URBAN AGRICULTURE'S POTENTIAL TO ADVANCE MULTIPLE SUSTAINABILITY GOALS

An International Resource Panel Think Piece

Urban Agriculture's Potential to Advance Multiple Sustainability Goals - An International Resource Panel Think Piece

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About This Think Piece

This document is an International Resource Panel (IRP) think piece, which is a technical or policy paper based on IRP scientific studies and assessments and other relevant literature. It is not a full study and assessment but a collection of science-based reflections that may catalyse the generation of new scientific knowledge and highlight critical topics to be considered in policy discourse.

Acknowledgements

Lead Authors: Elias T. Ayuk (IRP member, Ghana), Anu Ramaswami (IRP member, Princeton University, USA), Izabella Teixeira (IRP co-chair, Brazil)

Contributing Authors: Wisdom Akpalu (Ghana Institute of Management and Public Administration, Ghana), Kirti Das (Princeton University, USA), Emily Eckart (Princeton University, USA), Jaqueline da Luz Ferreira (Instituto Escolhas, Brazil), Vitoria Oliveira Pereira de Souza Leao (Instituto Escolhas, Brazil)

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International Resource Panel

Preface

By 2050, 70 per cent of the world's population will live in urban areas, and 80 per cent of food globally is expected to be consumed in cities. Thus, one of the biggest challenges we face as a society is: How do we feed the world's growing cities, while at the same time attending to the various social, economic, and environmental needs and aspirations of cities.

In recent years, urban agriculture has been identified as a solution to advance multiple sustainability goals, such as food security, climate and ecosystem resilience, health and well-being, job creation and social equity. However, the effectiveness of urban agriculture, as well as the policy action needed to tap into its potential, are not well understood.

Since 2007, the International Resource Panel has provided more than 40 impactful scientific assessments on the status, dynamics and implications of natural resource use in cities and in food systems. In this Think Piece, we evaluate to what extent, and in which conditions, urban agriculture can enhance the sustainability of urban-rural food systems and promote a circular economy in cities.

The Think Piece provides an overview of different urban agriculture typologies, ranging from household backyard gardens to community allotment gardens, from rooftop greenhouses to high-tech vertical farming. With a systems lens, it analyses the natural resource use implications of urban agriculture in its various forms and assesses its benefits and trade-offs across multiple sustainability goals, acknowledging distinct regional specificities.

We note that urban agriculture is not a panacea. In realizing its multiple benefits, the objective of urban agriculture needs to be clearly defined in the policy process, with due consideration of local context.

The Think Piece is accompanied by a policy guidance document that presents a road map for designing "fit-for-purpose" urban agriculture policies, taking into account the interaction between urban and rural systems. We call for action from both the agriculture sector and the urban planning sector to realize the untapped potential of urban agriculture in advancing the Sustainable Development Goals of Agenda 2030.

Izabella Teixeira
IRP Co-Chair

Janez Potočnik
IRP Co-Chair

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URBAN AGRICULTURE'S POTENTIAL TO ADVANCE MULTIPLE SUSTAINABILITY GOALS

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Key messages

Key Message 1: As environmental challenges grow and the COVID-19 pandemic highlights the fragility of food systems, one of the biggest challenges facing the world is feeding growing urban populations while attending to the social, economic, and environmental needs and aspirations of cities.

Key Message 2: Done well, urban agriculture can help feed people in cities and alleviate the triple planetary crises of climate change, nature and biodiversity loss, and pollution and waste. For example, hydroponic closed-loop systems can save 40 per cent of irrigation water and 35-54 per cent of nutrients.

Key Message 3: Despite the opportunities, we do not fully understand the effectiveness of urban agriculture and the policy actions needed to tap its potential. Local contexts and uncertainties need to be clarified, while diverse forms of urban agriculture must be integrated into a portfolio of approaches that cover land-based and vertical farming, poultry and fish farming, and high-tech indoor techniques.

Key Message 4: While there are trade-offs, a portfolio of urban agriculture policies integrated within a larger regional agricultural system can support the transition to a more resilient and sustainable food system while improving the circular economy of cities.

Key Message 5: When designed to support poor communities – in particular, households led by women – urban agriculture can reduce poverty, improve nutrition, reduce inequities, increase well-being and generate livelihoods. For example, a study in São Paulo, Brazil showed that enhanced urban agriculture could supply all 21 million residents of the city with vegetables while creating more than 180,000 jobs.

