frontiers | Frontiers in Sustainable Food Systems

TYPE Perspective
PUBLISHED 10 November 2022
DOI 10.3389/fsufs.2022.965011

OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to Land, Livelihoods and Food Security, a section of the journal Frontiers in Sustainable Food Systems

RECEIVED 09 June 2022
ACCEPTED 12 October 2022
PUBLISHED 10 November 2022

CITATION
Prain G, Simon D, Halliday J and Drechsel P (2022) Investment priorities for research and innovation in urban agri-food systems: Toward more resilient cities in the Global South. *Front. Sustain. Food Syst.* 6:965011. doi: 10.3389/fsufs.2022.965011

Investment priorities for research and innovation in urban agri-food systems: Toward more resilient cities in the Global South

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Urban and peri-urban agriculture (UPA) is widely distributed throughout the Global South. Despite urban population growth and diversifying food habits, UPA delivers an important part of urban food supply, as well as other types of services to cities, such as employment and waste reuse. Nevertheless, the extent and importance of UPA varies between different urban areas, while challenges like limited recognition, land conversion, and water pollution and competition threaten the potential of UPA to contribute to urban resilience. Key investment priorities for research and innovation for overcoming current challenges include incentivized peri-urban zoning, urban allocation of productive lands, and increasing capacities for controlled environment agriculture (CEA). Innovative repositioning of food marketing can help to strengthen supply of healthy food from UPA production, increase decent employment, and turn food markets into nutrition hubs. Priority innovations for contributing to the circular bioeconomy of cities include scaling the safe use of wastewater for irrigation through investments in the adoption of multiple risk-barrier approaches and scaling UPA-based ecosystem services for valorising solid waste and environmental management. Innovations in urban governance are required to support these processes by bringing food systems into urban planning through food mapping and the multisectoral platforms for dialogue and policy formulation across city regions and with vertical levels of government.

KEYWORDS

urban agriculture, food systems, controlled environment agriculture, informal markets, circular bioeconomy, resource recovery, city-region, food governance

Introduction

Ensuring sustainable and secure supplies of appropriate quality food for urban populations that do not exacerbate the climate crisis is a major global challenge. Eighty percent of global food production now ends up in cities, but only around 63% is consumed. The rest, about 931 million tons, becomes food waste (UNEP, 2021). The challenge of feeding cities is most acute in the Global South where most food loss occurs during harvest, storage, and transportation, while poor (food) waste management poses a public and environmental health problem for cities. A double burden of malnutrition afflicts low-income countries, with perhaps 300 million urban residents going hungry, while an epidemic of obesity and non-communicable diseases (NCDs) increasingly affects the poor in the Global South, primarily driven by increasing consumption of sugars, fat, and salt in processed foods (Popkin et al., 2012; Vilar-Compte et al., 2021). These nutritional challenges are being accelerated by urbanization processes and climate change. By 2050, two-thirds of the Global South population will be urban, while urban expansion is currently occurring mostly through slum and informal settlement growth (UN-Habitat, 2020). Informal employment, especially of women and men in food and other retail services, accounts for up to 80% of the total in some cities in the Global South (ILO, 2018). Inadequate and precarious incomes and congested housing conditions affect both economic and physical access to healthy food.

Large, "core" cities as well as small and medium "secondary" cities (Cardoso, 2022) have largely underappreciated opportunities to alleviate some of these stresses on urban food access and climate change by developing the actual and potential food supply within urban areas and from the surrounding urban foodsheds (Schreiber et al., 2021), which include peri-urban and nearby rural areas, i.e., from within city regions (Dubbeling et al., 2016, 2017; Blay-Palmer et al., 2018; Acharya et al., 2020). Up to 70% of the world's population is already living in these areas (Berdegué et al., 2014), food for about 30% of this population is produced there (Kriewald et al., 2019), and it is where most food marketing occurs. Accordingly, these are the spaces with the greatest opportunities to build the urban circular bioeconomy through recovering the vast volumes of solid and liquid urban waste and reusing them in nearby agricultural processes, as well as contributing to associated ecosystem services like flood reduction (Dubbeling et al., 2016; Evans et al., 2022). Moreover, where political instability, epidemics, or economic crisis accelerate challenges related to urban food supply, farming within or close to cities—urban and peri-urban agriculture or UPA—can help build urban resilience and is an increasing focus of attention (Malec et al., 2022; Yan et al., 2022).

