of the informal sector. Similarly, an individual may simultaneously be an 'own-account'[17] enterprise in the informal sector, hold a formal job and also be an employee in an informal enterprise. This is the situation described by Hart (1973) in 1960s Accra in his classic publication that helped launch the concept of the informal sector:

> Mr A. D. in 1966 worked as a street-cleaner at 6s. 6d. per day (which brought in between £6 and £7 per month, after deductions for social benefits and the timekeeper), as an afternoon gardener at £6 per month, and as a nightwatchman at £I4. In addition to this annual income of approximately £320, he grew vegetables on his own plot of land which brought in another £I00 or so. An average monthly income of £35 is not overmuch for incessant productive activity, but it is four times the minimum wage. He was 45 years old, unmarried, and used his 15-day annual leave for weeding and planting his 'farm'; he had never been home to the Frafra (in northern Ghana) area during his stay of almost 20 years in Accra. Accumulated profits went into a savings account towards his 'big plan' for a gracious retirement in his home village. (Hart 1973: 66)

As a number of contributors to the informality debate have pointed out, and the ILO itself has accepted, the informal sector is more like a continuum than a sector (ILO 2002; Portes and Haller 2005; Benanav 2019).

The part played by agriculture in the dynamic employment conditions in urban areas varies along the spatial continuum from the urban core to peri-urban areas, as a study in Kampala, Uganda illustrates (David et al. 2010; Prain and Lee-Smith 2010). With reduced space in inner city areas, there are fewer opportunities for agriculture and two-thirds of those sampled drew their main income from informal sector work, mainly in small-scale trading businesses or from informal employment such as construction (Figure 4). In both the old parts of the city and in newer developments, salaried work in the formal sector is important, especially in the new urban areas. Farming is the main income source

[17] Own-account enterprises are defined as those enterprises undertaken by single individuals without hired workers (ILO 2018).

for a smaller, but still significant proportion of the surveyed households. Based on 2003 working population when these data were collected, this might still account for about 70,000 people having agriculture as a main income source out of a total working population of about 500,000. The study reports that 85% of the sample had more than one income source and mixed farming and livestock keeping were identified as the second and third most common sources, after "business" (David et al. 2010). For the income data, this study drew on a relatively small, project-based household survey rather than the much larger census and national household surveys that they also used as other data sources, so results have to be interpreted with caution. But this is one of very few attempts to examine the variability of the role of agriculture as an income source along the inner urban to peri-urban transect, rather than in one or two poor locations in particular urban locations. What it highlights are the different opportunities offered by agriculture both as a main and subsidiary income source at different points on the urban–peri-urban continuum.

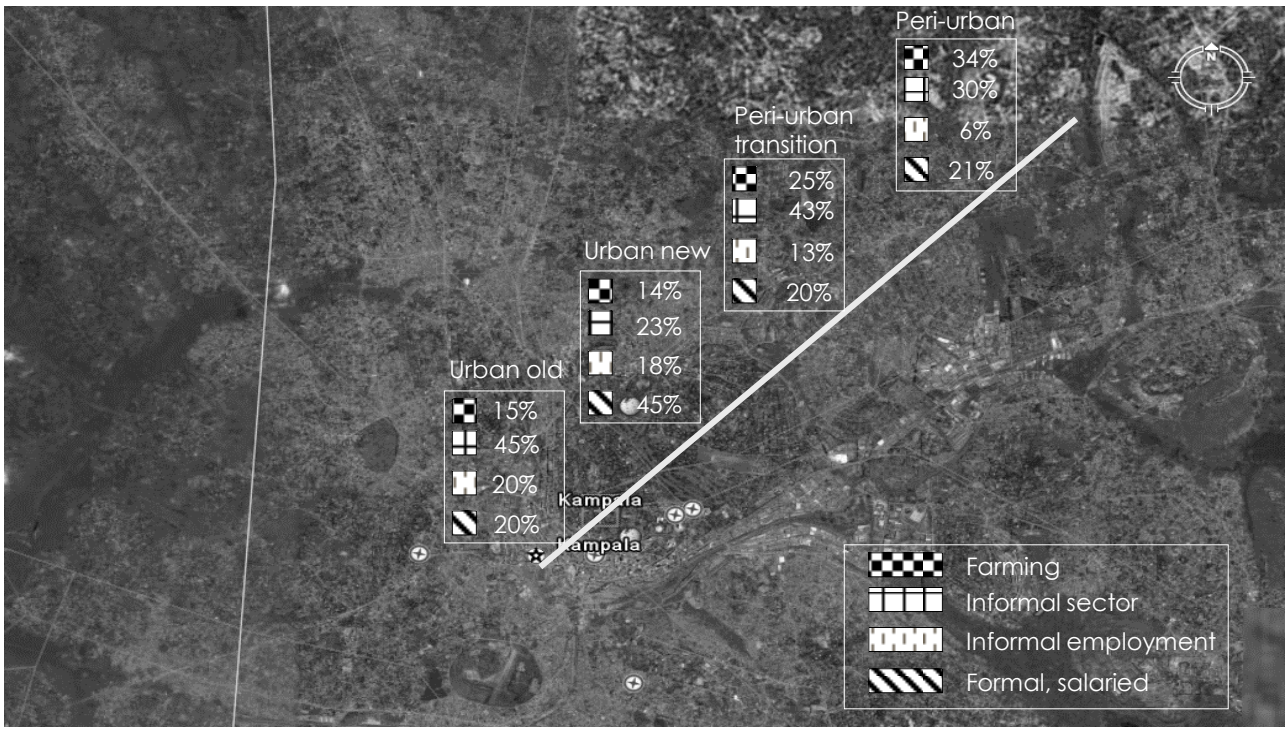

Figure 4. Livelihoods along the urban–peri-urban continuum: Primary income source of sample households in Kampala, Uganda.
Source: Data from David et al. 2010.

Locating local crop and livestock production within the urban informal economy also allows an alternative, bottom-up, user perspective on employment, income and UPA. That involves considering how choices are made about using urban and peri-urban space to participate in different, related links in food value chains, for example as producers or informal vendors or food processors of local foodstuffs, in "a geography of boundary crossing" as Rigg (2013) describes it in the context of Southeast Asia (see also Satterthwaite and Tacoli 2002). In some cases, these two dimensions of participation in the urban economy overlap, as when enterprising peri-urban producers – often women – market their own and their neighbors' agricultural products in inner city markets, as happens with informal vegetable marketing in Hanoi, Vietnam (Wijk et al. 2006). In Lima, Peru, producers of

vegetables in the peri-urban valleys in the Andean foothills market their own produce in Lima's district markets or sell to small-scale collectors who transport them to those markets, often via motorized tricycles (Arce et al. 2007).

The wholesale and retail trade sectors are estimated to account for a third of all 'informal' non-agricultural employment in the Global South (ILO 2020), and the 'informal food sector' accounts for a major part of that figure (FAO 2007). Food value chains and market systems linking small producers, various informal vendors and different kinds of service providers in the marketplaces where food is bought and sold account for a huge part of the urban economy. With seasonal variations and long value chain exceptions already discussed through the example of West Africa (Karg et al. 2016), a large percentage of food marketed in cities comes from the city region. Interventions to stimulate the contribution to that market from short-value chain produce supplied by urban and nearby peri-urban production areas can improve the livelihoods of producers and vendors, the health of consumers and the resilience of the city. Section 5 will discuss several marketing innovations to achieve these benefits, including green markets and shifting sourcing strategies of large institutional markets in urban areas, for example, schools, hospitals and food-based safety net programs.

The urban agri-food system also provides employment and income opportunities in ancillary activities linked to food production and sale. These range from portering in wholesale and retail markets to organic waste recovery, reuse and recycling (Drechsel et al. 2015; Senanayake et al. 2021). Information on the size of the informal workforce involved in organic waste management is difficult to obtain. One study estimates that between 1 and 5% of all urban employment is involved in informal and formal waste management, often the biggest budget item for local governments in the Global South (Hoornweg and Bhada-Tata 2012). A detailed literature review of solid waste management estimates on the basis of literature on selected cities in China, India, Africa and Latin America that there is a global range of between 13 and 56 million people working in informal waste management. The fraction of organic waste in global solid waste increases with declining wealth (Kaza et al 2018). The highest levels are above 60% (Hoornweg and Bhada-Tata 2012). This means there could be between 8 and 34 million informal workers in organic waste recovery and reuse in the Global South. Given the low levels of formal waste recovery in many countries, inclusion of these workers within local food systems is inevitable and important.

BOX 1. The informal food sector and COVID-19

The informal food sector offers individuals and households livelihood opportunities, but the conditions under which many producers and vendors operate are often unstable, and this especially affects women for whom this sector is their main source of employment. The instability of the informal sector was illustrated during the COVID-19 pandemic. Evidence gathered about responses in some countries indicates that decisions by national or local authorities to close informal food outlets was rushed, without necessarily weighing it against other important considerations, such as the absence of evidence that informality equals high risk of propagation of the virus, or the fact that these small-scale, informal or semi-formal businesses are the source of revenues and incomes for a very large number of poor but economically active people, especially women and unskilled youth (Béné et al. 2021). These authors note a particularly painful irony associated with these shutdowns. Many of these informal micro-enterprises that were closed down were already completely invisible to the national statistical systems and their disappearance due to the COVID-19 has therefore remained totally unnoticed to government agencies. A further element of their closing down has been the popular recognition that they often offer the only sources of affordable, convenient and/or accessible fresh food for a large number of urban dwellers.

Summary and conclusions

There is uneven evidence about the extent to which urban and peri-urban agricultural production offers a major source of income. In some poor inner city locations, such as in Cape Town and Johannesburg, it may provide little or no income from sales to those who are engaged in crop or animal production, even if it can provide indirect income through savings on purchased food. But in other cities, and perhaps especially in medium and small cities, it can be an important direct income source. As well as the variability across cities, there is also variability in the importance of UPA as an income source within cities, varying from the inner urban core to the outer, peri-urban areas. The evidence also indicates that agriculture is almost always one of several income sources.

Situating UPA within the employment context of the city region food system draws attention to the participation of producers and vendors in different types of short and long food value chains. The huge importance of informal food marketing as a source of income, but also its instability and vulnerability, was underlined in many countries during the COVID-19 pandemic. There are different ways to increase the stability and safety of existing food marketing, and there is potential to open up untapped markets that could offer both producers and vendors new opportunities; these are discussed in Section 5.

4.3 Agriculture and urban resilience: Responses to climate change and the importance of urban and peri-urban agriculture-linked ecosystem services

Following the pioneering work of Rees and Wackernagel (2008) and others there has been increasing research attention paid to the ecological footprint of cities (Satterthwaite 1999) and more recently the carbon footprint of cities – the direct urban contribution to climate change. “Cities are a major part of the cause [of climate change], suffering the most impacts and therefore play a primary role in finding an appropriate solution,” according to UN-Habitat (Dubbeling et al. 2011). Hoornweg et al. (2011) estimated that 80% of emissions are produced directly by cities or through consumption by the

urban population, and a small number of large cities and affluent populations within those cities have a disproportionate effect (Moran et al. 2018). The impact of cities on climate is a global phenomenon, and with rapidly increasing urbanization, especially in sub-Saharan Africa and Asia, this impact could potentially become more serious (Abdullah 2019).

The converse picture to this evidence of the contribution to climate change by affluent countries and affluent classes within cities in poor countries is the evidence that those most affected by climate change in cities of the Global South are the poorest citizens, those "who live in slum and squatter settlements on steep hillsides, in poorly drained areas, or in low-lying coastal zones" (UNFPA 2007). Coastal zones, in particular, are precariously settled by millions of poor urban dwellers. There are 3,351 cities located in such zones around the world, and 64% of them are in the Global South, almost all experiencing rapid expansion (UN-Habitat 2009). The severe exposure of poor urban populations compounds the problems of food and income insecurity discussed in the previous sections. These populations are not only vulnerable to the direct effects of extreme weather, storm surges and flooding, they are also affected by disruptions to food supply from the hinterland through changing rainfall patterns (Dubbeling and de Zeeuw 2011).

The good news highlighted in the volume edited by Abdullah (2019) is the "profound reconfiguration" of the positioning of cities in international development. They have shifted from "problem hotspots" in the 1980s to "active drivers of positive transformation" in the current period. This is evidenced by the rapid growth of city networks devoted to climate mitigation (C40, ICLEI – Local Governments for Sustainability, the Milan Urban Food Policy Pact, United Cities and Local Governments, and others) and the visibility of these networks in international and other change processes. These city networks will be discussed in more detail in Section 5. Despite the positive emergence of these city networks and the cross-learning involved, there is great inequality between the capacity of cities in the North and those in the South to respond to the climate crisis, especially the capacity for taking mitigation actions (Satterthwaite and Dodman 2013). These authors highlight the enormous difference in local government expenditure per person per year between the North and the South. For almost all countries in the Global North, the range is between $2,000 and $12,000. For most countries in the Global South, the figure is below $20, and for many countries, less than $5 per person per year. If figures could be separated out for capital investment, this massive gap would be even bigger, since a large part of local government expenditure in the South is to cover wages. Under these financial constraints, both mitigation and adaptation measures, such as reducing emissions from public transport, maintaining large green and wooded spaces to act as carbon sinks, or building defense measures to prevent flooding are difficult, and there is a serious lack of incentive to impose controls on private sector businesses, which bring cities much-needed investment and development.

Nevertheless, there are diverse options for responding to climate change that can complement and strengthen the urgent development goals of cash-strapped local governments (Simon 2012). These can include a shift from local use of diesel generators as essential energy backups under the common situation of interruptions to national energy supply, to the use of solar energy, which is increasingly affordable and reliable. Another area could involve environmental rehabilitation of ecosystem services, including wetlands, waterways and public open green spaces. These areas are often multifunctional and include agriculture, which itself offers different benefits (van Leeuwen et al. 2010; RUAF and FAO 2015; Curan and Marques 2021). The following sections examine the extent to which UPA contributes to resilient cities through mitigating climate change and supporting climate

adaptation actions, and how the ecosystem services provided by UPA contribute both to adaptation and to urban resilience. Finally, the paper briefly looks at how climate change and other processes in the urban environment threaten UPA.

Contribution of urban and peri-urban agriculture to climate change mitigation

Climate change mitigation involves either reducing emissions or providing a 'sink' to absorb greenhouse gases. The ability of UPA and especially urban forestry to provide urban sinks for greenhouse gases and enhance vegetative cover while also providing adaptation benefits and other ecosystem services has been commented on by several writers (Dubbeling and de Zeeuw 2011; de Zeeuw et al. 2011; Lwasa et al. 2014; Lwasa et al. 2015).

Echoing much of the global-scale literature discussed in Section 3, these writers also emphasize the contribution of local food production to reducing levels of emissions from long value chains. Even if agricultural commodity-related transport generates only about 5% of total emissions from agriculture (Crippa et al. 2021), this is still almost 1% of all annual anthropogenic emissions. Reduction in transport emissions is not the only mitigation through short versus long value chains. There are also savings on cooling, storage, processing and packaging, and through cyclical processes between urban domestic and industrial sectors and agriculture: use of excess heat, cooling water or carbon dioxide from industry for greenhouses (Dubbeling and de Zeeuw 2011; de Zeeuw et al. 2011). These synergies between agriculture and industry not only reduce emissions, but also contribute to the circular bioeconomy of cities and increased resilience, which will be further discussed in Section 4.4.