Key Message 6: When designed to develop a local food economy, high-tech indoor agriculture and local food hubs may play an important role. For example, vertical farming is expected to reach a value of $7.3 billion globally by 2025. However, when looking at the scalability of business models, decision makers should consider impacts on energy, land, labour, and water, and the effects of pollution on food quality and safety.

Key Message 7: Due to the proximity to consumers, diversified and coordinated urban-regional agriculture can promote resilience to food system disruptions, such as those caused by COVID-19.

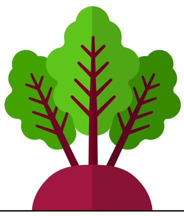
Key Message 8: Urban agriculture’s contribution to reducing environmental impacts from food systems depends on business models and local contexts. Cities must gather data that are more locally and context-specific to measure the environmental impacts of different modes of urban agriculture and policies designed to address them.

Key Message 9: Institutional, governance, behavioural and technical barriers need to be addressed to make urban agriculture part of a sustainable food systems portfolio. Proper attention must be given to land-use planning, urban-regional policy directives, and the cost of land and energy.

1. Introduction: Feeding the World's Bulging Cities

The world population is projected to reach 9.7 billion by 2050, with an estimated 70 per cent of the population living in urban areas (United Nations [UN] 2015; UN 2019). Most of this growth (90 per cent) is expected to occur in Africa and Asia (UN 2020a; Trottet *et al.* 2021). Currently, around 55 per cent of the population lives in cities. As this trend continues, an estimated 80 per cent of food will be consumed in urban areas by 2050 (Veolia Institute 2019; Food and Agriculture Organization of the United Nations [FAO] 2021). Feeding the world's cities means that food production systems will have to change in significant ways, including by bringing food production closer to urban areas.

Urban agriculture has been advocated worldwide as a strategy to provide food and many other benefits to city dwellers, especially as the planet faces the triple crises of climate change, biodiversity loss and pollution. This Think Piece explores the potential of urban agriculture to address these challenges. Specifically, how can urban agriculture be a nature-based solution[1] to support the transition to a more resilient and sustainable food system?[2] What is its potential to improve the circular economy[3] in cities?



This Think Piece applies a systems approach to assess the contribution of urban agriculture to achieving the Sustainable Development Goals (SDGs). In line with the mandate of the International Resource Panel (IRP), it assesses the implications that using different urban agriculture typologies has for natural resources and related environmental impacts. It explores urban agriculture's contributions to job creation, food security and nutrition. Specifically, it highlights the contributions of urban agriculture to circularity, climate change, biodiversity loss and the SDGs; synthesizes the approaches to and benefits of urban agriculture worldwide; and identifies challenges for transitioning to a circular urban agriculture.[4]

Definitions of urban agriculture vary widely (see Annex), with some mentioning intra-city and peri-urban agriculture and others referring generally to agriculture around cities, without specifying boundaries or distances. Meanwhile, separate terms for regional and local agriculture refer to farms at much greater distances from cities. In this Think Piece, the term "urban agriculture" includes peri-urban agriculture. It is based on the definition in FAO (2019), which highlights the growing of plants and the raising of animals within and around cities. The emphasis is on urban agriculture for food production and consumption.

1 *Nature-based solutions are actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits (UNEP 2021a).*

2 *The food system relates to all the "food system activities (growing, harvesting, processing, packaging, transporting, marketing, consuming, and disposing of food and food-related items) and to the outcomes of these activities, not only for food security and other socioeconomic issues, but also for the environment" (UNEP 2016).*

3 *A circular economy is one in which the value of products, materials and resources is maintained for as long as possible, and the generation of waste is minimized (https://www.resourcepanel.org/glossary).*

4 *In circular urban agriculture, the use of all by-products and waste streams along the whole food supply chain is recirculated and waste and inputs collide, limiting the use and exhaustion of resources such as soil, energy and water (D'Ostuni and Zaffi 2021).*