For cities to take up these opportunities, investment is needed in innovations that will enable these different components to contribute more effectively to resilient cities and city regions (Prain, 2022). This paper suggests priorities for investment in research and innovation in UPA, based on two recent non-systematic reviews of recent literature (Halliday et al., 2021; Prain, 2022) and the extensive personal experience of the authors. Sections Protecting productive land, boosting productivity, Repositioning informal food markets, and Recovering water and waste for the urban circular bioeconomy highlight innovations needed in agricultural production, food marketing, and in the productive reuse of otherwise wasted natural resources, like organic waste, characteristics of the circular bioeconomy (Carus and Dammer, 2018). However, this also requires innovations in the governance and planning environment. Production, marketing, and resource recovery and reuse often occur across spatial and sectoral boundaries and involve different levels of government. Section Innovating food systems planning and governance to support UPA considers some of the institutional innovations needed to facilitate effective and sustainable agri-food systems.

Protecting productive land, boosting productivity

Most agriculture within urban areas is practiced on small areas of land, often for subsistence, with surpluses exchanged or sold within the community (Prain, 2022). Where urban and especially peri-urban agriculture is practiced at a larger scale, outputs can be locally important as an urban food source. Furthermore, producing close to the place of consumption can shorten food supply chains and enhance trust between producers and consumers, as well as reduce transportation costs, emissions, and the risk of food loss due to poor infrastructure (Vittersø et al., 2019).

However, lack of secure land tenure is a significant barrier, especially in the context of rapid urbanization and land-use tensions arising between agriculture, business, and formal and informal residential settlements (Mougeot, 2000). People who grow crops on public land often face harassment and eviction by law enforcement agencies (Foeken, 2004; Prain, 2010; Cabannes and Marocchino, 2018).

Some local governments (for example Quito in Ecuador and Rosario in Argentina) have established programmes for urban residents to grow food on government-owned land to boost household food security and generate income through the sale of surplus (Prain, 2022). Examples of other innovative mechanisms with potential to secure land access in the face of urbanization pressures and political change include the following:

- Designation of urban agriculture zones in urban development plans, as provided for in the Nairobi Urban Agriculture Promotion and Regulation Act 2015 in Kenya (IPES-Food, 2017).

- Creation of a municipal land bank, a mechanism for registering and allocating the right to use public spaces that are suitable for growing food, as done in Rosario (Halliday et al., 2019).
- Shared governance, such as community land trusts in the United Kingdom that ensure joint stewardship of land and resources by local organizations and municipal governments (Community Land Trust Network, 2022).
- Failure to embed such programs within policy frameworks, can make them vulnerable to electoral change.

Increasing UPA productivity sustainably is an important area of innovation (Taylor, 2020). Some forms of controlled environment agriculture (CEA) can deliver high yields on very small areas of land (Artemis, 2020). Hydroponic and aquaponic systems that maximize natural energy sources (such as natural sunlight or gravity-fed watering) and local materials (such as coco coir, coco peat, perlite, or other by-products of local industry), practiced in greenhouses and polytunnels, are suitable for food growing in cities in the Global South, where land is expensive and may be contaminated, and at larger scales in peri-urban areas (von Kaufmann, 2018; Halliday et al., 2021).