Increasing climate change adaptation and other forms of urban resilience through urban and peri-urban agriculture's ecosystem services

Since its formulation in the Convention on Biological Diversity in 2009, there has been increasing attention to the role of ecosystem services in adaptation to climate change (UNEP 2019. These services are often 'nature-based', for example the maintenance or expansion of coastal mangrove forests as buffers against increased flooding risks. But agriculture also provides ecosystem services and can help cities adapt to climate change. The most common service attributed to agriculture is a provisioning service, delivering food security and poverty alleviation (Dubbeling and de Zeeuw 2011; de Zeeuw et al. 2011; Lwasa et al. 2014; 2015). The contribution of UPA food production to diversifying urban food sources is mentioned by several writers as strengthening the contribution of these provisioning services to resilient cities (e.g., Kinnunen et al. 2020).

Recent multi-city reviews of the situation in West and East Africa and other locations confirmed that the contribution of UPA to enhanced food security and livelihoods reduced social vulnerability and was thus an adaptation to climate change (Lwasa et al. 2014; Lwasa et al. 2015). Beyond this ecosystem service, these reviews found that the literature mostly focused on environmental and sustainability benefits rather than specifically exploring climate change adaptation through other types of ecosystem service. Evidence from other geographical locations identifies regulating and supporting ecosystem services provided by UPA and forestry. These include water filtration and flood regulation, nutrient reuse and biodiversity maintenance, storm protection, erosion control, pollination and micro-climate moderation through establishment of green spaces (UN-Habitat 2009; Lwasa et al. 2014). As emphasized in the paper by Dubbeling and de Zeeuw (2011), green areas and shade trees can reduce the heat island effect, buffering temperatures by as much as 5°C. Dubbeling et al. (2011) also cite the way that the protective location of UPA on risk-prone land can act a buffer

to prevent use of that land for building, which could provoke floods, landslides and other disastrous consequences. They also point out how cultivated plots can help adapt to extreme rainfall events, with water stored and infiltrated rather than leading to erosion through storm-run off.

Lwasa et al. (2014) suggest that findings from the United States and other locations may well be applicable to the targeted cities in East and West Africa, and they refer to studies in Lagos and Kampala which have identified improvement of soil hydrology and stabilization of slopes from UPA and urban forestry as part of flood protection. In fact, flood reduction seems to be a key ecosystem service provided by agriculture in cities in both West and East Africa. Modifying heat effects and flood risk have also been identified through a recent literature review as the main ecosystem-based adaptation options addressed in 110 articles covering 112 cities (Brink et al. 2016). Yet there is no reference to agriculture as providing ecosystem-based adaptation among these articles. This may be because research on the contribution of UPA to climate change adaptation is not framed yet in terms of ecosystem-based adaptation, but it may also be because of the dominance of the hard natural sciences identified by Brink et al. in this field.

The first introduction of the idea of ecosystem-based adaptation within the Convention on Biological Diversity focused attention on the way ecosystem services can conserve biodiversity as part of climate change adaptation. UPA has been identified as contributing to the maintenance or expansion of biodiversity, not only through diversifying cultivated species and varieties within cultivated spaces to increase adaptation, but also through stimulating the presence of wild fauna and flora, including wild relatives, within and around UPA plots (Dubbeling and de Zeeuw 2011; de Zeeuw et al. 2011). Among the fauna supported through these urban ecosystems are pollinating insects, seed-distributing birds and mammals. While biodiversity conservation and expansion is increasingly recognized as an important ecosystem service of smallholder farming in general, it is still under-researched (Vignola et al. 2015). Given the intensity of climate change effects in urban and peri-urban areas, further systematic research on adaptation-based ecosystem services provided by UPA is certainly needed.

An ecosystem service provided by UPA that contributes indirectly to climate change adaptation and directly to urban resilience is the recovery, reuse and recycling of liquid and solid wastes generated through urban environmental and economic processes (Dubbeling and de Zeeuw 2011; de Zeeuw et al. 2011; Lwasa et al. 2014). Waste is the excreta of urban consumption, which is why it is closely related to the carbon footprint of cities, the contamination of cites and their level of livability. It is why it is one of the major challenges facing urban authorities throughout the world (Hoornweg and Bhada-Tata 2012). For these broad considerations which go beyond climate change adaptation and touch on the whole metabolic and social processes of cities, this topic will be addressed separately in Section 4.4. To complete Section 4.3, it is necessary to consider whether UPA is constrained by climate change itself, or by other endogenous or exogenous factors, from providing ecosystem services to cities.

Constraints on the contribution of urban and peri-urban agriculture to resilient cities

Is it possible that the important UPA-based ecosystem services identified in the previous sub-sections may be compromised by exogenous or endogenous pressures undermining UPA? These concerns lay behind assessments that were carried out during 2011 and 2012 in nine cities in sub-Saharan Africa and Asia to understand the possible stressors standing in the way of UPA contributing to urban food

security and resilient cities (Padgham et al. 2015).[18] These studies identified two principal types of constraints: those relating to the exogenous factors of urbanization and climate change affecting the availability or quality of natural resources within or surrounding urban areas for cultivation or animal raising; and those relating to the endogenous processes of agriculture, especially the generation of contaminants. In relation to both these sets of stressors, they also identify problems with the related issue of the enabling environment.

Across the nine cities Padgham et al. (2015) found a similar picture of diminishing access to water and land. The most common pattern in peri-urban areas involved competition for water between agriculture and increasing demands from new residential, commercial and industrial needs, a pattern occurring in many other locations (cf. Diaz Caravantes 2014). In Chennai, India, the study even found that farmers identified water as a more profitable commodity to sell to new urban residents than to use for irrigating their crops.

The study also identified a growth of urban land markets in the urban fringe (especially in Dar es Salaam, Tanzania; Kampala, Uganda; and Tamale, Ghana) as well as urban renewal projects involving the relocation of urban populations to new peri-urban sites, which put pressure on agricultural land. Factors pushing urban residents to seek residential space in peri-urban areas are similar across the world, including in the Global North: rising housing costs in urban areas, as in Kampala and Ibadan, Nigeria. The situation is exacerbated in some cities such as Dar es Salaam, where perverse housing subsidies for civil servants accelerate the conversion of peri-urban agricultural land. Some of this residential and commercial development is illegal, and Padgham et al. (2015) found that some illegal building in Ibadan and Dakar, Bangladesh occurred in drainage areas, increasing problems of flooding already worsening with climate change. Agricultural buffer lands around drainage areas has been identified as an ecosystem service that UPA can provide to reduce flooding risks (de Zeeuw et al. 2011).

Another pressure on peri-urban agricultural land documented for these cities, but also widely reported in Latin America and in other cities in Africa and Asia, is the establishment of informal settlements on the peripheries of cities on what were agricultural lands, because no other options exist for desperate migrants seeking alternative livelihood options in urban centers. In Kampala, Tamale and Ibadan, this is occurring on ecologically valuable wetlands, leading not only to loss of agricultural land but also the loss of ecosystem services providing flood protection and treatment of contaminated water. In Dhaka, in-filling of water bodies as part of unplanned development leads to loss of fishing areas and dry season farming. Padgham et al. (2015) also report for Kampala and Kathmandu, Nepal another common trend in peri-urban areas around the world: the take-over of agricultural land for quarrying and brick-making as the demand for construction materials increases dramatically in urban areas (Douglas 2006). Flooding and landslides are unintended consequence of this land use.

In addition to these urbanization pressures on UPA, Padgham et al. (2015) also identify pressures coming from climate change-induced events like increased temperature at night, more intense and unseasonable rainfall contributing to flooding events, soil erosion, and also more frequent droughts.

[18] The cities were Addis Ababa, Ethiopia; Chennai, India; Dakar, Senegal; Dar es Salaam, Tanzania; Dhaka, Bangladesh; Ibadan, Nigeria; Kampala, Uganda; Kathmandu, Nepal; and Tamale, Ghana. The cities range from large megacities with more than 10 million residents to one secondary city with less than 1 million (Tamale).

These city studies identified resulting reduction in farming, but also changes in farming behavior. For example, producers shifted from high- or medium-maintenance crops like rice and maize to crops like cassava and finger millet, with much lower water and nutrient demands. Of course, these shifts also have implications for the macro- and micro-nutrient benefits and income. Changing cultivation practices under climate change pressures have also been reported by other scholars, for example from vegetables to rice where flooding is a problem, or from maize to millet where drought periods increase (Grothmann and Patt 2005).

Many authors have addressed the public health risks associated with UPA, and especially associated with use of wastewater or polluted surface water for irrigation, as well as contamination of crops with pesticides and heavy metals (Birley and Lock 1999; Karanja et al. 2010; Drechsel et al. 2010; Graefe et al. 2019; Buscaroli et al. 2021). The multi-city assessment by Padgham et al. (2015), in common with many writers, identify health risks to food crops from the use of wastewater or polluted surface water for irrigation as one of the major endogenous stressors. Yet as has been discussed in earlier sections, the importance of using nutrient-rich wastewater as an irrigation source will only increase with growing urban pressure on water resources. The safe use of this resource will be further discussed in Sections 4.4 and 5.

Many of the negative consequences of exogenous pressures on UPA like urbanization and climate change, or endogenous stressors like health risks from agricultural practices, can be reduced through a supportive policy and regulatory environment. Across the nine countries assessed by Padgham et al. (2015), supportive policies were identified in some cities, such as Kampala and Tamale, and policy frameworks were in place in other cities like Addis Ababa, Ethiopia and Dakar, Senegal that could potentially make UPA more viable and safer. The existence of policy frameworks highlights a common problem identified across these case cities and in many other contexts: the gap between policy formulation and planning and implementation (Cabannes and Marocchino 2018; Santandreu 2018). Sometimes lack of implementation occurs because of ambiguous jurisdictions between local authorities, which can be exploited to avoid action, as happened in Dakar and Tamale. In the Asian cities of Kathmandu, Dhaka and Chennai, the studies found no protection for UPA in land use planning. The need to address these problems will be further discussed in Section 5.

Based on findings from the case cities, Padgham et al. (2015) draw on a resilience assessment framework devised as part of the Asian Cities Climate Change Resilience Network supported by the Rockefeller Foundation (Tyler and Moench 2012). The framework applies a set of criteria to assess resilience that are grouped according to characteristics of UPA systems, such as the degree of flexibility and diversity of crop-livestock systems; characteristics of the actors or agents involved in UPA, such as the capacity of producers to respond to market signals; and finally the institutions that underpin UPA, such as the degree of open communication between urban and peri-urban producers and planners.

As might be expected, Padgham et al. (2015) found considerable diversity when they applied this framework to the case cities. In general they found high levels of redundancy and diversity in local production systems, which tends to increase resilience. On the other hand, the systemic problems with access to land and water, mostly without institutional support, was a general weakness. Equity in access to resources, transparency and communications were all found to contribute to a lack of resilience, indicating the need for substantial attention to the institutional dimension of UPA.

Padgham et al. provide suggestions for how to remedy some of these institutional failures, and several of these will be considered in Section 5.

Summary and conclusions

Although cities are major sources of greenhouse gas emissions – with large variability between cities and within cities between the wealthy and the poor – cities also suffer the major impacts of climate change, especially the poorest sectors of the urban population. For both these reasons cities need to be part of the solution to climate change. Recent city proactivity and coordination on this issue is a hopeful sign, especially compared to national-level timidity and competition. UPA is playing a role in this response, both through mitigation and adaptation. The contribution to climate change mitigation is mainly through the provision of a productive urban sink through green spaces and especially through urban forestry. The reduction of long value chains with corresponding reduced emissions from transport, cooling, packaging and other energy saving on transporting food over long distances is another mitigation effect. These savings can be further increased through synergies in energy use between local industry and agriculture.

UPA also contributes to climate adaptation through several ecosystem services, especially provisioning services that provide food security and poverty reduction while also increasing urban resilience through a more diversified food supply. Other ecosystem services provided by UPA that contribute to climate change adaptation include water filtration and flood regulation, acting as buffer zones against building encroachments in vulnerable landscapes and micro-climate moderation, especially important for reducing the heat island effect in cities. There is also evidence of a contribution to conserving biodiversity in urban and peri-urban areas.

There are both exogenous and endogenous stressors that constrain the contribution of UPA to resilient cities. The most important exogenous stressor is urbanization, which leads to competition for natural resources, especially land and water. But climate change itself threatens UPA through higher nighttime temperatures, extreme rainfall and flooding events, soil erosion and droughts. Endogenous processes involved in UPA, such as the widespread practice of using wastewater or contaminated surface water can present important public health risks. Both exogenous and endogenous stressors can be reduced through supportive policy and regulatory environments, and there is evidence of these functioning in some cities in the Global South. But many cities either lack this enabling environment or have policy frameworks that are not implemented and policy and institutional action is needed, which is presented in Section 5, to enable UPA to fully contribute to resilient cities.

4.4 How important as a contribution to the circular economy is recovery and reuse of organic wastes through urban and peri-urban agriculture?

On a visit to a large landfill site in the Philippines in the early 2000s, I spent some time with a group of adolescents who were working as independent waste pickers and sorters of landfill waste. Organic wastes had already been intercepted by pig raisers who were also active in the area of the landfill, so these youths were dealing with inorganic materials. The group had seven piles. In turn we discussed each pile, its frequency in the landfill, where it could be sold and the likely price. We moved through two types of plastic, glass, wire, cardboard and cans, and then came to the seventh pile. “Oh”, one of the boys said, “that’s garbage”.

The generation of municipal solid waste (MSW) is one of the most challenging byproducts of urbanization, and one of the biggest concerns of city governments. Informal resource recovery and reuse of organic wastes has been common among swidden farmers and smallholders for millennia, but the formal functioning of cities involves a linear input-output system – energy in, waste out. As part of a widespread rethinking about the unsustainability of that model and the need to move to ideas of a circular economy,[19] it is argued that instead of considering MSW as a sources of urban pollution, which it can be, it be considered as a nutrient resource that can be recovered, reused and recycled, especially through agriculture, for the economic benefit of individuals and households in urban and peri-urban areas, and for the social and environmental benefit of the city and its region. This is a way to turn an urban problem into an environmental and economic solution (Drechsel and Kunze 2001; Beuchler et al. 2006; Cofie et al. 2006; Polprasert and Koottatep 2017) – 'waste into wealth' as it is framed in massive numbers of books and papers.[20] As was mentioned in the preceding section, more recently there has been greater attention to the role of organic resource recovery and reuse as a contribution to climate change mitigation and adaptation.