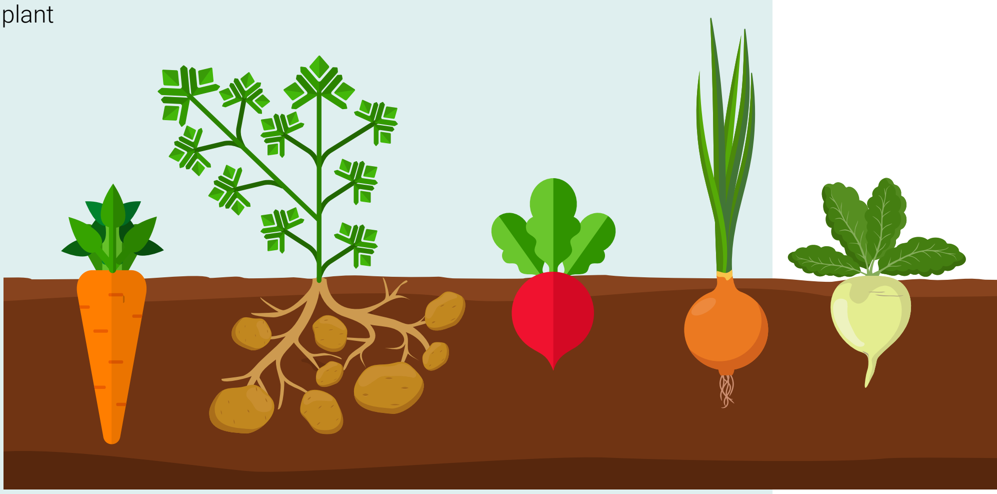
A review of 100 cities by the Intergovernmental Panel on Climate Change (2019) found that urban food consumption is one of the largest sources of material flows and carbon footprints in cities. In a 2016 report, the IRP suggested four key actions to decrease pressures and impacts on natural resources, one of which is to test innovative ideas in cities (United Nations Environment Programme [UNEP] 2016). Urban agriculture can be part of a broader strategy towards a circular economy, especially if allied with food waste management and shifts towards healthy, sustainable diets. Here, the aim is not to propose urban agriculture as the solution to agricultural sustainability, but to analyse its potential contributions to promoting sustainable urban food systems.

Most cities depend on conventional industrial agriculture and global value chains, which degrade soils and require large amounts of water (Wuppertal Institute, UN-Habitat and UNEP 2019). Consolidation in the retail sector increases the power imbalances of food systems (UNEP 2016), and greater urban-rural divides and food transport distances favour unsustainable diets (IPCC 2019). Climate change, socioeconomic shocks and urban encroachment put the urban poor at higher risk of vulnerability (Dubbeling, van Veenhuizen and Halliday 2019). The COVID-19 pandemic has aggravated urban food insecurity, affected livelihoods and food prices, and increased the urban waste burden (Kihara and Nzuki 2020; Lal 2020).

Cities offer several favourable conditions for urban agriculture. These include high levels of carbon dioxide concentration (which speeds plant growth), financial resources, and access to unused resources such as vacant spaces, roofs, waste heat, organic waste and run-off water. The capacity to recover and reuse these resources makes urban agriculture an important element of a circular economy (Veolia Institute 2019).

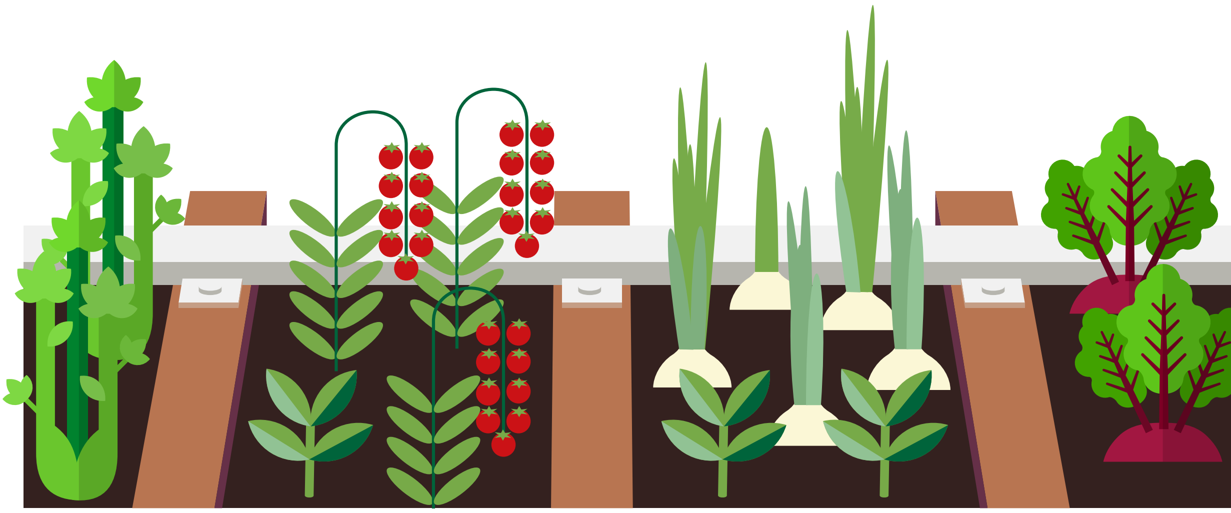
Urban agriculture initiatives and policies are seen as an emerging solution to the need to find alternative ways to grow food and feed cities. If done right, urban agriculture can benefit multiple sustainability outcomes, close the loops of nutrient cycles and build a resilient food system (Ellen MacArthur 2019; Veolia Institute 2019; Kihara and Nzuki 2020). Urban agriculture also provides job opportunities and can support greater community development as well as social integration of disadvantaged groups (*e.g.*, the unemployed and women) into economic activities (Wuppertal Institute, UN-Habitat and UNEP 2019).