Although there is potential for some forms of CEA to complement rural systems' ability to provide urban communities with fresh produce, CEA is not a silver bullet for urban food security or sustainable development in the Global South. Start-up and running costs are high, as is the risk of failure, especially where no local training or tailored extension services are available (Halliday et al., 2021). As such, CEA entrepreneurship depends heavily on access to funds and education and training. Practitioners of CEA often seek to recoup start-up costs by charging a premium or focusing on specialty crops for high-income consumers that command a higher price than varieties that are traditionally grown in the area and form part of local diets. Some pledge to reduce their prices or to switch to local varieties once they are technically and economically feasible, but there is no firm indication of when that may happen. Until—or unless—it does, the contribution of CEA to food and nutrition security will be minimal (Pinstrup-Andersen, 2018; Halliday et al., 2021). For the potential of CEA to be realized in the Global South, there is a need for significant investment in several areas:

- Removal of entry barriers associated with investment costs through innovative approaches to accessing start-up funding through public and private sector actions (Cabannes, 2015);
- Improved operational viability through tailored training and extension services;
- Research into CEA cultivation of local crops that are traditionally grown and consumed locally, especially throughout the year to reduce price fluctuations (Jensen, 2002; Mytton-Mills, 2018);
- Research into CEA techniques to minimize energy use, reduce environmentally harmful practices, and optimize efficiency within specific local contexts (Halliday et al., 2021);
- Adaptation of technologies used in high income countries to suit the specific needs and challenges in lower income contexts, incentivized through trade and development programmes (Halliday et al., 2021).

Repositioning informal food markets

With 55% of global food consumers now living in urban areas and almost 80% of global food production destined for urban consumption (FAO, 2019), there is increasing pressure on urban market systems to provide stable physical and economic access to food. Although informal food vendors make a major contribution to urban food systems (Giroux et al., 2021), the evidence from many cities in the Global South suggests that urban physical markets are struggling to respond to needs (Davies et al., 2021). A study covering 171 urban food systems in Asia suggests that informal food markets and street food are simultaneously "the most valuable and problematic parts" of those systems (Acharya et al., 2020, p. 94). Physical access is frequently difficult for sellers, market support workers, and buyers. Especially in the case of retail markets, infrastructure is often limited, including lack of adequate lighting, toilet facilities, and clean water (Marocchino, 2009). These affect food safety (Grace, 2015) as well as gender equity, with women's participation as both vendors and customers made more difficult (Siebert and Mbise, 2018).

Yet these informal markets are where most low-income urban consumers get their fresh food (Crush et al., 2011; Davies et al., 2021) and they are also major sources of employment for the urban poor (Prain, 2022). They have the chance to contribute to urban food system transformation through providing better and more equitable access to safe food and decent employment, as well as reducing carbon emissions though short food supply chains (Crippa et al., 2021). As the main sources of fresh food for the poor, these markets can help reduce obesity and associated NCDs brought on through consumption of processed food high in sugar, fat, and salt, often obtained through fast food outlets and supermarkets (Popkin et al., 2012; Hawkes et al., 2017; Global Nutrition Report, 2020).

To achieve this, there is need to invest in innovative food market repositioning, in terms of functions, infrastructure, spatial locations, and role in public health. *Functional diversification* of food markets highlights opportunities to innovate in the multiple ways that food moves from producers to consumers and emphasizes how diversity in trade as well as in production and consumption can contribute to food system resilience (Hertel et al., 2021). Diversification through repositioning institutional food markets is one opportunity.

These markets account for a significant proportion of total food consumed in cities in the Global South, through schools, hospitals, and via social support programmes (Swensson et al., 2021). Current food procurement policies can be non-transparent and result in long supply chains (Freudenberg, 2016). Understanding and testing innovative policies for targeting procurement from urban and peri-urban suppliers could potentially reduce emissions, improve food safety and quality, and provide increased stimulus to UPA (Kelly and Swensson, 2017).

Another kind of diversification is to strengthen short supply chains between UPA producers and consumers through alternative food sourcing by urban wholesale and retail markets, by drawing on the model of farmers' markets (Hanson et al., 2022). Increased sourcing of food from local producers is now a goal of the World Union of Wholesale Markets (WUWM, 2021) and innovations in retail markets can provide greater access to local food. This can help increase food safety and quality through promoting, for example, ecologically grown, and potentially more trusted products (Arce et al., 2007; Boossabong, 2018; Santandreu, 2018). Low or no packaging combines with reduced transport to contribute to lower emissions.