The scale of the waste problem currently facing city authorities is enormous. It is visible in the streets and vacant lots of inner city areas and the smoldering landfills on the periphery. According to the United Nations Environment Programme (UNEP), 11.2 billion tons of MSW is generated each year globally, mostly from urban areas.[21] It is not surprising that the volumes that are generated correspond directly to levels of wealth, which is also an indicator of the proportion of inorganic to organic waste, inorganic waste rising with income. UNEP currently estimates that in low-income municipalities in the Global South, 50-70% of MSW consists of organic waste, meaning around 3-4 billion tons of organic MSW is produced annually. This estimate of the percentage of organic waste is remarkably consistent with more detailed assessments at city level reported from more than 20 years ago (Cofie et al. 2006).

Even though some level of management of MSW is one of the most common services provided by local governments throughout the world (Hoornweg and Bhada-Tata 2012), the infrastructure for waste management continues to be limited and is still considered one of the major problems facing municipalities in low-income countries (Drechsel and Kunze 2001; Senanayake et al. 2021). According to WHO, two billion people still do not have access to basic sanitation, so human excreta can be a source of public health hazards in many urban locations. Municipal waste collection is also limited in low-income countries, making it difficult to manage the high volumes of organic wastes adequately. This presents environmental hazards, for example, blocked drainage channels leading to flooding in lowland areas, and social nuisances, such as piles of discarded banana peels rotting on the roadside.

There is increasing recognition that a first step in addressing the problem of MSW is to reduce the production of it. Consumers have a responsibility of course, and there is increasing attention by governments to try to change consumer behavior in this respect. One example is that Chinese banqueting culture generates a huge wastage of food and the Chinese government is trying to change that.[22] But the problem of food waste goes beyond consumer behavior, since it involves wastage along the food value chain from production, along transport channels and in wholesale and retail markets

[19] https://ellenmacarthurfoundation.org/cities-and-circular-economy-for-food
[20] A search of the term 'waste into wealth'(?) on Google Scholar yielded 1.25 million hits.
[21] https://www.unep.org/explore-topics/resource-efficiency/what-we-do/cities/solid-waste-management
[22] https://www.straitstimes.com/asia/east-asia/china-to-strengthen-push-to-reduce-food-waste

as well as in the catering industry, so the first step of waste reduction needs to be throughout the food system (Reitemeier et al. 2021).

The scale of the MSW problem is recognized in the Sustainable Development Goals with the commitment to "by 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses" (Target 12.3).[23]

Adequate management of waste is a key part of urban development and beyond the reduction of waste, there is a role for UPA in recovery, reuse and recycling, a contribution that has been identified as one opportunity for the development-friendly greening of cities (Simon 2012). Recovery, reuse and recycling of organic wastes is labor-intensive and can be facilitated by, and add value to, UPA. This can contribute to different aspects of city resilience, including climate change mitigation and adaptation. The following two sections will examine the evidence for the contribution of agriculture to recovering and reusing solid wastes and the use of wastewater.

Recovery and reuse of solid waste

Organic solid waste contains nutrients that can be valuable both as animal feed and as fertilizer or soil conditioner for crop production or other types of urban uses. There are several ways that organic solid waste can be recovered and reused, some practices going back millennia (adapted from Cofie et al. 2006):

- Fresh and cooked waste from markets, restaurants and hotels as animal feed
- Food processing byproducts as feed
- Direct application of agricultural and market waste and other solid waste on and into the soil as mulch or soil conditioner
- Direct application of animal manure such as poultry/pig manure or cow dung
- Direct or mixed application of human excreta or bio-solids to the soil
- Planting crops directly onto waste dumps
- Mining of old waste dumps for application as fertilizer on farmland
- Diverse types of composting of solid waste or co-composting of solid waste with animal manure or human excreta.

The reuse of these different solid wastes present different challenges and yields different amounts of nutrients and other properties which are appropriate for different applications. They also carry different health risks and associated public attitudes. The issue of risk will be addressed in the following section.

Restaurant waste and processing byproducts are widely reused for pig feed, but they are sometimes difficult to digest and tend to increase formation of fat. So in Hanoi, Vietnam they are not fed to younger pigs, which receive agricultural byproducts such as sweet potato vines; food waste is instead fed to fattening pigs (Cesaro et al. 2019). In Kampala, Uganda, in addition to fresh and cooked food wastes from homes, restaurants, slaughterhouses and markets, other wastes such as crop byproducts and food processing byproducts from the brewing industry are also used for pig feed (Kyomugisha et al. 2007).

[23] https://sustainabledevelopment.un.org/sdg12

Kitchen waste and paper have been identified as the major components of domestic organic wastes and have been found to contain just 0.29% nitrogen and 0.16% phosphorus (De Bon et al. 2009). So, if directly applied to kitchen gardens, they are unlikely to increase the fertility of the soil significantly. But these solid wastes do have value as soil conditioner, and in some cases this may be the major value for urban soils with low organic matter. Animal wastes contain much higher mineral levels, which vary by animal source (Moreno-Caselles et al. 2002). The use of human excreta as a plant fertilizer has been widely practiced in antiquity in many parts of the world. The solids have both organic matter and nutrients, but the major part of the nutrients derive from urine (Drechsel et al. 2015). Its use continues in different parts of the world in rural and peri-urban areas, for example in northern Ghana (Cofie et al. 2005) and in rural and peri-urban China, typically in a mix with animal wastes, household organic wastes and some crop residues in a co-composting site under or close to the house (personal observation). However, public health concerns associated with increasingly dense urban settlements as well as public attitudes present challenges to the use of this nutrient source in UPA.

Planting directly onto old waste dumps, as is practiced in peri-urban areas of Kolkata, takes advantage of the residual nutrients in these areas, but also carries the risk of heavy metals and other contaminants. Mining of waste dumps carries similar risks and is likely to yield very uncertain levels of nutrients, given the variable content of these dumps (Datta et al. 2021).

A great deal is known about the technical aspects of composting different organic wastes (Cofie et al. 2006; Drechsel et al. 2015). Different organic materials may be processed into compost in different ways, through co-composting of manures and vegetative waste, or through vermiculture, and all can increase the concentration of nutrients and the quality of the compost. But many other factors also play a part in the decomposition of wastes and their eventual quality, such as carbon to nitrogen ratio, aeration, turning frequency and temperature (Cofie et al. 2006). For UPA livestock raisers, crop producers and other potential urban users of solid waste like nursery owners and landscapers, their interest is in the possibility that the urban nutrient sink can provide them low- or no-cost inputs to improve productivity, food production and income, and that the opportunity cost of acquiring nutritious input/feed is kept low. As well as technical knowledge about composting, there is also considerable agri-business knowledge and various proposals about turning composting into an enterprise and for improving the policy and regulatory environment for these enterprises (Drechsel et al. 2015; Senanayake et al. 2021). From the point of view of cities and their management of wastes and their move toward circular economies, the key question is the level of demand for direct or composted solid waste. What volumes of organic wastes can be directly and safely reused, or processed economically into a quality compost and sold on to users? Can it make a difference to the kinds of environmental problems identified above and offer economic benefits to urban producers and entrepreneurs?

An assessment of current use of different kinds of soil ameliorants by farmers in Ghana and their willingness to pay for municipal compost (Danso et al. 2006) found that, depending on regional availability, the most common types were poultry manure (especially around Kumasi), different types of chemical fertilizers, ‘black soil’, cattle dung and human excreta, particularly septic sludge around the northern city of Tamale (Cofie et al. 2005). Around the city of Bamako, Mali, cereal farmers (by preference) and horticulturalists (through lack of the preferred animal manure) are willing to pay for organic wastes for direct application, though the lack of removal of contaminants by farmers facing

land tenure uncertainty led to health concerns and plans by the local government to produce commercial compost (Cofie et al. 2006). It is reported that farmers would not be willing to pay the expected price of the processed compost, raising key issues about the realistic pricing of a commodity that embeds social and environmental as well as commercial value.

There is evidence of considerable demand for some of these solid wastes in the Nairobi, Kenya city region and also evidence of complex flows of solid wastes linking rural, peri-urban and urban production systems (Njenga et al. 2010). The documented flows of organic solid wastes in and around Nairobi reflect the situation in 2003 (Figure 5), showing significant demand for cattle manure produced by the animals of pastoral Maasai populations located 60-100 km from the city. Different kinds of urban agri-enterprises bought the manure, including horticulture producers, landscapers and plant nurseries. But a large quantity that was trucked into Nairobi to a manure trading center was then shipped out again to large rural producers of vegetables, tea and coffee for export. Other sources of manure come from livestock within the city. Based on estimates in Njenga et al. (2010) and earlier work on urban agriculture in Nairobi (Lee-Smith et al. 1987), there may be more than 30,000 farmers in the Nairobi area using manure from the region, with more than 10,000 producing it on their own mixed crop-livestock farms.

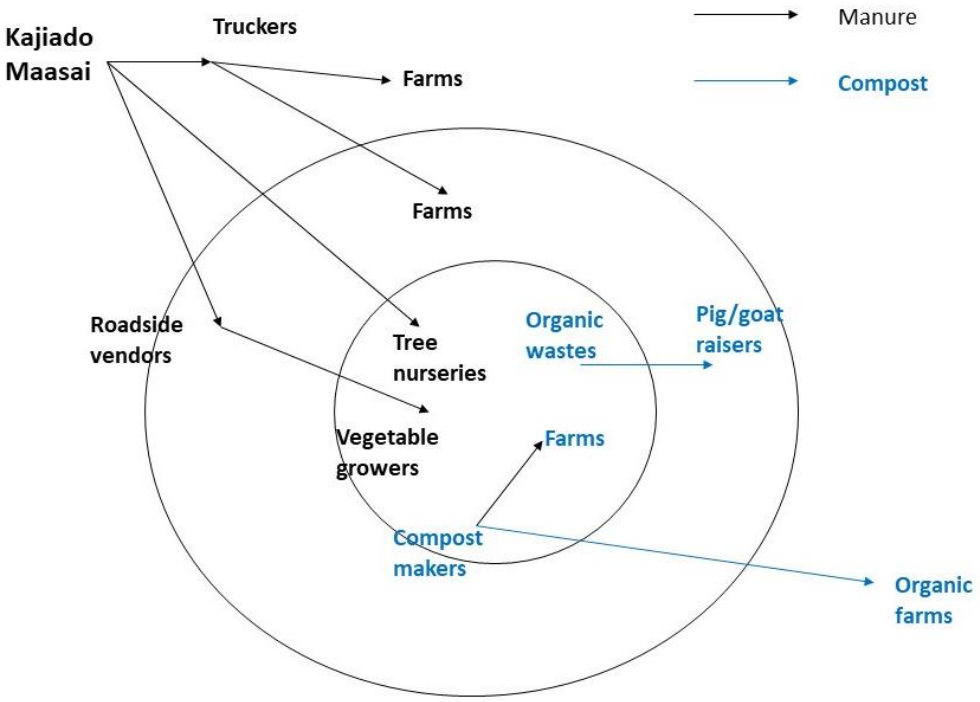

Figure 5. Rural–urban manure and compost markets in and around Nairobi, Kenya.
Source: Njenga et al. 2010.

Njenga et al. (2010) also examined the production and use of compost in Nairobi and surroundings. Researchers identified 14 community-based organizations that were thought to be the total number doing composting at that time, though composting by individual farmers, schools and other institutions were not included in the assessment. Among the surveyed community-based organizations, 2,500 tons of organic waste were used annually. This represented only 0.6% of the total organic waste produced in Nairobi at the time of survey. If individual and institutional use of waste were included, the total figure could certainly be higher, but the figure still remains a small proportion

of the total amount of organic waste generated by the city. In 2003, there was no public sector involvement in composting, and this partially explains the limited impact on total organic waste produced. An assessment of stakeholder involvement in composting in Hanoi, Vietnam indicates the need for both public and private stakeholder involvement, but also the challenges of such complex partnerships (Le et al. 2018).

As part of a four-city study, another assessment looked at the *use* of manure and compost, but not the *production* of compost (World Bank 2013). The authors found that 82% of sampled farmers used manure, and 44% used vegetable compost (Jyotishi et al 2011). They also found that 64% were using chemical fertilizer, which likely reflects national government policy in India of providing significant subsidies to keep fertilizer prices low. A similar situation was reported in Balangoda, Sri Lanka, where an innovative municipal initiative to produce compost from MSW was to some extent undermined by the cheap cost of subsidized fertilizer (Gianfelici et al. 2016). These authors note however that the application of chemical fertilizers to already poor soils led to leaching. The soils needed not only nutrients, but organic matter to condition the soil. This can be provided by compost and manure, but not by chemical fertilizers.

Wastewater use

Wastewater recovery and reuse has become a global imperative, given the predictions about widespread depletion of water resources, including of surface water in urban areas (UN-Water 2018; Flörke et al. 2018). Current definitions of wastewater vary between countries and are sufficiently broad that they merge with definitions of organic solid wastes in the degree of concentration of fecal sludge coming from on-site sanitation systems (Drechsel et al. 2010). But in its more liquid form it presents a different challenge compared to MSW. Treatment of wastewater is much more common in the Global North than in the Global South, though in urban areas of arid countries like Tunisia, Egypt and Chile, treated wastewater is used for agriculture (Drechsel et al. 2015). Nevertheless, the vast majority of wastewater used for irrigation is untreated. It is estimated that ten times more area is irrigated with diluted or raw wastewater in the Global South compared to areas irrigated with treated wastewater in the North (Scott et al. 2010).

The large area of agricultural land currently irrigated with diluted or raw wastewater in low- and middle-income countries reflects the informal demand from farmers for this abundant nutrient resource – wastewater irrigation in one of Mexico's central valleys delivers 2,400 kg of organic matter, 195 kg of nitrogen and 81 kg of phosphorus per hectare per year (Drechsel et al. 2015). In Nairobi, farmers access large drainage pipes carrying wastewater and allow it to irrigate vegetable plots. In sampled plots, levels of nitrogen, phosphorus and potassium were medium to very high in the soil profiles (Karanja et al. 2010). As well as adding nutrients, yields are increased though soil amendment from the organic matter. In the Nairobi case, organic carbon was medium to high throughout the soil profile. Availability of wastewater can also allow year-round cultivation in regions that experience dry seasons. As is the case with solid waste, the benefits of wastewater have been well studied. Two outstanding issues need to be addressed: one is the mitigation of food safety and occupational health risks arising from its use; the other is providing regulated access to wastewater in which the safety measures are applied. Both these issues will be taken up in Section 5 in relation to innovations and investments.

Summary and conclusions

As part of a movement away from the unsustainability of the linear energy in/waste out model of city functioning, there is increased attention on reducing, recovering, reusing and recycling MSW and wastewater through a focus on the circular bioeconomy. Waste management is one of the most commons services provided by local government throughout the world, yet it is still one of the major problems facing them. Reduction of waste, not only by consumers but throughout food value chains, is a key response. Beyond reduction of waste, UPA has a role to play in offering a development-friendly greening of cities through waste recovery, reuse and recycling.

A wide range of options exist for recovery and reuse of MSW. These include reuse as animal feed, crop nutrients and soil improvers, and municipal composting. Composting has a huge potential, but so far the evidence suggests that only a small amount of MSW is being recycled as compost, owing to a number of constraints, including challenges involving public–private partnerships.