Despite the many benefits of urban agriculture, possible trade-offs exist. Urban agriculture competes with other, more profitable, options for the city, such as parking lots and buildings. In addition, water quality and air pollution concerns can greatly affect food quality and safety. Moreover, the extent to which urban agriculture can, for example, address biodiversity loss or reduce the local carbon footprint (*e.g.*, by serving as carbon sinks) could be limited depending on the food production system used. Overall, information and data are lacking on the environmental impacts of the different typologies of urban agriculture across the globe. In any case, urban agriculture should aim to maximize synergies and reduce trade-offs.



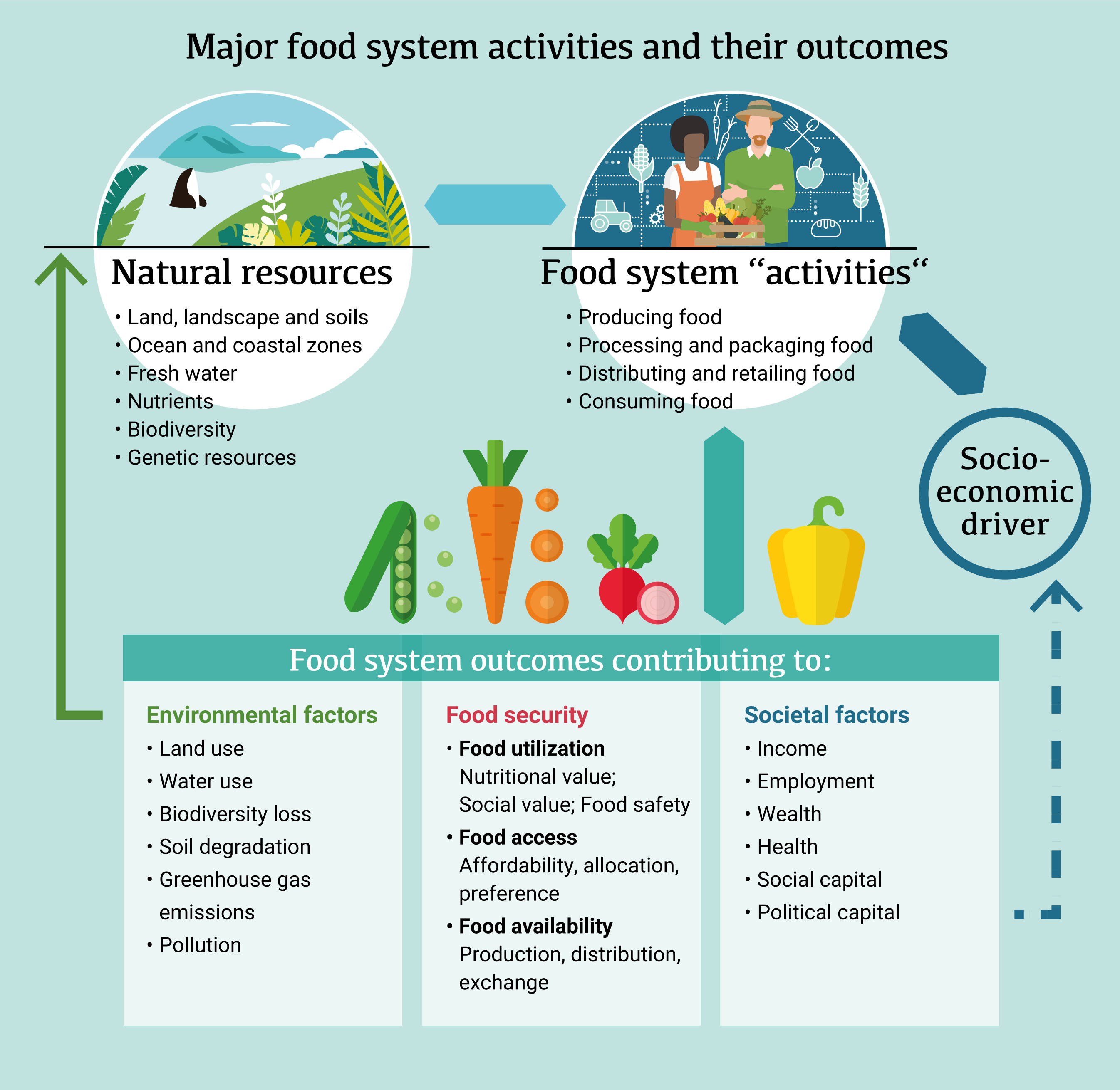
Realizing the frontier of urban agriculture in improving health and environmental outcomes is limited. Urban agriculture has both environmental benefits and disbenefits; very few studies explore whether the practice is resource efficient (Santo, Palmer and Kim 2016). Where it can play a role in resource circularity (by using nutrients from food waste), studies suggest that much more land will be needed than is available in cities (Miller-Robbie, Ramaswami and Amerasinghe 2017). Data and case studies show that the benefits of urban agriculture may only serve niche purposes in cities. Its potential benefits are likely not universal but will be context-dependent and specific to addressing the needs of underserved populations, providing recreational benefits and providing opportunities for high-tech production of niche items such as herbs, helping to complement the diet.