Market upgrading and decentralization include the urgent need for investment in research-led innovations to improve hygiene and hence food safety through human-centered design approaches (HCD) to sanitary facilities, water provision, and sales points (Lestikow et al., 2017; Sharpe et al., 2019). Such upgrading also needs to involve innovative and mutually acceptable ways to deal with market waste, reduce health risks, and recover an urban resource e.g., for compost (see section Recovering water and waste for the urban circular bioeconomy). A crucial emerging research and investment priority relates to improving phytosanitary conditions in wet markets to avoid cross-species viral infections, such as may have triggered the COVID-19 pandemic from Wuhan's wet market (Open Access Government, 2022).

Sometimes, upgrading may include innovative processes of decentralization, especially where access becomes a major constraint. A primary consideration for market upgrading and decentralization is the need for participatory consultation with stakeholders, to avoid actions that do not appropriately take account of user needs, cultural practices, and capacities (Marocchino, 2009; Song and Taylor, 2018; Acharya et al., 2020).

To confront the urban crisis of unhealthy eating and obesity, multiple approaches have been attempted, including efforts to change the market environment through laws and incentives, and efforts to increase informed choice (Brambila-Macias et al., 2011; Hawkes et al., 2017). Policy changes to favor consumption of healthier foods have been limited, especially in low-income countries and greater policy research and action is required in this area (Hawkes et al., 2017; Farrell et al., 2021). To what extent can changes in retail food markets contribute to improved diets through informed choice or other means? As indicated, in low-income urban settings most fresh food is obtained from these markets. Choice of food purchases is complex and though price is a major driver (Smit, 2020), a range of strategies are involved in the often personalized way that preferred food is obtained from sellers, including via the "casero" system in Latin America (Alfaro, 2019, 2022). Farmers' markets, sometimes in combination with social and nutrition programs have taken advantage of such personalized buyer-seller relations to strengthen informed choice about healthy foods through nutrition information campaigns. Documentation of these activities mostly comes from the Global North (e.g., Dannefer et al., 2015; Hanson et al., 2022), but through personal experience of the authors they have also been observed in farmers' markets in the Global South. Direct interventions to improve the nutrition of vulnerable groups have also been undertaken through farmers' markets in the North through voucher systems, incentivising those groups to purchase healthy fresh food (Dannefer et al., 2015; Hanson et al., 2022). Voucher schemes have been used to stimulate consumption of healthy foods among vulnerable groups in the Global South by linking health facilities with agricultural producers (Cole et al., 2016) but not so far as we are aware through markets. It is suggested that drawing on the farmers' market experiences with nutrition education and voucher schemes in the North and on the health system-agriculture voucher schemes in the Global South, there is an investment need for research innovation on the role of retail food markets to contribute to increased nutrition knowledge and to be a partner in social programs to incentivize increased consumption of healthy food.

Recovering water and waste for the urban circular bioeconomy

By 2050, 80% of all food will be consumed on the 1–3% of global land area covered by towns and cities (Liu et al., 2014; Ellen MacArthur Foundation, 2019). The generation of large volumes of organic waste and wastewater within these hotspots poses a significant challenge, involving waste minimization and resource recovery and reuse to benefit the circular bioeconomy. Urban and peri-urban agriculture systems can absorb and benefit from food waste, either as feed for livestock or as organic fertilizer, and can create value from wastewater through irrigation. Of particular interest is the nutrient and energy rich fecal matter from on-site sanitation systems (septage) which are serving over 3 billion people globally (WHO and UNICEF, 2019). The opportunities are large, since less than 2% of the nutrients in the food entering urban areas are recovered from urban waste streams (Ellen MacArthur Foundation, 2019). However, wherever waste becomes an agricultural input, food safety is a key concern. For example, the farmland under planned irrigation with treated wastewater is globally at least 30 times

smaller than the irrigated area exposed to untreated wastewater, indicating a significant hazard for public health (Drechsel et al., 2022). Based on a decade of research on the circular bioeconomy (Sally and Merrey, 2019), research investment priorities have to bridge between the perspectives of farmers in need of inputs, and the city with abundant waste, which might however not be safe for reuse.