The use of wastewater for agriculture is a crucial part of resilient cities, given the competition for water between agriculture and other urban uses. The vast majority of the wastewater currently used for irrigation is untreated, meaning that there are significant public health risks associated with this practice. Safe use of wastewater for UPA is a priority, and Section 5 discusses different options.

5. Innovation and resilience in city region agri-food systems: Investment needs

This paper has argued through the previous four sections that there is good evidence about the abundance of cropland within urban clusters and in their immediate hinterland and that significant numbers of urban dwellers are using that land for food production. Local food production is not the dominant source of food except for small numbers of families, but it contributes importantly to a diverse food supply that many writers consider the most sustainable way that cities can feed themselves. A recent paper categorizes these diverse sources and flows of food and the relationships involved in their production and forms of exchange as six distinct food systems (Moustier et al. 2021). Since these multiple flows and relationships co-exist within the same households and micro, small and medium enterprises and change over time with seasonal shifts and employment circumstances, it is preferred to consider this variation as diverse food flows and elements of the food environment within the food system, with a key differentiation identified between 'modern', formalized flows and relationships with regulation and contracts, epitomized by supermarkets and their backward and forward linkages, and informal flows and relationships, which includes most UPA and a huge proportion of employment in cities (Tefft et al. 2018).

The diversity of food supply includes locations within the city region, with an intensity that varies across the region and also across seasons. There is a compelling argument that this is the best way to understand urban food systems and the food environment of cities. The city region encompasses locations, especially the dynamic peri-urban interface and the rural 'outer edge' of that space, where agriculture is an important income source for individuals and households. Nevertheless, there are clear pressures on agricultural land both within the urban core and at the peri-urban interface, especially the 'inner edge' of that interface where cities are constantly expanding.

The urban, peri-urban and rural areas comprising the city region also provide livelihoods for diverse types of food-based enterprises, including wholesale traders, street food vendors, processors, market retailers, porters and other service providers and these sources of livelihood are essential for city resilience, though many of these types of work are precarious. The city region food system involves not only two-way flows of food, labor and finance, but also of agricultural inputs, organic nutrients and contaminants. The contaminants associated with organic and synthetic agricultural inputs and outputs can be threats to a city's resilience through their impacts on public health and they need to be mitigated. On the other hand, reusing and recycling the nutrients and organic matter in liquid and solid wastes benefits agriculture and can itself provide additional opportunities for income and livelihoods. Urban and peri-urban livestock raising and crop production – involving 'productive green spaces' in environmental terms – together with their capacity to reuse and recycle liquid and solid organic wastes, can contribute to mitigating and adapting to climate change, further enhancing the resilience of cities. Municipal governments, in partnership in some cases with national governments, and very often with the private sector and civil society, have a key role in taking advantage of the opportunities of local food production, distribution and consumption and the reuse and recycling of natural resources to benefit their populations and the environment and to confront public health risks. As a prelude to discussing innovation and investment opportunities, it is important to consider further the changing relation of municipal governments to food.

5.1 City governance, food and agriculture

Among the Sustainable Development Goals there is a global agreement to ensure safe, equitable access to healthy, appropriate and sufficient food, inclusive access to decent work and more sustainable forms of production and consumption, ensuring resilience in the face of climate change. There is a special commitment through Goal 11 to make cities and urban communities more sustainable in relation to housing, transport, waste management, the provision of green spaces and climate change mitigation and adaptation, and this Goal clearly involves an obligation by cities themselves. Different dimensions of this civic responsibility have been recognized and adopted by multiple city networks in recent years. Some of the major networks, and those championing specific aspects of the Sustainable Development Goals, are as follows:

- United Cities and Local Governments is a global network of cities and local, regional and metropolitan governments and their associations which is committed to representing, defending and amplifying the voices of local and regional government to leave no one and no place behind. The network seeks to make the ideals of the Sustainable Development Goals a lived reality. It has approximately 240,000 members in over 140 countries.
- ICLEI – Local Governments for Sustainability is a network of more than 2,500 cities and city regions accounting for at least 20% of the global population. It pledges to make sustainable development the only model for development in the urban twenty-first century, through low-emission development, nature-based development, circular development, resilient development and equitable and people-centered development.
- The Milan Urban Food Policy Pact has so far been signed by a group of 217 cities, which commit to sustainable diets and nutrition, social and economic equity, sustainable food production (through UPA), safe, fair and efficient food supply and distribution and reduced food waste.
- C40 is a global network of mayors of nearly 100 world-leading cities collaborating to take urgent action to confront the climate crisis. Membership is based on performance in addressing the climate crisis in order to be considered climate leaders.
- The Resilient Cities Network consists of leading urban resilience practitioners committed to building and investing in urban resilience. It is spread across five geographical regions and operates through communities of practice, at present mainly Resilient Recovery and Waste Management in Crisis.
- The FAO Green Cities Initiative is a new initiative to build a network of cities of all sizes and through sharing and co-learning improve the urban environment, strengthen urban-rural linkages and build the resilience of urban systems. It helps provide access to a healthy environment and healthy diets through sustainable agri-food systems and green spaces through urban forestry. It complements another network supported by FAO on City Region Food Systems.

Though many of these networks have large memberships, there are still many cities that have not yet signed up to specific commitments in the areas of sustainable development, equitable and sustainable food policies or climate change mitigation and adaptation approaches. Some national and municipal governments can still provide a disabling environment for UPA and its contribution to food, incomes and an improved urban environment, as earlier parts of this paper have indicated. As many studies have made clear, insecure access to land for cultivation means that producers can easily be harassed or evicted. With the expansion of residential and commercial developments at the peri-urban

interface often unplanned, agriculture and food production have often lost out. Despite their importance for supplying food to low-income populations, local wet markets are often lacking infrastructure and security, especially for women, and street food vendors are also vulnerable to harassment or violence. The informal food sector also faces challenges around food safety and has opportunities to enhance the healthiness of foods sold (McGregor et al. 2006; Marocchino 2009; Cabannes and Marocchino 2018).

Until quite recently, food has been a marginal or non-existent topic in most city administrations and urban planning units in the Global South (Cabannes and Marocchino 2018; Acharya et al. 2020). According to Acharya et al., food in cities was "everybody's business and nobody's business". These writers have identified the entrenched rural/urban dichotomy as a key explanation, and especially the idea that food and agriculture were part of the rural domain and the responsibility of Ministries of Agriculture. This perception was reinforced through the dominant international understanding of food security until the late 1990s, that of ensuring global availability of food and minimizing fluctuations in food supplies, especially to urban areas, through application of the concept of food stability (Løvendal et al. 2004). The ideological dichotomy of rural/urban was also a legacy of colonial regimes in the Global South, which imported ideas about "chasing farming out of cities" (Prain 2010b) or, as in Yaoundé, Cameroon, created situations where "urban agriculture has been playing hide-and-seek with urban management for a century" (Bopda and Awono 2010). The dichotomy between food and agriculture and urban concerns has existed in the donor community, within multilateral agencies, in national governments, and of course within cities, where different agencies have been responsible for health (sometimes including nutrition), food safety, markets and management of food and other wastes, frequently with no agency responsible for agriculture.

In Section 4.1, the dichotomy between food and food security on the one hand and urban issues on the other was raised as a major reason for the "invisible crisis" of urban food insecurity (Crush and Frayne 2010). Attention to the dynamism of the peri-urban interface helped to highlight the fallacy of the rural/urban dichotomy and showed how food production and food marketing merged across rural and urban space and needed policy and planning attention (McGregor et al. 2006). Publications by UN-Habitat (2009) and a regional conference for Africa on Urbanization and Food Security (FAO 2008) identified urban governance as the key dimension of intervention to address urban food security, and a number of types of interventions were identified, such as forward planning for the needs of the poor, monitoring of urban poverty, attention to the affordability of safe and health foods and encouraging their production in urban and peri-urban areas as well as in rural farmland. The same year as the conference, the African Food Security Urban Network was formed in Southern Africa, with strong university leadership and active involvement by NGOs and municipal networks linked to ICLEI.

There has been a particular weakness in the inclusion of food in urban planning and an even stronger regulatory exclusion of food production (Davila 2006; Cabannes and Marocchino 2018). The major challenges affecting urban areas that have been discussed above, such as the growth of under- and over-nutrition, inequality and poverty in city populations; issues affecting the informal food sector; access to land for local food-related activities; and the urban challenge of climate change are all factors that need an urban planning response according to Cabannes and Marocchino (2018). And a response is needed not just in megacities, but also in the small and medium cities and their immediate rural hinterlands where the bulk of the global population lives and where most poverty is concentrated (Berdegué et al. 2014).

A measure of how far cities have yet to travel to systematically include food in city governance is provided through a 2019 survey of 170 cities in 21 Asian countries, ranging in size from under 200,000 population to eight cities of more than 10 million (Acharya et al. 2020). The authors found that only 8% of these cities were "food smart". This designation was based on the extent to which cities demonstrated through their diagnostics, plans, regulations, initiatives and actions that they are **proactive** (forward-looking to future food-related problems and opportunities), **integrative** (multisectoral and well-coordinated across public and private entities involved in food issues) and **inclusive** (attending to the disadvantaged, vulnerable and poor and engaging with civil society). The authors concluded that nearly 75% of the cities surveyed "are either approaching food issues in a reactive, firefighting mode or are at a comparatively early stage in the development and implementation of a forward-looking, coherent, and inclusive approach to food policy and governance" (Acharya et al. 2020: 55). Where there has been policy action, it has more frequently involved supporting food production rather than consumption. Given that cities are frequently characterized as the passive recipients and consumers of linear food supply chains, the "food court" vision of cities as these authors characterize it, this is ironic. They found just under 20% have programs for food banks or food reuse, only 24% have food-based social support like food stamps or communal kitchens, and just under 50% have food security provisions to deal with crises.

Acharya et al. (2020) also identified significant information fragmentation and gaps faced by urban planners and policymakers in relation to the urban food system, making redesign and monitoring difficult. A similar point was made by Padgham et al. (2015) about the quality of information about UPA, based on their study of nine cities:

> Information about UPA is fragmented and largely out of date, as was apparent across the nine cities examined in this assessment. The lack of reliable data on the contribution of UPA to urban food systems, food security, and livelihoods in cities reflects the informal nature of the enterprise and its various non-income dimensions that do not conform to official information-gathering efforts that prioritize economic indicators within the formal economy. (Padgham et al. 2015: 198)

The implication of these various concerns is that "official information-gathering" needs to be modified to address the reality of cities where up to 80% of the economy is informal.

As has been argued in much of the literature on urban food systems in sub-Saharan Africa and on city region food systems cited earlier, urban and peri-urban food production need to be understood in relation to food marketing, food consumption and the environmental services it provides in a food systems perspective (Blay-Palmer et al. 2018). Acharya et al. (2020) did not find that the wealth of countries was a unique indicator of being food smart, suggesting that other factors apart from financial resources play a part in enactment of particular food system policies, which also echoes one of the messages of Crush et al. (2011) from their study of 11 cities in Southern Africa: that there will be variability in the contexts where institutional and policy actions can successfully support urban and peri-urban food production and other aspects of the urban food system.

The focus in this section is strengthening the enabling policies, regulations and practices of municipal government vis-à-vis urban food systems and the environment and thus remove the disabling, discouraging or marginalizing policies. How can cities support local food production and a vibrant local food marketing sector, while ensuring that the foods that come from the city region and beyond are

safe and have a reduced carbon footprint? How can they strengthen the circular economy of cities through facilitating recovery and reuse of solid and liquid wastes through agriculture, while reducing health and environmental risks? It is important to keep in mind the widespread opinion across different studies that variability in urban food supply is likely to contribute to greater city resilience, so it is unrealistic and undesirable that city food economies can be 100% homegrown. It is also important to recognize the greater resilience in diverse working opportunities, with agricultural production a part of that livelihood diversity, more or less important depending on location and circumstances.

The creation of an enabling environment for urban food systems is not the unique responsibility of local government, but local government has a major responsibility to lead and coordinate and build partnerships. It is suggested that to achieve this goal, investments will be needed in partnerships of local and national governments, with the private sector and with civil society, focused around three types of innovation: infrastructure/technology, incentives and incubation – '3i' innovation for short. These involve both senses of innovation, as new soft and hard infrastructure, technologies and practices, and also as new multistakeholder processes of incubation and scaling (Hall et al. 2006; Hall and Dorai 2013; Wigboldus et al. 2016). There is a need to invest in both innovative physical and institutional infrastructure – like new kinds of green markets – to increase sustainability, efficiency and equity. There is need to invest in technical innovations along the value chain, including production, marketing, processing and storage. Incentive structures are a kind of institutional innovation, including capacity building, social inclusion and financial reconfigurations, so as to involve different stakeholders in supporting, investing in and practicing urban food production, processing and marketing. There is also a need to invest in innovation as part of a process, from niche proof-of-concept activities to supporting more widespread uptake through business incubation and scaling activities, recognizing that financial support will be needed over a certain time in different types of food-related enterprises before they become viable and independent (Hall and Dorai 2013). The next section will explore the need for 3i investments to enable city regions to move toward 'edible landscapes', that is to say, urban and peri-urban spaces that are planned, designed and protected with food, food production and food systems in mind (Bhatt 2005).

5.2 Protecting and boosting the edible landscape of city regions

Two key challenges face local governments in relation to protecting and expanding food production across urban and peri-urban spaces. The first concerns the recognition that UPA does not respect sectoral or administrative boundaries. Local food production is a part of the urban food system, contributing to subsistence and to fresh and processed food for different urban markets, providing employment that enables the purchase of other types of food, the generation and consumption of waste, participation in producer or irrigation groups and so on. Urban food systems are themselves involved in spatially diverse points of supply and distribution that can best be understood at the city region level, a space that is occupied by multiple administrative jurisdictions. There is a need for cross-sectoral and multistakeholder food and natural resource policy coordination across these jurisdictions to ensure an efficient, inclusive food system within the city region.

The second challenge is about the disappearance of agricultural land under construction sites, quarries or brick-making businesses that service relentless urban growth and the diversion of surface- and groundwater resources to those residential, commercial or industrial needs. This loss of land and

water resources occurs within urban boundaries and is a threat to small-scale food production for low-income residents as well as the contribution of small-scale agriculture to conserving green spaces, with environmental benefits for the city. The challenge is also critical in peri-urban areas where larger areas of cropland and livestock-raising enterprises are under threat from urban encroachment. Local governments are faced not only with finding ways to protect these areas as components of local food value chains with environmental and food security benefits for the population, but to help boost the productivity of these systems either through bringing unused spaces into production or supporting technical innovation or a combination of both.