This Think Piece looks at urban agriculture from a food systems perspective. As shown in Figure 1, urban agriculture interacts with the natural resource base in different ways during the processes of growing plants and raising animals in and around cities. The outcomes of urban agriculture have direct consequences on environmental and social factors and on food security. These consequences vary by urban agriculture typology and are context specific.



5 *Keeping resource materials at the highest possible value along the entire value chain (UNEP 2016).*

Figure 1: Relation between resource use, environmental impacts and food system activities



Source: UNEP 2016

Table 1 illustrates the wide diversity of urban agriculture typologies across the globe. It highlights three features of urban agriculture – market engagement (for sale or not for sale), ownership (private or public) and location (indoor or outdoor) – as well as the types of technologies used for indoor urban agriculture.

Table 1: Typologies of urban agriculture across the globe, by region

Region	Market Engagement		Ownership	
	For Sale	Not for Sale	Private	Semi-public and Public
United States	Commercial food production farms*; community-supported agriculture	Household gardens; community gardens	Household gardens; commercial farms	Community gardens and greenhouses**
Europe	Onsite services farms; commercial food production farms; community-supported agriculture	Household gardens; community/allotment gardens*****	Household gardens; commercial farms	Community/ allotment gardens and greenhouses
Asia	Commercial farms; informal/ unauthorized urban and peri-urban agriculture	Household gardens; community/allotment gardens; informal/ unauthorized urban and peri-urban agriculture	Household gardens; commercial farms	Community/allotment gardens; informal/ unauthorized urban and peri-urban agriculture on public land
Africa	Small-scale commercial and semi-commercial farming in urban and peri-urban areas	Household gardens; small-scale subsistence farming in urban and peri-urban areas	Household gardens; commercial and semi-commercial farms	Informal and unauthorized public spaces in urban and peri-urban areas
Latin America	Commercial food production farms; small-scale commercial farming in urban areas; small- and medium-scale in peri-urban areas	Household gardens; community gardens; small-scale subsistence farming in urban and peri-urban areas	Household gardens; commercial farms	Community/ allotment gardens and greenhouses

** A farm run for commercial purposes as opposed to for home consumption.*

*** A structure with its walls and roof made mostly of transparent material, such as glass, in which plants that require regulated climatic conditions are grown.*