From a (peri)urban *farmer perspective*, organic waste—mostly food waste in cities—offers a low-cost feed for livestock and an organic soil input for crops after waste composting. Both options have a long tradition and there is usually high demand, although this varies depending on quality (FAO, 2013). Municipal waste compost is often poor in nutrients and seldom a priority for farmers where manure or chemical fertilizer are available (Gaur and Singh, 1993). Farmers specialized in urban cash crops, such as leafy vegetables, depend on regular irrigation even in the rainy season. Unless there are enforced restrictions, crop and fish farmers accept any water source, including reliable (and often nutrient rich) wastewater, treated or not (WHO, 2006; Drechsel and Keraita, 2014; Amoah et al., 2021).

From a *city perspective*, waste collection, mostly over 50% organic in low- and middle-income countries, is a major expense (Kaza et al., 2018) and options like composting and feed use would reduce food waste and could also generate revenues from resource recovery (Otoo and Drechsel, 2018; Senanayake et al., 2021). However, use of food waste as feed can also be a biosafety risk, e.g., meat residuals transmitting foot and mouth disease unless the waste is well-processed (Salemdeeb et al., 2017). To improve the *quality* of municipal compost, an option is co-composting, e.g., with the proven safe use of nutrient-rich septage from onsite sanitation systems which can improve poor economic returns and enable scaling (Nikiema et al., 2014). Absence of cross-sectoral partnerships between public waste management and private fertilizer companies is another *scaling barrier*, resulting in poor marketing (Hoornweg et al., 1999). As a result, the often-postulated win–win situation where farmers in dire need of crop nutrients seize on urban waste compost remains so far, an exception (Drechsel, 2022). The opposite happens with respect to wastewater, which is usually a free resource, and its use is spreading quickly but in an unsafe manner, putting both farmers and consumers at risk. There have been significant efforts after the publication of WHO (2006) to develop multiple risk barriers from farm to fork (Amoah et al., 2011) but their *adoption remains very low* (Drechsel et al., 2022).

This situation calls for investments in research and innovation with respect to:

- Improved source segregation (separation of organic from non-organic waste) in households to benefit livestock farmers, business models to enhance the formal arrangements between food waste supply and demand by farmers, and improved farmer capacity in safe waste-processing to enhance biosafety (Jayathilake et al., 2022);
- The transformation into compost of food waste (not used as feedstock) for urban crop farmers, including location-specific financial and institutional business models and a supportive regulatory and financial environment to exploit research-based quality improvements and increase the viability and scale of municipal compost use (Lazurko et al., 2018);
- Research on innovative behavior change techniques, such as nudging (Barker et al., 2021), along the farm-to-fork contamination pathway, especially where risk awareness is low, to facilitate adaptation and scaling of research-based safety practices where the use of untreated wastewater in irrigation and aquaculture is common (Drechsel et al., 2022).

Innovating food systems planning and governance to support UPA

Where urban governments do actually address agriculture, it is commonly in terms of counterproductive modernist planning perspectives that deem urban food production inappropriate so that it is zoned out and often expressly prohibited. By contrast, where encouraged, as in Dar es Salaam and Kampala, urban food production systems are diverse and important, often including large-scale commercial operations using a range of technologies. They are by no means solely small-scale and subsistence-oriented (Lwasa et al., 2014, 2015). They also form important elements of urban green–blue infrastructure systems (Simon et al., 2021).

Effective, transparent governance is essential for coordinating and integrating the various activities and stakeholders involved in UPA as part of equitable and sustainable food systems. Land in and around cities used for growing food often traverses the boundaries of different local authorities with different priorities, powers, and resources. Collaboration is also required across multiple institutions in the public, private, and non-governmental sectors, with diverse sectoral jurisdictions, roles, resources, and powers, that seldom collaborate and often undervalue UPA. The need for governance innovations is underscored by the urgency of climate change and sustainability challenges, for which current boundaries and systems are often inappropriate, and, by extension, to promote achievement of Sustainable Development Goals 1, 2, 11, and 13 (United Nations, 2022).

Many countries lack appropriate national or regional legislation to support UPA and promote the circular agri-food economy. Local governments can, nevertheless, take important steps through integrated cross-sectoral planning and action on food production, marketing, and waste management, including resource recovery through municipal composting and feedstock

use. Nevertheless, jurisdictional and spatial mismatches, along with inadequate political support, are common constraints worldwide (Simon, 2021; Treutwein and Langen, 2021).