Innovative planning and governance: Stakeholder engagement for city region food systems

Within all levels of government there are multiple competing interests that make food policy development and implementation difficult, and agents of policy change can be located at different levels or in different combinations (Tefft et al. 2020). Change can be led by city governments themselves, sometimes where there is a power vacuum at the national level or a national crisis. But often it is because city governments are "the natural pioneers of food system governance in rapidly urbanizing contexts" (Acharya et al. 2020: 67). The demographic, political and economic reasons for this pioneer status were discussed in previous sections. City-level 'pioneer' initiatives may also depend on strong actions by civil society. This was the case with Quito, Ecuador, where a strong civil society actions combined with a dynamic mayor (Tefft et al. 2020). But urban food system change can also occur through the influence of national policies and direction, sometimes via gateway issues like urban agriculture (Japan, Philippines, Kenya), food safety (Philippines) or nutrition (Bangladesh). In other cases there are hybrid combinations of both city action and national influence, where local initiatives build on or use national initiatives and policies. Below the paper looks briefly at examples of some of these different sources of food policy

Medellín, Colombia: Horizontal and vertical linkages to forge city region food system cooperation

Medellín, Colombia became a 'food city' in 2015, when the national government was still heavily focused on the FARC insurgency and efforts to reach a truce, with limited political space for other concerns, and the city faced the challenge of supporting large numbers of food-insecure refugees from the insurgency (Tefft et al. 2020). The city-led approach involved strong leadership from the mayor combined with the forging of horizontal linkages between civil society and the municipal government, and within the government between different departments to pool resources. The ability to overcome internal competing interests in the establishment of internal horizontal governance relations within the municipality of Medellín and with civil society was probably a factor facilitating the establishment of collaboration with 31 municipalities within the province. This broad horizontal alliance was a factor that influenced the formation of vertical governance relations with the provincial government of Antioquia which helped consolidate the city region food system in Antioquia.

The formation of horizontal governance arrangements for urban and city regional food systems face several political economy challenges and threats (Tefft et al. 2020). These relationships not only cut across administrative boundaries, they also often cut across rural and urban development policies and agencies, as well as sectoral policies and agencies (Berdegué et al. 2014). They will face inevitable political transitions between old and new city authorities where priorities and alliances often change, sometimes completely reversing food system policies (Santandreu 2018). Threats also include interdepartmental rivalry and powerplays. Facilitation and partnership brokering by food professionals can help to overcome these challenges as well as to stimulate and guide planning

processes (Blay-Palmer et al. 2018). In the case of Medellín this facilitating role was provided by a team of food systems specialists from FAO and RUAF (Dubbeling et al. 2017).

A key entry point for food policy action in Medellín was the recognition by local authorities of the urgency of addressing local food and nutrition insecurity and addressing that problem at a city region level, sourcing increased amounts of food from urban and peri-urban agriculture. A Food Security Unit launched programs targeting the vulnerable, while a Territorial Management Plan protected existing agriculture, prevented agricultural fragmentation and promoted organic agriculture. These and other policies allowed the city region to develop.

Rosario, Argentina: From urban agriculture to city region food system

Rosario is another example of a city-led initiative on urban food systems governance and the elaboration of a city region approach to food systems where urban agriculture was the starting point (Dubbeling et al. 2016; Blay-Palmer et al. 2018). The economic, political and social crisis that gripped Argentina in 2001 seems to have led to national paralysis in relation to urban food policy, despite growing food insecurity throughout the country. Innovative action was taken at the city level, first through the spontaneous expansion of urban agriculture for additional food and income, then through the incorporation of urban agriculture into municipal policy. Loss of peri-urban land to urbanization and conversion to export crops over the following years led to long-value-chain supply of vegetables to the city. As part of efforts to reverse this situation and recover the historical supply of fresh fruit and vegetables from the peri-urban greenbelt surrounding the city and to reduce use of agro-chemicals, Rosario established ecological agriculture and substituted food products coming from long distances with ecological produce. Rosario established a vertical collaboration with the Province of Santa Fe to further protect the peri-urban greenbelt, leading to the formation of a city region. This also gradually began to include strengthened linkages with civil society organizations and cooperation with other municipalities within the region in an expanding series of horizontal relationships. The municipality doubled the area of protected peri-urban horticultural land in its development plan, and facilitated direct marketing of ecological horticulture products to local hotels and restaurants under a 'Product from My Area' label, which also generated a 20% mark-up on normal vegetable prices. A Metropolitan Coordination Unit was established in the Rosario Metropolitan Area to coordinate the protection of the greenbelt lands producing vegetables among the different localities involved.

Nairobi, Kenya: The influence of national government on the local food system

This case depended on guidance to the Nairobi city government from national sector strategies, plans and policies, which also provided technical expertise from national agencies represented within the municipal and provincial levels. These national policy and advisory inputs were also supplemented by access to financial transfers from the different line ministries involved. This model, which depends on vertical relationships, is often associated with decentralization processes and delegation of responsibilities. For these reasons, there is a tendency for food system implementation to occur along sectoral lines (Tefft et al. 2020). This probably leads to reduced tensions and power plays because there is less developed horizontal, cross-sectoral and multistakeholder coordination. This may be why there is little evidence in the case of Nairobi of the establishment of a city region food system approach. The strong sectoral focus of national staff within city line agencies partly explains this. But once again, the entry point for food systems policy development was identified as UPA, and there was strong civil society support and policy action on UPA at both the municipal and national level over several years (Lee-Smith 2010). Support from the municipality for UPA has provided training and

capacity building in sustainable crop cultivation and livestock raising; facilitating collaboration between different stakeholders in managing organic waste; and facilitating activities in quality aquaculture. The municipality has led the monitoring and regulation of UPA in accordance with relevant legislation and also monitors hygiene and sanitation issues in the handling and treatment of agricultural products. There have been efforts to collect and manage data on UPA activities and programs as a learning process for improving the role of the municipality.

Lima, Peru: "One step forward, two steps back" for the urban food system

In Peru, the environmental and social challenges facing Lima caused by a desert location, declining water resources and the severe social conditions of millions of citizens located in informal desert settlements surrounding the city has created strong pressure to address food issues. The presence of a national food security strategy provided a basis for the municipality of Lima to develop its own projects, policies and food standards, and these built on a long tradition of small-scale cultivation within the city and larger horticultural plots along the irrigated river valleys that dissect the city (Santandreu 2018; Tefft et al. 2020). Although the Lima Metropolitan Government (which has both municipal and regional competencies) incorporated UPA within environmental and food policies, it was unable to influence peri-urban agriculture, since the metropolitan territory is divided between 42 district municipalities with distinct administrative responsibilities. One is the responsibility for land use and policy. Although the metropolitan mayor exercises some influence over the district mayors, these were never converted into a city region framework of cooperation. This was mainly due to many of the district mayors being from different political parties than the metropolitan mayor (Santandreu 2018). As well as focusing on intra-urban agriculture for these political reasons, the Metropolitan Government also established a network of green markets, which benefited peri-urban organic producers who were able to sell their vegetables, fruits and other products at premium prices (Arce et al. 2007; Tefft et al. 2020). Nevertheless, in Lima, policies were not sufficiently embedded to survive political changes within the Metropolitan Government. A new administration in 2015 moved priorities away from UPA, providing the basis for a recent assessment of this recent history of policy and regulatory support for food systems: "one step forward, two steps back" (Santandreu 2018).

Quito, Ecuador: strong municipal food systems initiatives supported programmatically and financially by national government

Food systems issues in Quito's local government originally related to the geological and climatic vulnerability of the Andean location. On top of the environmental issues, it took an economic crisis with large-scale in-migration, similar to the situation in Medellín, that led to food being included in city planning. This may have been accelerated through the autonomous adoption of urban agriculture by large numbers of the low-income population, both in the inner city areas and on the peri-urban hillsides. The recognition of the food insecurity issues combined with the spontaneous cultivation practices led the city government to initiate one of the key catalytic city-level programs in Quito, AGRUPAR, a participatory urban agriculture initiative which linked with civil society. This received strong national government support with policy innovation at both levels accelerating change processes. The presence of food systems specialists actively supported innovation toward a city region food systems perspective (Dubbeling et al. 2017).

Multistakeholder engagement in urban food systems in Asia

There are few examples of multistakeholder engagement in city region food systems in Asia.[24] Colombo, Sri Lanka has been examined as an example of a city region and the stakeholder interactions reviewed (Dubbeling et al. 2016). There seems to have been a strong role played by the provincial government agencies in driving the process. A key concern for the provincial government was the urbanization processes that threatened natural water flows and drainage, which in turn posed flooding threats to Colombo. Taking a city region perspective, the provincial government agencies, especially the Ministry of Agriculture promoted the role of agriculture in buffering vulnerable lands to prevent construction. Yet stakeholder coordination was limited, both vertical relations between the provincial government and local authorities, and also horizontal collaboration among municipalities. The authors suggest that the established hierarchical relations and roles of the provincial and local authorities was a key factor.

The recent regional assessment of urban food systems conducted by the World Bank (Acharya et al. 2020) uses the concept of city region as a basic geographical space over which different recommendations for distinct stakeholders, such as civil society organizations, large food companies, and city leaders and policymakers, for whom the following recommendation is made: "Advocate among national leaders and technical agencies to reform national laws and regulations and strengthen specific national guidelines to better enable or facilitate (food system) actions at the city-region level" (Acharya et al. 2020: 103). The concept is taken as self-evident and stakeholder action assumed to be often appropriate in that space.

Multistakeholder engagement in urban food systems in Southern Africa

The stakeholder engagement in food systems in Southern Africa has followed a rather different approach than the cases described in Latin America and Nairobi, being based on strong external facilitation. The African Food Security Urban Network (AFSUN) was established through a joint initiative between universities in Canada and in South Africa . These universities and partner NGOs initially identified nine countries and eleven cities of differing size and complexity, based on the presence of local expertise and the expression of interest and engagement by local policymakers (Crush and Frayne 2010). Crush and Frayne recognize that food production and distribution networks operate across and between cities and countries in Southern Africa, and families often operate "stretched household" food security strategies, straddling rural-urban and national boundaries. But there is no suggestion that the selected cities exist within any kind of integrated foodshed or city region in the sense utilized by Blay-Palmer et al. (2018), or that such a focus is a priority. Rather, the selection of the cities provides a regional platform that has been researcher-led, for addressing key issues affecting urban food security such as HIV/AIDS and gender, the possibility of supporting learning between cities, and the organizational structure to facilitate training, research, policy and advocacy. The platform also champions community support structures. The AFSUN authors also indicate that the capacity of national governments is still weak to be able to deal with urban food systems and food security issues and that civil society organizations are also still challenged in this area. Engaging at city

[24] There exists a different version of the city region that has been studied in Southeast and East Asia as the 'extended metropolitan region', also referred to as *desakota* or 'city village' (Simon et al. 2006). According to these authors it has a strong Asian morphology, with poly-centric urbanization and continued agriculture around those urban centers. With the different municipalities and their surrounding agriculture in the Rosario and Quito city regions, there may be several similarities.

level is expected to offer maximum opportunity for building a knowledge base through research, capacity building and cross-learning.

Lessons for investment opportunities

Multistakeholder engagement had different degrees of formalization and different degrees of emphasis on horizontal and vertical collaboration in the different cities. In Belo Horizonte, Brazil and Quito, Ecuador, there is formalization of both vertical and horizontal relations in the Municipal Council of Food and Nutrition Security, and the AGRUPAR organization respectively (Tefft et al. 2020). Lima on the other hand represents a case where only informal influencing could be established between different authorities and organizations, whose relationship was ambiguously both vertical (the metropolitan authority and the districts) as well as horizontal (a distribution of different jurisdictions across space). This contributed to the political reversals with urban food systems and UPA.[25]

Taken together with the evidence accumulated in previous sections about the interconnectedness of food systems and the environmental and economic value of stimulating increased food supply from urban and peri-urban sources, the lessons from these brief cases do suggest the need to support and strengthen multistakeholder engagement in the urban food system, which concerns food systems governance, including governance of UPA.

There are a number of key investments that can be identified.

1. **Promoting institutional innovation** as an area of innovation requiring at least as much attention as technical innovation. This is not a new observation, but when the focus of attention is the supposedly 'technical' fields of agriculture and food, there is a danger of looking for innovative solutions only from the technical experts. This is a mistake that has been made countless times within the CGIAR for example: looking for technical fixes, for example in 'solving' the issue of high-quality crop seed through better ways of eliminating pathogens, when many of the problems were in the institutional arrangements for delivering seed to farmers (Danielsen et al. 2005).
2. **Innovative investment in building institutional infrastructure**. Time can profitably be used by stakeholders for building the necessary institutional infrastructure for urban food systems governance. This means providing the opportunity for stakeholders to share their own goals and objectives, assess requirements and negotiate relative commitments and contributions on the basis of strengths and weaknesses of the different national and city-level authorities and agencies involved (Horton et al. 2009).
3. **Cross-sectoral engagement and partnership**. The partnership negotiation described above needs to be conducted in recognition of the fundamental requirement for cross-sectoral engagement in relation to food systems governance and in particular, the governance of UPA. As the previous sections made clear, there are nutritional, marketing, employment, environmental and even educational considerations in building urban food systems and these different sectors can be encouraged to interact and cooperate.
4. **Participatory approaches to consultation and decision making**. Another key ingredient illustrated in the case studies that can be encouraged by strategic investment is a participatory approach to consultation and decision making, also referred to as multistakeholder planning (de Zeeuw and Dubbeling 2015). This means ensuring the

[25] Factors determining the types of stakeholder arrangements and partnerships that exist in particular circumstances are quite common across many research and development fields and it is possible to identify a number of success factors in relation to trust, transparency and mutuality (Horton et al. 2009).

involvement of local civil society stakeholders and the case studies show that in several cases they were highly instrumental in building food system governance arrangements. Participatory approaches also ensure that the voices of women and men involved in UPA and other aspects of the food system can be heard. Participatory planning and budgeting is increasingly mainstreaming in different local governments in the Global South, including in relation to food planning (Cabannes and Marocchino 2018), but participatory governance processes also need to be supported.

5. **Development of national food policy frameworks**. The case studies have shown that national food policy and food systems frameworks can stimulate or leverage food systems actions and framework development at urban and city region level. Financial investments in helping national governments to develop such policies and frameworks where they do not exist can therefore have high potential payoffs in terms 'scaling down' to lower levels of government.
6. **Identification and facilitation of 'development brokers'**. To support 'scaling down' processes of national frameworks and the reverse influencing by city-level proactivity on national governments in food systems governance, it can be important to invest in identifying and facilitating external 'development brokers' that can support and mediate horizontal and vertical relationships and joint learning, including to strengthen city regions. FAO, RUAF and at one time also the CGIAR have played this role in relation to food system governance.
7. **Addressing information fragmentation and gaps**. Several writers cited in this report have noted the fragmentation or gaps in information about urban food systems that can weaken governance processes. This is an important opportunity to invest in better data collection, processing and management in order to strengthen food systems governance. Some specific aspects of strengthening data collection will be mentioned in the following sub-section.

Box 2. Food systems governance and COVID-19

The balance between vertical and horizontal relationships involved in food governance seems to have been radically changed through the COVID-19 situation. It appears that vertical, directional decision making has been considerably strengthened in relation to food security by national governments, at the expense of horizontal, more negotiated relations (Blay-Palmer et al. 2021).