**** Modification of the natural environment to increase yield and/or extend the growing season (Merle 2002).*

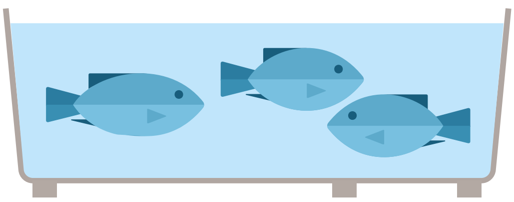
Indoor or Outdoor		Indoor Technologies	Source	Region
Indoor	Outdoor			
Indoor household gardens; commercial greenhouses; vertical farms	Outdoor household gardens; commercial farms; community gardens	Controlled-environment farming***; vertical farming****	McClintock 2014; Mok *et al.* 2014; Ramaswami *et al.* 2021	**United States**
Indoor household gardens; commercial greenhouses; vertical farms	Outdoor household gardens; commercial farms; community/allotment gardens	Controlled-environment farming; vertical farming; underground farming	de Vries and Fleuren eds. 2015; Lohrberg *et al.* eds. 2016; McEldowney 2017; Skar *et al.* 2019; Nicholls *et al.* 2020; Broom 2021	**Europe**
Indoor household gardens (mainly container and balcony); commercial greenhouses; vertical farms	Outdoor household gardens (mainly rooftop); commercial farms; community/allotment gardens; informal/unauthorized urban and peri-urban agriculture	Controlled-environment farming; vertical farming (mainly in developed Asian countries)	National Academy of Agricultural Sciences 2013; World Bank 2013; Hamilton *et al.* 2014; Sahasranaman 2016; Nandwani and Akaeze 2020; Harada *et al.* 2021	**Asia**
Indoor (animal husbandry)	Outdoor household gardens; commercial and semi-commercial farms cultivating crops and raising livestock	Not applicable	Orsini *et al.* 2013; World Bank 2013; Magnusson and Bergman eds. 2014	**Africa**
Indoor household gardens; vertical farms	Outdoor household gardens; commercial farms; community/allotment gardens	Vertical farming (few experiences in Brazil)	Monteiro and Monteiro 2006; Lattuca 2011; Maciel *et al.* 2018; Feola *et al.* 2020; Instituto Escolhas and URBEM 2020	**Latin America**

**** *The practice of growing plants and crops in vertically stacked layers (Birkby 2016).*

***** *A community garden (US) or allotment garden (UK) is a plot of land made available for individual, non-commercial gardening or growing food plants.*

2. Urban Agriculture and the Sustainable Development Goals

Urban agriculture encompasses several of the United Nations Sustainable Development Goals (SDGs), such as eradicating poverty, ending hunger, achieving gender equality, contributing to well-being, promoting sustainable cities and supporting ecosystem services. Numerous sources also point to urban agriculture's potential to contribute to a circular economy, where resources are circulated and waste is minimized. However, challenges remain to transitioning to circular urban agriculture, and the conditions required to adapt it to the urban context are little explored. Given the diversity of typologies and contexts, it is crucial to equalize the possibilities and risks of urban agriculture to promote desirable policy guidelines and business models.



2.1 Role of urban agriculture in the transition towards a circular economy

Geissdoerfer *et al.* (2017) define a circular economy as "a regenerative system in which resource input and waste, emission, and energy leakage are minimized by slowing, closing, and narrowing energy and material loops". Thus, circularity refers to the economy running in cycles to conserve resources and ensure sustainable development. In a circular economy, resources stay in the economy for as long as possible. Circularity has gained currency as an option that has to be intensified to ensure sustainable development.

Within the context of urban agriculture, circularity focuses on agricultural production and engagement in related activities using minimal amounts of external inputs, closing nutrient loops and reducing negative discharges into the environment (de Boer and van Ittersum 2018). Urban agriculture is key for transitioning the global economy to circularity because resources per person tend to be lower in urban areas, while the generation of potentially reusable waste tends to be larger. Thus, both the demand for circularity and the supply of inputs needed to develop circularity converge in urban centres.

Food transported long distances to urban centres often arrives in poor condition and with degraded quality, especially when refrigeration facilities are lacking. Urban agriculture means producing and buying locally, which can potentially diminish the environmental and climate impacts of food distribution and transport. Reconnecting consumers and farmers reshapes the traditional supply chain, with the potential to reduce food