Investing in institutional innovations for city-region food governance

The most appropriate scale for coherent planning, governance, and financing of urban food supply and security is now increasingly identified as the functional urban area or city region (Blay-Palmer et al., 2018; Cabannes and Marocchino, 2018; Acharya et al., 2020; Simon, 2021; Jayathilake et al., 2022; Prain, 2022). The city-region scale is most appropriate for addressing such disjunctures by providing an appropriate functional regional framing for integrated, multi-stakeholder agri-food policy and planning for a sustainable and resilient food system (Dubbeling et al., 2016, 2017; Blay-Palmer et al., 2018; Acharya et al., 2020).

In some contexts, such as China, city regions now have specific boundaries and dedicated governance systems (Wu, 2016) but more often they are functional and relational, focused—for purposes of this paper—on the food system (FAO RUAF Foundation, 2015; Karg et al., 2016; but see also Battersby and Watson, 2018). This does not imply that all foods can or must be produced locally; some mid-to long-distance transport of produce requiring larger areas for cultivation or different agro-ecological conditions will probably remain necessary. The delimitation of such regions might vary seasonally or for particular agro-commodity groups. This introduces governance challenges and requires institutional innovation to protect and boost production, enabling equitable, low emissions marketing, and promoting waste reuse. Investment is required to design and establish contextually appropriate institutional guidelines—including supportive "infrastructure" (Palmer et al., 2020), particularly as many stakeholders will not have experience of working together across the various types of boundary that may be encompassed by a city region. These guidelines should be co-produced through transdisciplinary, multisectoral participation based on mutual respect for diverse experience and expertise. The required research and investment would include inclusive procedures and rules, with appropriate facilitation to act as "honest broker" and to mediate the inevitably unequal power relations that often permeate such processes even when participants agree to appropriate principles of engagement (see Hemström et al., 2021; Simon, 2021; Prain, 2022, p. 55–56).

A crucial element of each specific context is the interface between such innovative horizontal governance processes and the vertical engagement by local governments with the strategic city region and higher levels of provincial and national government. For example, having an appropriate, urban-oriented national food system strategy can stimulate local action, as has happened in Kenya (Prain, 2022). For national policies to influence urban food systems, appropriate policy frameworks and multistakeholder cooperation needs to be in place at local level (Halliday et al., 2019).

Investing in geospatial innovations on urban food production and food deficits

Promoting sustainable and equitable urban food supply and security faces two challenges. First, urban and city-region food systems are diverse and fragmented, embracing formal, semi-formal, and informal components of different scales. Second, the systems are highly dynamic and subject to rapid change as a result of ongoing urban (re)development and land-use change. Low-income and informal producers on vestigial land pockets or using temporarily vacant land are particularly vulnerable. For these reasons and because many elements of the system may be deliberately concealed, investment in geospatial research is required to make these widely visible in order to gain a comprehensive and strategic overview and GIS database that can be updated regularly is a critical planning tool (Prain, 2022, p. 57–58).

In mapping the geographies of food production and consumption, identifying areas of food deficit and food deserts are important on equity grounds. This requires investment in secondary and primary data sourcing and analysis, including from social welfare programmes. For food production, the land use, irrigation, and harvest records require collation, but remotely sensed data will be essential, requiring both equipment—including use of drones and other innovative technologies—and capacity strengthening. Making food systems visible in this way could become a key step to making them more equitable and more sustainable, whilst taking steps to reduce the risk that this becomes a means of increasing control and taxation of hitherto unrecorded production.

Conclusions and recommendations

Growing populations, economic change, and climate change are putting great pressure on the natural, physical, and social resources of cities of the Global South and the ability of their food systems to feed urban populations appropriately. Furthermore, food waste management is a major concern of municipalities, and linear solutions are increasingly unsustainable. Circular waste flows could offer win–win opportunities for UPA and boost urban resilience. Building governance and planning structures for a greater recognition and integration of the food system within urban, peri-urban, and nearby rural spaces—the city-region food system—can help respond to many of these challenges.