Protecting and boosting agricultural resources: Land, water, technology

UPA acts at two levels. It is a popular, spontaneous intervention in local food systems by individuals and households under particular circumstances to increase food provisioning for the household and/or to earn income through sale of food produced to city markets. But it can also be an entry point, a point of departure for local leaders and civil society organizations to build a more comprehensive approach to food availability, access and utilization through linking production with post-harvest facilities, markets, nutrition programs and recovery and reuse of organic wastes – in other words, establishing food systems governance, including with a city region food systems perspective. This governance capacity can then further strengthen and sustain the practice of urban agriculture through planning, policies and programs in a virtuous cycle. But cities are complex entities. Urbanization processes themselves threaten the capacity of UPA to contribute to this virtuous cycle. After building

governance capacity, this is the second challenge for city innovation, to protect and boost urban and peri-urban agriculture.

The most urgent need for innovative interventions and investment is occurring within peri-urban areas, especially at the inner interface, where agriculture confronts the expanding city. This is where horticulture and livestock raising contribute significantly to the urban food system. Innovations are needed to enable agriculture to make a visible, significant economic and environmental contribution to this dynamic space.

Improving perceptions and understanding of UPA through mapping

In many cities in the Global South, outer urban districts in fact are located at the peri-urban interface, with part of the district absorbed within the urban through residential construction, location of businesses and factories and presence of connecting roads and mass transit systems. The other part of the district includes a mixture of horticultural plots, animal-raising facilities, and the preliminary conversions of land use to contribute to urbanization: brick-making and quarrying (Douglas 2006). One of the challenges in relation to the administration of such transitional spaces is the 'invisibility' of the peri-urban part of the district in terms of policy and finance, and the high visibility of the urbanized part. This unequal treatment is partly related to revenues and taxes coming in from the commercial and residential properties and corresponding demands for council services, but it is also where the greatest numbers of electoral votes reside. For the local government to begin to help sustain the agricultural part of the district, it needs to become more visible and understood as a legitimate occupation, as a revenue source and as a contribution to the city-wide food system on which all citizens depend. It also needs to be seen as a valuable contribution to the well-being of the urban ecosystem. In many circumstances in relation to peri-urban agriculture, the sequence visibility, understanding, political will and commitment is a more powerful force than regulatory instruments for the protection of agricultural spaces. The invisibility or marginality of agriculture is even more acute in more densely settled parts of cities, and the importance of changing perceptions about agriculture as one component of livelihoods within the city is also important.

Mapping is a tool for bringing alive the food system and is a way of making agriculture visible within that system (Cabannes and Marocchino 2018). Being able to visualize agriculture's scale within a city district can stimulate a dialogue among stakeholders about the food security and economic potential of cultivation and livestock raising. Mapping can also alert stakeholders to the ecosystem services provided by agriculture through its visible buffering role near areas with environmental risks (Lwasa et al. 2014). This process of making peri-urban agriculture visible and moving from there to its institutional recognition and policy formulation was a key component of work conducted in Lima, Peru from 2003 to 2010 (Raymundo et al. 2007; Castro 2007). Mapping is also identified as a tool used by municipal authorities in Asia to support planning activities and curb pressure of urban expansion on farmland (Archarya et al. 2020).

Directly supporting municipal geographic information systems (GIS) capacity or working through external 'development brokers'. Ideally the use of geospatial techniques to visualize the use of natural resources within an urban or peri-urban space and more generally to make urban planning more knowledge-based (Baud et al. 2016) would be undertaken by municipal governments themselves. Though higher levels of government in the Global South may have access, many lower levels do not have the hardware, the software or indeed GIS capacities for this work. In such cases support may

need to be provided to an external 'development broker', such as a national university, NGO or international agency with GIS capacity and equipment, to demonstrate the importance of spatial knowledge for food systems and UPA planning and to help build GIS capacity within local governments. Further support would be needed to enable local governments to have access to equipment and software for undertaking their own geospatial analysis in real time and historically of the changing peri-urban areas around cities.[26]

Use of agritourism and pedagogy to highlight the role of UPA. Other innovative ways of making agriculture at the peri-urban interface and within the city more visible and more positively integrated with the urban core can be via agritourism and school activities. Such activities not only showcase for local government officials the value of UPA as a multifunctional resource, but also increase the value of these agricultural areas in the perception of urban residents (Fang et al. 2005; Dubbeling and de Zeeuw 2011). These require the establishment of training programs in agritourism for local governments personnel and specialist agricultural training for teachers.

Peri-urban interface: Agricultural land use and land use planning innovations

The enormous loss of agricultural land at the peri-urban interface has been discussed in earlier sections. In many parts of the Global South this is occurring through informal land markets and 'land grabbing' operating in an environment without land use planning or with policies on land use that are not being implemented. Formulating zoning policies, for example, is a first step, achieved once perceptions have shifted about the value of agriculture among national and/or municipal decision makers. What this means in practice is matching the commercial pressure exerted by business interests for land use conversion – which of course is responding to urban pressures for housing and commercial space – with arguments and actions in response to the imperatives of environmental protection, contributing to urban food security and protecting jobs.

There seems to be some evidence that this shift is occurring in some regions. In Asia, just over 60% of a sample of 170 cities in 21 countries have some land zoning for agriculture in city plans (Acharya et al. 2020). This does not mean that these zoning plans for agriculture are fully implemented, but it does indicate a shift in perceptions.

Although there is a considerable experience and a large toolbox of measures for land use zoning that have been developed and applied in rich 'crowded' countries to protect farmland near cities (Acharya et al. 2020), there is limited experience of their application in low- and middle-income countries. With the exception of China (Tefft et al. 2020), many of these countries have less well-resourced municipal authorities and greater informality in the land market. Even though Kenya has a national policy on land use, including the protection of agricultural land, and this authority was devolved to Nairobi in 2013, land grabbing within Nairobi continues.

Establishment of well-supported 'incubator' agricultural zones in peri-urban areas. Zoning has to start somehow. As the study by Acharya et al. (2020) indicates, although there are 61% of cities in their Asian sample that have land zoning for agriculture *in their plans*, it is not clear what percent have implemented these plans and in what way. Establishing incubator or pilot areas in municipalities where no plans exist or where plans are yet to be implemented can help municipal governments and

[26] Raymundo et al. (2007) and Castro (2007) report the case of a brokering role undertaken by an international research and development program on urban and peri-urban agriculture together with a district government in Lima, Peru.

peri-urban producers demonstrate the importance of protecting and boosting agriculture on the urban fringe. There are multiple actions that can support such zoning initiatives:

- Incentivize agricultural investment by farmers through improved access to financing (Cabannes 2012). This author notes a number of trends regarding both private and public sector financing of UPA. Urban farmers are often unwilling to accept loans and very commonly self-finance, meaning that there are limited options for investment. Private finance institutions are often unwilling to lend to urban farmers, seeing them as high risk, either because of harvest failures or likelihood to default, though without evidence that defaults were higher than other sectors. The public sector in some cases provides limited financing for UPA, for example in China. Though many local municipalities lack resources to make their own loans, they can encourage private sector lenders to be more open to supporting urban farmers.
- Municipalities can also provide licenses, make guarantees to those farming within incubator agricultural zones and more generally to maintain rural land tax rates and not shift urban rates, provide exemptions from water tariffs and so on (Mubvami et al. 2006).
- Municipalities can provide more attentive agricultural extension services to those farming within the incubator zone. There is variable information on how far cities provide these kinds of services. Acharya et al. (2020) report that almost two-thirds of the 171 cities in Asia that were sampled have extension services. For Africa and Latin America, the services are much rarer, with private sector input businesses mostly providing agricultural information (Prain et al. 2007).
- Incubator agricultural zones can be used to publicize the economic and environmental advantages to the city of protecting and boosting agricultural areas, much as new residential developments publicize the 'Garden of Eden' they are offering to house buyers. It means highlighting the ecosystem services that agriculture provides to the city.
- Such incubator agricultural zones can also be further supported and publicized through drawing on horizontal linkages with other municipalities and civil society organizations, as well as seeking the backing of vertical levels of government.

It is not suggested that investment in peri-urban agriculture should only be made to the proposed 'incubator' agricultural zones. The support services identified above should ideally be made available to all households farming within the municipal jurisdiction. But to build both city and public support for the protection of peri-urban agriculture, it is suggested that if these incubator zones can be established, they should be specifically nurtured and supported.

Zoning for agriculture at the peri-urban interface means excluding other land uses, particularly for commercial/industrial and residential development. In some cases tax incentives to commercial and industrial enterprises may be offered to encourage compliance with the zoning policy (Mubvami et al. 2006).

Peri-urban interface: Agricultural water use innovations

Perhaps the major innovation and investment issue in relation to the needs of peri-urban agriculture is the critical need for safe recovery and reuse of wastewater. This concerns both the recovery and reuse of the nutrients and organic matter suspended and dissolved in the water and the water itself, given the increasing competition for, and decline in the availability of, both surface and groundwater. Investment options for increasing availability of safe wastewater will be discussed in the section below on the circular bioeconomy.

Peri-urban interface: Technical innovations

This paper discussed earlier the identification of rural bias in food security research and a related bias has been the overwhelming focus of agricultural technology innovation toward extensive rural agriculture. For intensive peri-urban production systems supplying fresh vegetables, fruits and animal products over short distances to urban centers, there is more limited technical innovation, apart from private sector seed development.[27]

Key areas requiring incubation investment include:

- Year-round vegetable production using alternative varieties and controlled environment agriculture (CEA), in areas where existing varieties and conditions are limited by heat, drought or cold (Halliday et al. 2021)
- Comparative testing of high-nutrient varieties of preferred vegetables (Ebert 2014; Ebert 2020)
- Seedling production systems for priority vegetables and fruits, which may involve testing alternative seedling production sites, comparing peri-urban with rural sites (Schreinemachers et al. 2021)
- Comparative agronomic and health-risk assessments of biocontrols and biofertilizers (Velivelli et al. 2014; Pirttilä et al. 2021)
- Testing of alternative management options for commercial use of wastewater (furrow irrigation and low-cost drip irrigation) (Drechsel et al. 2015)
- Productivity and health effects of alternative sources and preparations of organic wastes as animal feed (Senanayake et al. 2021).

Intra-urban agriculture: Access to land

With important exceptions such as the wetlands that penetrate into the old parts of African cities like Kampala, Uganda and Yaoundé, Cameroon, most agriculture within city areas, whether homestead or off-plot, is small-scale, with crops grown or animals raised for own consumption, and often the responsibility of women. Where data were available in Table 2, almost two-thirds of all types of farming was under the responsibility of women. Subsistence production is even more commonly undertaken by women. As was discussed earlier, one reason many poor urban individuals and households do not take up this type of cultivation or animal raising is because their living accommodation within informal settlements is itself precarious. This precarity has multiple food security implications and greater housing security could improve food security, including in some cases through having the option of intra-urban agriculture.

Those who take up crop production or animal raising within the city, especially women, face major challenges, which were discussed in Section 4.1. Where they grow crops on public spaces like roadsides, riverbanks, railway tracks etc., producers face harassment and eviction. When they are involved in animal raising, even in isolated areas of the city such as the edges of landfills, there are frequent efforts at eradication on health grounds (Foeken 2004; Prain 2010b; Cabannes and Marocchino 2018). Several policy options exist within urban areas to provide more stability to this

[27] Section 3 discussed the large areas of cereals grown within urban and peri-urban areas, which often benefit from the same kinds of extensive technologies (mechanization, fertilizer use, etc). But as also emerged in the global assessment, horticultural crops were one of the most widely distributed categories of crops in urban areas across different regions (Thebo et al. 2014).

kind of small-scale, off-plot food production and can provide the basis for capacity development, testing and incubation investment in other cities, especially in sub-Saharan Africa.[28]

- **Government provision of plots on public land.** Cities in several Latin American countries, for example in Colombia, Ecuador and Argentina, have opened up government land to residents, creating small plots for cultivation. This is analogous to allotments in the UK and other European countries, though in the Latin American context they had more ambitious livelihood goals. In Quito, Ecuador, the AGRUPAR program was started in 2002 with a broad set of goals relating to overcoming food insecurity, obesity and diet-related diseases and the need to create income and employment opportunities through support to local productive value chains, sustainable agriculture and local economic development. AGRUPAR offered residents the change to register for access to plots of land and by 2016 there were 2,500 gardens with a total surface of 27 hectares, producing 105 different food products. Almost half of the produce from AGRUPAR farmers is marketed, mainly through 14 'ecological' farmers' markets located in different parts of the district (Baker and de Zeeuw 2015; Dubbeling et al. 2017).

- **Temporary access to private land destined for construction.** A more temporary and private sector arrangement has existed for several decades in Quezon City and other parts of Metro Manila in the Philippines and perhaps in new developments in other megacities in the region. Developers of residential sub-divisions, before construction begins, make the future housing plots available to vegetable farmers, in return for small rental payments. No tree planting or constructions are allowed, but otherwise producers have been able to use the land for production and easily accessible marketing options with local vegetable traders. Production continues until construction begins and they need to vacate the lot (personal interviews and Murakami et al. 2010). Such arrangements could be encouraged by local governments through preferential tax and administrative arrangements for those developers that use their land in this innovative way. It actually has benefits beyond the economic. These undeveloped spaces are often repositories for large pieces of discarded property like furniture, white goods and tyres. Cultivation of these spaces also 'beautifies' them, as Filipinos describe it.

- **Community land trusts.**[29] This is an innovative approach to communal management of land being pioneered in the UK, which could offer another model for local organizations, in partnership with municipal governments, to steward land resources for multifunctional purposes – agricultural production, education, leisure and city greening for climate change mitigation and adaptation.

- **School gardens.** Another source of cultivable land in inner city areas are schools. There is a long history of involving schools in agricultural production and nutrition education through school gardens (Gonsalves et al. 2020). Working with schools on food production, as a means of influencing family diets through the children and actually producing food for consumption in

[28] The use of urban 'on-plot' compounds in Africa and in other regions for fruit trees, livestock raising and growing vegetables and medicinal plants is common, and there is a large literature. Except as part of urban greening discussed later, no investment proposals for this type of urban agriculture are put forward. An urban planning intervention in Kampala, Uganda sought to build on that type of urban agriculture by designing new homes with sufficient space to establish homestead gardens. The selected project site would have interfered with other livelihood activities and also ran into planning resistance and other problems. See: https://www.mcgill.ca/mchg/pastproject/edible-landscape/kampala/project

[29] https://www.communitylandtrusts.org.uk/policy-vision/

the school, is a policy option that many national and provincial Education Departments are pursuing and others could.

Those cities that already allocate areas of land for individual cultivation and agri-business such as the AGRUPAR program in Quito may be the best candidates to take the next step toward community land trusts to formalize cultivators' management of the land. Such an arrangement would protect local producers and those involved in farmers' markets against policy reversals of the kind experienced in Lima, Peru, which dismantled a whole program of local cultivation and marketing, Mi Huerta (My Vegetable Garden), in a short space of time (Santandreu 2018). The municipality of Quito has been the major funder of AGRUPAR, but moving toward a community stewardship of the land would require further incubation funding to enable a piloting phase of the stewardship arrangement to become established. Such experiments could provide valuable lessons about the wider potential of such models.