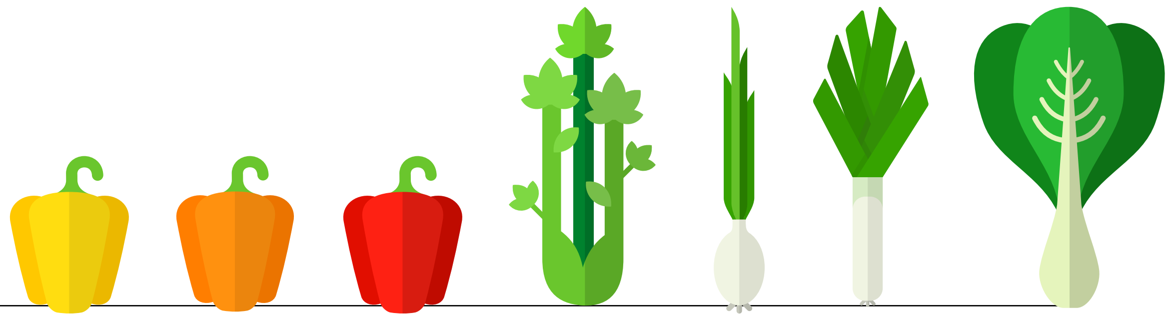
losses and greenhouse gas emissions. Connecting city dwellers with food production can also bring greater transparency to the benefits and impacts of the production chain and subsidize better choices.

Globally, around 71 per cent of municipal solid waste ends up in landfills; this includes food waste, which represents roughly a third of all food produced for human consumption (Zacarias-Farah and Geyer-Allély 2003; FAO 2011a; UNEP 2021b). Advancements are paving the way to use food waste to create circular food systems in urban areas. Hydroponics and aquaponics[6] – which contribute to waste reduction, nutrient recycling and water reuse – have gained traction globally, although more research is required to determine their economic feasibility and large-scale implementation (Love *et al.* 2015; Browning 2018; Markets and Markets 2020).

In Europe, niche operations are using waste coffee grounds to grow mushrooms for local consumption (GroCycle 2021; Haagse 2021; PermaFungi 2021). Biochar, created by burning biomass through pyrolysis, has also shown promise in improving soil quality, sequestering carbon and reducing water pollution (Lehman 2007; Lehman and Joseph 2015; Cornell University 2021). Production of biochar using food waste, for example from large farms, has greater bioresource potential than composting and anaerobic digestion of municipal solid waste, which also create nutrients but occur at a relatively small scale.

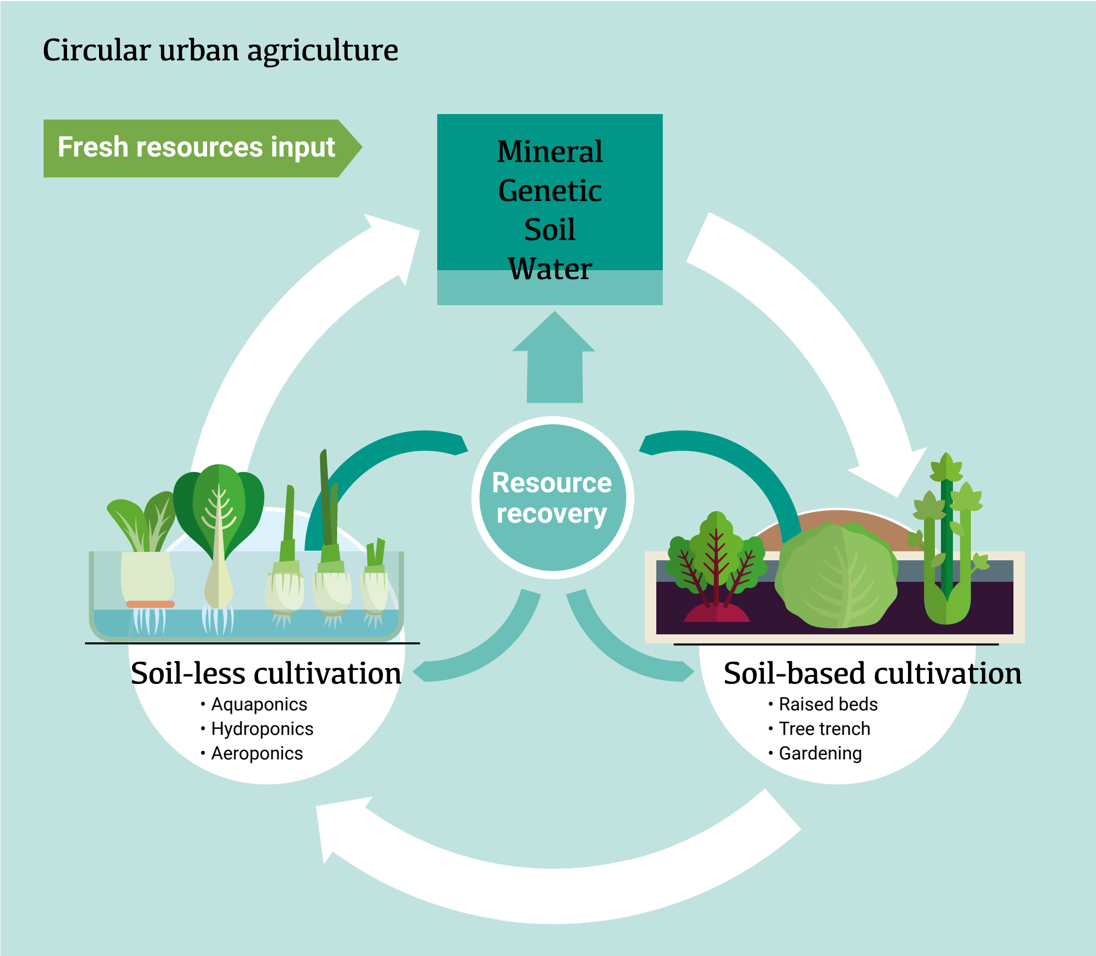
Figure 2 illustrates the concept of circular urban agriculture. The two-way linkages between soil-based and soil-less cultivation and resource recoveries highlight the principle of making maximum use of available resources.