The perspective articulated here is that opportunities exist for investing in innovations in different parts of the city-region food system that build on UPA research over recent decades (Yan et al., 2022) and can be adapted and scaled for greater urban

TABLE 1 Selected UPA research and innovation investment priorities.

Investment area	Research innovation needs	Policy, institutional, and financial innovation
Controlled Environment Agriculture (CEA)	CEA productivity and adaptation options especially in low-income contexts	Improved regulatory, financing, and incentives environment for protecting productive land and enabling CEA investments
Informal food markets	Mutually acceptable food safety and quality protocols (water, waste, hygiene, health)	Diversification of market functions, upgrading, and decentralization
Circular bioeconomy	Locally feasible safety protocols for waste reuse and incentive systems for their adoption	The enabling environment for the safe use of waste derived resources
Multi-stakeholder planning and governance	Visualizing the relevance of urban food systems	Horizontal and vertical linkages between stakeholders and sectors applying a city-region perspective

Source: Authors.

resilience, especially in the Global South. Table 1 summarizes key recommendations for investments in innovative research as well as policies and implementation options.

Boosting sustainable intensification of food production even on limited urban spaces is possible, e.g., through CEA, contributing to reduced resource use and urban emissions. For this and other UPA production systems, enabling policies and innovative start-up financing will be needed, as well as protecting peri-urban agricultural spaces through zoning and incentives policies, and designating and protecting urban public land areas for food production (Mougeot, 2000; Cabannes, 2015).

Informal food marketing is an essential but fragile component of the food system in the Global South. Innovative research and investment to reposition markets via participatory upgrading can increase food safety (including prevention of phytosanitary risks), equity, and efficiency. Market diversification to expand green marketing and reorient institutional markets toward local food procurement can generate nutrition, health, and climate change benefits. Investing in innovative partnerships between public health policy-making, nutrition services, and local food markets can also strengthen their contribution to healthier diets, food preparation, and hygiene.

A food systems perspective on organic waste can help cities become more resilient through moving toward circular bioeconomies. Urban and peri-urban agriculture can recover and reuse organic wastes in animal feed and composting and wastewater as a source of irrigation. Investments are needed in applied research to improve the quality and safety of the resources derived from waste and achieve the required behavior changes as well as effective public–private partnerships linking waste management and agriculture for scaling.

For city-region food systems to provide healthier food, decent employment, and reduced emissions, investment is needed in new types of food planning and governance. Food systems do not respect administrative boundaries, so more agile partnerships will be needed. These must be both horizontal—across the different multisectoral jurisdictions and interests of the city region where food production, distribution, and consumption occur—and vertical, to link with and influence national initiatives and strengthen cross-learning. Given that elements of the food system are often informal, invisible, and inequitable, mapping the geographies of production, distribution, and consumption can help make inequalities more visible and reduce vulnerabilities. A key investment should support cross-regional learning as there are high-potential examples that lend themselves to appropriate adaptation.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material. Further inquiries can be directed to the corresponding author/s.

Author contributions

The paper drew on two reports commissioned by the Commission on Sustainable Agricultural Intensification (CoSAI), on urban and investment opportunities for innovation in urban and peri-urban agriculture and in controlled environment agriculture, authored respectively by GP and JH. GP led the introduction, the section on markets, and the discussion. JH led the section on protecting productive land and boosting agricultural productivity. PD led the section on the circular bioeconomy and DS led the section on governance. All authors contributed reviews of all sections.

Acknowledgments

The authors acknowledge with appreciation the contribution to this paper of work on investment opportunities in innovations in urban and peri-urban agriculture and in controlled environment agriculture undertaken through the Commission on Sustainable Agricultural Intensification (CoSAI). We would also like to thank two reviewers of the paper and the paper editor for very helpful comments. We gratefully acknowledge all funding partners of the CGIAR Research Program on Water, Land and Ecosystems (WLE), and the One-CGIAR initiative on Resilient Cities through Sustainable Urban and Peri-urban Agri-Food Systems, who

supported this research through their contributions to the CGIAR Fund (https://www.cgiar.org/funders/).

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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