Intra-urban agriculture: Technical innovations

There are undoubtedly major opportunities for private sector investment in vertical agriculture, hydroponics and aquaponics within urban areas, including in some low- and middle-income countries such as India (Halliday et al. 2021). This publication describes those opportunities and provides investment and policy recommendations.

5.3 Marketing safe, nutritious food through enterprises and decent work

UPA production, especially in peri-urban areas, is intimately connected to the city regional food system and the short food supply chains supplying food to city markets. Based on the earlier review of literature on livelihoods and food markets and the issue of consumer access to nutritious food, there are two main areas for innovation and investment that build on the economic, social and health opportunities offered by food marketing in the Global South: making food markets work better for producers and consumers; and making the work of those involved in food marketing more remunerative and decent.

Making food marketing work better for producers, vendors and consumers

Though supermarkets are rapidly penetrating the retail sector in cities of the Global South, starting in Latin America and currently expanding in Asia and sub-Saharan Africa (Reardon and Hopkins 2006), they still account for a relatively small volume and frequency of purchases for lower-income customers and are mostly used to purchase the least healthy processed or semi-processed products rather than fresh products, which are often packaged in quantities too large for purchase by these consumers (Crush et al. 2011; Davies et al. 2021). Furthermore, because of standardization requirements, supermarkets do not typically source products from local suppliers (FOLU 2019). But supermarkets are a dominant and growing part of food retailing throughout the world, and food producers of all kinds and in all locations in the world will try to access that market, so they are a critical component of urban food systems (Global Panel on Agriculture and Food Systems for Nutrition 2020).

Nevertheless, for the foreseeable future, open wet markets and small-scale retail outlets will continue to be the most important sources of fresh food, especially vegetables, fruits and animal source foods for low-income consumers, and the most important points of sale for local producers. There is evidence that, in some cities, policymakers are aware of their responsibilities vis-à-vis wet markets. In the World Bank-led survey of Asian cities, almost three-quarters have policies on publicly-owned wet

markets, though the challenge of addressing what has been described, together with street food culture, as "the most valuable and problematic parts of urban Asia's food systems" is still to be fully addressed (Acharya et al. 2020: 94).

Renovating wet market infrastructure for the benefit of producers, vendors and customers

The open wet markets where most wholesale and retail sales are made are frequently located in congested parts of inner cities. In a large survey of low and low-middle-income households in 18 small and medium urban centers in Zambia and Kenya, distance from food retailers to both make sales and to obtain food was cited as a major barrier (Davies et al. 2021). Accessing space in such markets can be problematic and in many markets producer-vendors spill out into surrounding streets, making access even more difficult. Yet at the same time these are important social spaces, including the relations between sellers and customers; places for sharing, for meeting friends and for gathering information about food and other topics. Within many open markets there are also agricultural input suppliers, veterinary shops and other business development services of importance to producers.

It is proposed that three strategies be adopted in relation to infrastructure to address the problems.

Decentralization: Many urban areas already have both central wholesale markets and small local markets distributed across the urban space. Bangkok, Thailand has three main central fresh food markets and 337 small local markets (Boossabong 2018). The aim of decentralization would be to construct intermediate, satellite markets, larger than local markets, near the interface with peri-urban agricultural production. These would need to be located on main roads and close to expanding urban populations, for example new informal settlements or residential areas. One model for these satellite retail markets is the 'village super market' designed and built through support from SOLIDARIDAD, an international NGO funded by multilateral, public and private sector donors.[30] The design provides sufficient space for producers and vendor to sell their food products; accessible toilets and washroom areas for women and men to maintain better hygiene; an environment that can easily be cleaned, thus reducing the risk of food contamination in many existing wet markets;[31] and through easier cleaning, the capacity to recover organic wastes for use in composting.

However, such processes of decentralization and infrastructure development need to be undertaken with a high degree of stakeholder consultation, especially involving women and men producers, vendors and customers to avoid undermining livelihoods, infringing rights and dislocating the local market system. The aim of such decentralization should be to improve the livelihoods and working conditions of market vendors and local producers and access by poor consumers, and not to get street vendors off the streets (Song and Taylor 2018). Municipal efforts to unilaterally relocate markets and vendors to new locations on the periphery of cities can create serious social upheaval.[32]

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[30] https://www.solidaridadnetwork.org/news/village-super-market-a-facility-for-improving-food-systems-in-bangladesh

[31] Some studies have shown that higher pathogen loads are being delivered to fresh food products in district markets than come from products leaving farms where wastewater irrigation has been used (Karanja et al. 2010).

[32] Closing down the existing inner city wholesale market in Lima and transferring it to the periphery was very unpopular in Lima, provoking massive protests from wholesalers, retailers and customers. The failure to build a promised retail market next to the new wholesale market has led to dislocation in the marketing system. See: https://trome.pe/actualidad/parada-comerciantes-minoristas-marchan-exigen-reubicacion-mercado-tierra-prometida-22095

Diversification: The main issue with diversification in relation to food marketing and the opportunities offered by short food supply chains is the establishment of green markets. Examples from Lima, Peru, suggest that little or no infrastructure is required. Some of the Lima weekly green markets 'piggy-backed' on other organizations' facilities; in some cases the districts built modest structures to house the market, in other cases markets were held close to the production areas. The initiative and the modest investment costs for the green markets in Lima came either from the Metropolitan authority, or from District initiatives and provided venues for urban and peri-urban producers to sell ecological or organically certified vegetables, cheeses and processed foods like biscuits and cakes to consumers directly (Arce et al. 2007; Santandreu 2018). Another example comes from Bangkok, where social enterprises established green markets and organized food box delivery services across the city, to provide alternative food sources direct from producers (Boossabong 2018).

A related form of diversification involves food hubs, which have been particularly associated with procurement, processing, warehousing and distribution of food within short food supply chains (Moustier and Renting 2015). A recent, innovative approach to food hubs is being developed as part of the Lima 2035 vision.[33] The food hub idea under development would ground the hub in the cultural and gastronomic history of the city, so combining sales and purchases of healthy local foods with food sovereignty and food history.

Upgrading: With the opening up of new satellite markets, existing inner city markets can be repositioned and upgraded. Upgrading would be primarily designed to improve accessibility, hygiene, cleanliness and organic waste recovery through construction or upgrading of toilets and wash areas, especially for women, use of tiling, and expansion of raised stalls.

The main consideration for both decentralization and upgrading is the need for a consultative process involving local stakeholders such as wholesaler associations, retailer groups, consumers and others, and should give strong consideration to gender issues (Marocchino 2009). The review of food marketing in earlier sections already drew attention to the vulnerability and discomfort many women face in urban markets. Most urban markets have committees which are usually under municipal departments responsible for markets and commerce. The consultative process led by the relevant municipal authority and the Market Committee needs to agree on targeted infrastructure improvements that can open up greater opportunities for commercial, social and health benefits.

Repositioning urban food markets as knowledge centers for healthy diets

The functioning of these markets as social spaces offers the opportunity to invest in them to achieve a much broader set of purposes, especially to expand knowledge about nutrition and health and to nudge consumption practices in a healthier direction. This involves cross-sectoral cooperation between market committees and health and nutrition agencies to make important changes in how markets are organized. The involvement of the market committees can be achieved through the incentive of upgrading investments. Some changes can include:

- Repositioning vendors of nutrient-dense vegetables and fruits to the most visible parts of the market like the main entrance
- Providing poster materials on the nutrition benefits of certain foods to be displayed where vendors are selling those products

[33] https://www.rockefellerfoundation.org/meet-the-top-visionaries-food-system-vision-prize/lima-2035

- In countries like Bangladesh, where social norms discourage women from attending markets, introducing special access times to the market for women only
- Through private sector initiatives, mobilizing teams of mobile vendors to take healthy food and nutrition messages to informal settlements and other parts of the city
- Establishing small 'learning corners' in food markets. In some green markets, learning corners are often established to share information about food production, conservation, processing and preparation. Such learning corners can be established through the cross-sectoral cooperation between health and commercial agencies of the city as well as private sector and civil society organizations.

Reorientating institutional markets toward local food purchases

Although supermarkets do not tend to source their food supplies from local suppliers, there is a wide range of institutional markets within cities which could, as a matter of policy, source their food needs from urban and peri-urban suppliers, thus supporting the local economy and providing an incentive to producers to continue their agriculture.[34] Institutional markets include hospitals, schools, prisons, government canteens and local universities. Current tendering processes for the supply of foods to these institutions are problematic in terms of the nutritional quality of the food purchased and presence of corruption (Freudenberg 2016). External financial support will be needed during an incubation period to transform food supply in a transparent and fair way from open tendering to positive discrimination in favor of peri-urban food supply. Issues of volumes, timing and the like will arise and this incubation period should enable these issues to be resolved.

Making food marketing work more remunerative, safe and decent

As has been seen, food marketing makes up a major part of the informal sector of urban areas, and the informal sector accounts for up to 80% of urban economies in the Global South. A large percentage of those involved are individual women and men ('own-account businesses') wholesaling, transporting or retailing fresh produce which may be from their own plots or bought from others. They are selling fresh produce from market stalls, small kiosks, mobile vehicles and street corners, and preparing and selling cooked food on the street in or small restaurants. The poorest are involved in portering food and other products in the market, cleaning markets and selling the organic wastes. Many of these different own-account workers are in survival mode, as a recent publication from the International Labor Organization made clear (ILO 2020) and the conditions of work are arduous and often unsafe. Many will hope to move from the informal sector to formal employment, but that shift is increasingly difficult. An alternative is to try to upgrade skills, innovate and expand business operations in the same or in new areas of the food sector so as to increase income and if possible, the safety and quality of work. From the point of view of city authorities, there is also interest to improve working conditions and move toward more decent work – as the ILO describes working conditions that are remunerative, safe and dignified (ILO 2002), and also to ensure the safety of the foods that are being sold to consumers by those working in the food sector.

[34] In São Paulo, Brazil, for example, public procurement alone could generate enough demand for 71,500 hectares of regenerative cropland (equivalent to 73% of total peri-urban cropland) if the city were to adopt purchasing guidelines favoring local and regenerative production (FOLU 2019).

The following options will require different kinds of investment:

- Producer and vendor business schools – drawing on and adapting eight years of experience and development of Farmer Business Schools in Asia (CIP 2017), urban producers and vendors of different kinds would be provided with tools to assess current and new markets, adapt products to these identified markets (e.g., ecological or organic foods) and develop business plans
- Large-scale capacity development on hygiene practices and food handling in long and short food supply chains, with involvement of commercial food outlets in the formal sector to help support this capacity development program
- Micro-credit and other financing schemes for vendors and producers to implement business plans[35]
- Support to private sector to establish low-cost, alternative energy sourced storage facilities
- Identification of novel short food supply chains for processed products involving producer–private sector partnerships (for example, use of beetroot widely produced in peri-urban areas of Lima to produce a food colorant in wide demand internationally)
- Providing technical and organizational contributions to building digital networks enabling local producers and vendors to more easily communicate about supplies, demand, prices and locations of products, to improve overall profitability, benefit sharing and reduction of waste and losses
- Support to establishment of social enterprises to act as brokers of local ecological/organic products for supermarkets.

There are also lessons learned in the Global North in the area of urban agriculture, enterprise and marketing that can be drawn on. One is the Urban Green Train, a European project that aims to encourage business-oriented initiatives involving small and medium-sized enterprises, policymakers and research organizations to respond to the demand for urban green innovation in relation to environmental technologies, eco-friendly products and healthy food. RUAF, a partner of the CGIAR Research Program on Water, Land and Ecosystems, is also a member of Urban Green Trains. The link between educational foundations like RUAF and the private sector is a model that should influence the kind of investments that should be sought in relation to UPA and urban markets.

5.4 Making city regions more resilient through a safe, climate-responsive, circular bioeconomy

In response to climate change there is intense pressure on leaders of urban areas to reduce the carbon footprint of their cities. In the second half of 2021, the pressure has been ramped up further with COP 26. Demonstrating the close linkage between urban food systems and climate change, the Milan Urban Food Policy Pact dedicated its 7th Forum, held in October 2021, to the analysis of the best way to change food systems to tackle the climate emergency. One of the most urgent and feasible ways to do that is to move cities from a traditionally linear mode of resource input and waste output to a circular mode of resource input, resource recovery and resource reuse. This is crucially combined with an overall reduction in consumption and waste. UPA contributes significantly to achieving this transformation through innovative approaches to the circular bioeconomy (Palahí et al 2020) that

[35] There are a wide range of innovative financial options to support UPA and informal vendors, which go beyond the scope of this paper. See Cabannes (2012; 2015).

have been under way for some years (Drechsel et al. 2015). Some need investment support for scaling and some need investment for further incubation.

Less visible and more indirect forms of bio-circularity derive from the way UPA provides ecosystem services to urban populations. The clearest ecosystem service is food provisioning, providing nourishment that allows the reproduction of the urban population. The supporting service of water filtration leads to better health for the urban population, which includes people who undertake UPA, and allows the system cycle to continue. These less visible processes are important and the fact that micro-level ecosystem services accumulate to have macro-level effects are relevant for investment considerations.

Investing in waste reduction

In light of the size of the waste problem discussed in Section 4.4, organic waste reduction is integral to city region food systems and to UPA. Internationally and nationally, there are a wide range of campaigns and voluntary agreements to reduce organic waste, which are aimed at businesses and the public (Senanayake et al. 2021). One French supermarket campaign, 'Inglorious Fruits and Vegetables', used pictures of deformed products to reduce the thousands of tons of unwanted products thrown away each year (The Flexitarian, 2014). This campaign resonates with the story around ecological and organic vegetables and fruits, often produced in peri-urban areas, that their blemishes are badges of a safer, environmentally healthier, production system.

Prevention of waste through establishing cellphone-based digital networks linking market vendors and producers. These networks can improve the coordination of demand and supply, so reducing wastage on the farm or along the supply chain.

Prevention of waste through promoting 'glorious and inglorious peri-urban vegetables and fruits'. Picking up on the messaging around 'inglorious fruits and vegetables' and 'blemishes as ecological badges' there seems to be an opportunity to combine these messages in the promotion of glorious and inglorious peri-urban vegetables and fruits as sometimes inglorious looking, but always ecologically glorious in saving transportation losses and damage and reducing emissions.

Prevention of waste through redistribution of cooked, unsold meals from restaurants and near-expiry foods in supermarkets. Although sophisticated food monitoring and expiry date monitoring and reassessments exist in the food industry, they are mostly expensive and used in the Global North (Senanayake et al. 2021). Redistribution systems of cooked, unsold restaurant meals and near-expiry supermarket foods could have more traction in low- and middle-income countries. In Malaysia, a social enterprise start-up has developed an app to connect restaurants and supermarkets to foodbanks and other potential users of excess food for the very poor. Other examples exist in India, Indonesia, Kenya, South Africa and in Latin America (Senanayake et al. 2021). Incubation funding for encouraging similar start-ups in other low- and middle-income countries should be encouraged with local government social safety net programs also potential participants in such food redistribution programs.

Investing in organic waste recovery and reuse

Cities are nutrient sinks and the organic wastes generated contain nutrients and organic matter which are potentially valuable as different kinds of feedstock and as compost.

Three public or private sector uses of the feedstock were identified by Senanayake et al. (2021):

Gourmet mushrooms can be grown on a feedstock of food waste (that has not either been prevented or reused) and/or inedible food parts, such as peels and outer leaves. They can also use inedible wastes from particular food sectors, such as coffee grounds from restaurants and cafés. This is a potential for-profit or social enterprise urban business that can sell to restaurants, hotels and canteens. Investment would be needed to train personnel in the preparation and seeding of the feedstock and managing mushroom growth. Incubation investment would help support start-up and operational costs. Potential constraints could include the difficulty of accessing sufficient separated organic waste and also to maintain a supply of organic waste in competition with other collectors.

Insect rearing can be undertaken using food wastes of different kinds and the final product used variously as animal feed, a medicinal ingredient in the pharmaceutical industry or as soil fertilizer. One advantage is the self-sustaining basis of the business: some of the larvae are allowed to develop into adults, which lay eggs for the following cycle. Black soldier flies are reared in this way by private businesses or public–private partnerships. Private companies raise cockroaches in China, also used in Chinese medicine, pharmaceutical uses and as animal feed. In many parts of the world, insects form a traditional dietary ingredient, although the spread of western diets and sensibilities may have reduced the prevalence. With the recent growth of interest in the use of insects as a source of protein for humans, as traditional animal protein sources are being discouraged because of the contribution to climate change, this could have large future potential.

Swine feed. This is an ancient use of food waste that is still widespread, especially using the large volumes of restaurant and food and beverage processing wastes generated in urban areas. This use has been standardized for safety practices (avoidance of bovine spongiform encephalopathy) and has been commercialized in Japan, South Korea and Taiwan. Given the increasing demand for pork meat, especially in China, Southeast Asia and Latin America, this has the potential to be a major source of reuse of organic wastes. There is urgent need for capacity development among informal livestock raisers, especially around the length of cooking needed for the waste before feeding. Modest investments would be needed for preparation of training materials and the organization of training sessions for peri-urban pig raisers by partnerships of public health and agriculture departments of municipal governments and local civil society organizations. Ideally training on the appropriate and safe use of food wastes should be combined with information on animal management, veterinary issues and the use of manure in agriculture. Well managed piggeries on the edge of cities, safely processing food wastes into pork and contributing to increased productivity of nearby agriculture could be a nuisance-free, positive contribution to resilient cities, offering multiple ecosystem services to urban populations. The alternative is a clandestine, high-risk livelihood activity, which moves from one municipality to the next as each one applies eradication measures.

Investing in recycling

Three types of organic waste recycling are identified by Senanayake et al. (2021):

On-site composting/energy recovery. This envisages the use of composting machines, anaerobic digesters or a bokashi system (fermentation technique) to process mostly large volumes of on-site wastes. This includes waste generated by large retailers or food processors, although variable sized machines can cater also for households. For low- and middle-income countries, the relatively high initial investment costs makes this an unlikely option at this smaller scale. Within the Global South,

household composting has been widely promoted and piloted over the years as a way to reduce waste and recover nutrients. This has had mixed results (Sewak et al. 2021).

Social community composting. This involves a centralized site for the collection and composting of organic wastes – including garden waste – that are either collected by volunteers or organized via drop-off arrangements. The compost may be sold to help finance the operation. It is more realistic that public sector financing is provided, which can be seen as payment for the social contribution to city management of wastes. External investment would probably be needed initially to 'incubate' the community enterprise in order to demonstrate the viability of the service to municipal authorities.

Off-site compost and energy recovery. This business involves large-scale composting or anaerobic digestion to produce compost, fertilizer and energy. Since it requires large amounts of solid waste, this system is a public–private partnership with the municipal waste collection. In some cases (e.g., Los Baños, Philippines) the municipality itself collects the waste and operates the composting facility, but this is vulnerable to political transitions to new administrations with other priorities. Whether the facility is privately or publicly run, the major constraint concerns how to ensure unpolluted waste separation and delivery to such an enterprise. Waste collection itself is a major challenge for many municipal authorities in low- and middle-income countries, especially in informal settlements within and surrounding cities. Without the guarantee of a continuous appropriate waste stream, the incentives for large private sector investments are limited. The appropriate waste stream depends on separation and that depends on the effectiveness of behavior change approaches to increase public awareness about organic waste issues and separation (Sewak et al. 2021). As Senanayake et al. (2021) note, this is much lower in the Global South than in the North and this may account for the large number of business models in this publication derived from experiences in high-income countries. Large-scale investment in public awareness campaigns combined with pilot waste separation and collection activities run by municipalities (these have been ongoing in many parts of the Global South, for example in several cities within Metro Manila, Philippines) combined with initial small-scale communal composting seems a more feasible option.

A major contribution that national governments can make to efforts to recycle solid wastes as soil conditioner and organic fertilizer is to reduce or eliminate subsidies on fossil fuel-based fertilizers.

Investing in wastewater use

The use of untreated urban wastewater for agriculture, whether in a raw form or diluted in surface water, is widely practiced by producers in the Global South (Thebo et al. 2017). They recognize its value as a free source of nutrients and organic matter and a contributor to better harvests. The downside are the public health risks from microbiological sources and to a lesser extent from heavy metals and other chemicals that may be present in the water (Drechsel et al. 2010).

Two main categories of low-cost innovations have been identified for mitigating the microbiological health risk involved in using untreated wastewater (Keraita et al. 2010). One category involves the partial or complete removal of pathogens from the water prior to use on crops. Methods include use of filtration, usually involving sand filters, or alternatively sedimentation. This ranges from a relatively complex and expensive three-tank system, with contaminated water entering one tank, standing and sedimenting in the second tank, and the water in the third tank being used for irrigation. There are also simpler, single sedimentation ponds, where pathogens sink to the bottom of the pond before the

water is used. Where land is expensive and limited, occupying part of agricultural land with one or more ponds or tanks is a significant loss for the farmer (Moscoso et al. 2007).

The other category of innovations involve modification in the application of the wastewater to reduce contamination of the crop (Keraita et al. 2010). This includes drip irrigation, which can be sophisticated and expensive, but also susceptible to blockages, or simpler, more rustic versions. Furrow irrigation produces less contamination than use of watering cans, but even with watering cans there are methods of application – applying at a reduced height – that reduces splashing of soil and water onto the crop.

However, the protection of public health is not just an issue with producers. Evidence from studies of health risks from urban agriculture involving wastewater irrigation in Nairobi found higher levels of pathogens coming from local wet markets than came from wastewater irrigation (Karanja et al. 2010). Food safety needs to be approached from a food systems perspective, as is advocated by Drechsel et al. (2015). Farm level actions to reduce risk are part of a whole set of food system actions that will contribute to safe food on the plates of city residents (Figure 6). As well as farmers changing their practices, safe food also includes hygienic handling practices by vendors and street food sellers, and the creation among consumers of an awareness about the importance of safe produce, so that they demand it in the market.

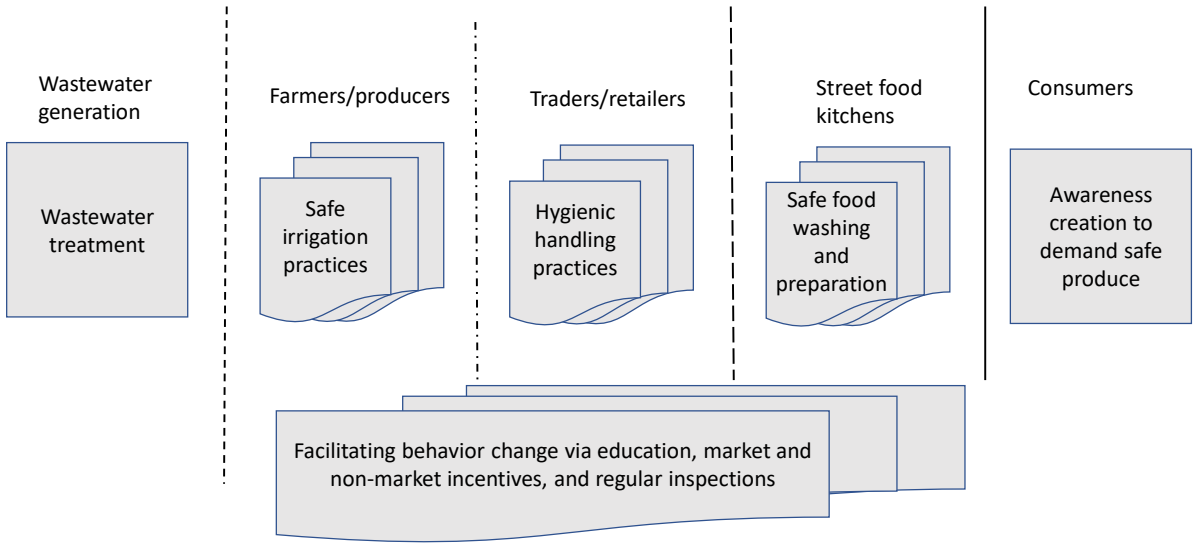

Figure 6. The multiple-barrier approach for consumption-related risks along the food chain as applied in wastewater irrigation.
Source: Drechsel et al. 2015.

As this report has emphasized, use of wastewater for agriculture is a critical component of the circular bioeconomy of cities and the contribution of cities to global resource conservation and climate change mitigation. Knowledge sharing about both health risks and solutions is a key part of enabling safe expanded use of this resource, so that investment in knowledge networks through farmer and city platforms and through vertical governmental linkages is vital and can build on the great potential of

digital networks to strengthen sharing. This report has also emphasized the importance of multistakeholder consultation and decision making, and many local-level actors, especially the farmers themselves and local governments, need to be part of the solution to safe use of wastewater. As Keraita et al. (2010) argue, though safety measures will benefit consumers, there need to be personal incentives for the farmers to take up the safety practices. The most persuasive incentive would be a premium price for the safer product. Willingness to pay this higher price on the part of consumers depend on the last component of Figure 6, awareness raising and demand creation for safe produce. In order for consumers to be able to trust that particular produce is safe, it helps for it to be marketed separately. This is where investment in green markets discussed in Section 5.3 can provide that separate marketing channel for safe produce. Alternative or additional incentives would be a labeling system supported and guaranteed by the local government. These different options need to be tested, and external incubation investment can facilitate such testing.

Investing in the provision of ecosystem services through urban and peri-urban agriculture

There is sufficient evidence that agriculture can contribute important ecosystem services to cities, through reducing flooding risks, filtering water, conserving biodiversity and regulating pollination processes. A type of ecosystem service provided by peri-urban agriculture is the protection of water sources from which cities receive potable water. Agricultural buffer areas can prevent contamination by industry or upstream residential settlements. This strategy was adopted by the municipal government of Seoul, South Korea through an agreement with farmers to protect the watershed to ensure the quality of the water. The city of Medellín, Colombia also recognizes this function of peri-urban agriculture (Tefft et al. 2020).

The whole issue of valuation of ecosystem services provided by agriculture (not just regulating water supplies and pollution, but also the supporting service of pollination and biodiversity conservation, the food provisioning service functions, and cultural services of leisure and recreation in the green agricultural areas) needs greater investment, to identify innovative ways of monetizing these services as a way to strengthen UPA and sustain its contribution to resilient cities. One important aspect is the climatological, psychological and cultural services that are provided by ordered green productive spaces in and around cities (Wadumestrige et al. 2021). Many of the proposed investments discussed earlier, if they can make UPA more sustainable, will also strengthen the contribution of ecosystem services, which in turn, adds to the value of the practice in a virtuous cycle.

6. Conclusions

This paper has located the issue of UPA and the potential areas for innovation investment within the context of sustainable food systems, including the food environment, consumption behavior, food supply chains and food waste issues, as well as the policy and institutional context. That context involves municipal governments and their relation with the national government, as well as relations with civil society and the private sector. To address the reality of cities as densely populated cores with a constantly changing transitional peri-urban area, consisting of an inner edge with high levels of urban impact – land use changes, pollution, competition for labor – and a more distant outer edge influenced by the urban market and merging into rural areas, the food systems thinking and practice also embraces the food, environmental and informational connections within the broader city region.

It is important to emphasize again in these conclusions the important variability in cities and city regions. Part of the explanation for contrasting findings, for example between the multi-country studies that drew on national household surveys compared to city assessments, can be accounted for by variability between primary and secondary cities and their regions. In secondary cities, access to land within the city, at the peri-urban interface and in the rural hinterland is much easier. As Berdegué et al. (2014) point out, these secondary city regions account for a very large proportion of the world's population. It is essential that investment in innovations described in Section 5 and highlighted below keep in mind this variability and include it in targeting investments.

The impact of urbanization on the peri-urban interface of cities is dramatic, and it is mostly affecting agricultural land. As has been seen that agricultural land has multifunctional benefits for the city. It contributes to the urban food system with a lower carbon footprint compared to long food supply chains, and provides a range of ecosystem services to the city that contribute to climate change adaptation and mitigation, as well as accelerating the necessary transition of cities toward circular bioeconomies. Productive green spaces within cities are also under threat, and as has been seen, also contribute important climate change adaptation and mitigation services as well as other kinds of services, such as food provisioning and cultural services. A high priority for investment should therefore be in innovative policies and incentives to protect peri-urban agricultural land as a vital resource and also protect and stimulate access to plots of land within urban and peri-urban areas. Examples of innovative policies and incentives were suggested in Section 5.

A second priority also targets the transition of cities to circular bioeconomies, through the role of UPA in recovery, reuse and recycling of liquid and solid wastes produced in huge quantities by urban businesses and households. Probably the biggest challenge is to increase safe agricultural use of wastewater, since urban competition for water between industrial, commercial, agricultural and residential uses will intensify in many parts of the Global South in coming years. Simple, low-cost innovations are available, involving both treatment and improve irrigation practices. A range of innovations are also available to add value to organic solid wastes through their reuse or recycling in agricultural processes.

As part of the city region food system, UPA is also intimately connected to marketing and consumption of food within the city and the existential challenges discussed in the Introduction of precarious urban

employment in the food sector and changing consumption patterns toward less healthy food. A high priority for investment should be in food market innovations described in Section 5 which offer double benefits. Through repositioning wet food markets and institutional markets to better link with urban and peri-urban producers and to be promoters of healthy food and decent employment, there is a chance for city authorities, in collaboration with the millions working in the informal food sector, to reposition the urban food system itself, toward healthier food and away from high-sugar, high-fat 'convenience'.

Policy innovation is already underway toward a repositioning of urban food systems, led by the more than 200 cities participating in the Milan Urban Food Policy Pact.[36] Through collaboration with FAO and the RUAF Foundation, they have developed an innovative monitoring and evaluation tool for assessing progress by local governments in implementing food systems and food policy changes (Carey and Cook 2021). It is recommended that the application of this tool by local governments should be part of any new investments into any of the innovations indicated above. This will help those governments, as well as investors, to determine how effective the investments are in strengthening UPA and achieving urgently needed food systems transformations.

[36] https://www.milanurbanfoodpolicypact.org/the-milan-pact

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