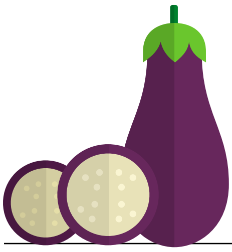
Economic circularity provides resilience to new risks (such as COVID-19) and supports the need for more efficient food production and distribution methods in cities. Urban centres provide fertile test beds for developing circularity-supporting techniques such as vertical farming, hydroponics and rooftop



6 In hydroponics, plants and crops are grown without using soil, either in containers with nutrient solutions or where the solution is circulated past the roots (https://www.livinggreenfarm.com). Aquaponics, which combines aquaculture and hydroponic, is a system of aquaculture whereby the waste from farmed fish or other aquatic creatures supplies the nutrients for the plants and crops grown.

Figure 2: Circular urban agriculture





Adapted from Deksissa et al. 2021.

greenhouses. Soil-less cultivation typologies such as hydroponics and integrated-rooftop gardens are being promoted as the best agriculture systems that ensure circularity by closing nutrient loops and supporting regeneration of the environment (Putra and Yuliando 2015). Compared with linear systems, hydroponic closed-loop systems can save 40 per cent of irrigation water and 35-54 per cent of nutrients daily (Rufí-Salís *et al.* 2020). Additionally, household organic waste can be composted to fertilize organic food production (Deelstra and Girardet 2000). The reuse of nutrients from manure and waste is very significant in many African countries (Magnusson and Bergman eds. 2014) as well as in Latin America (Box 1).

The economic literature on circularity has just emerged in the past few years (Lahane, Prajapati and Kant 2021). This is particularly true in the developing world where, although many activities are consistent with circularity principles, they are not formally documented. In general, making the shift to circular behaviours might be more "intuitive" in low- and middle-income economies, requiring fewer behavioural changes as compared to richer countries, since a high share of economic activity entails repairing items and recycling waste (Marini 2021).

BOX 1:
Organic waste as compost for urban agriculture

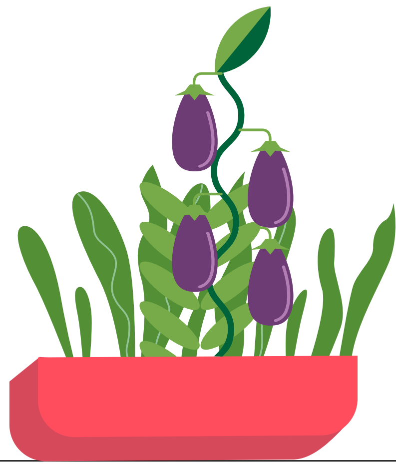
A circular economy solution that urban agriculture can provide for cities is the use of urban organic waste as an input for food production. In São Paulo, Brazil, a municipal programme to install five composting yards has made it possible to process waste into organic compost. In the first half of 2020, the yards received 7,100 tons of waste and produced 1,400 tons of compost, which is offered for free to urban farmers and residents (São Paulo 2021). A study in São Paulo showed that a typical commercial composting unit could incorporate 31 tons of organic waste from markets and urban pruning every three months, or 125 tons annually (Instituto Escolhas 2021).

2.2 Urban agriculture and climate change

Urbanization is closely linked to climate change. Greenhouse gases, including carbon dioxide, are emitted at higher levels in urban areas due to the burning of fossil fuels to support transport, industrial, commercial and domestic activities (Dubbeling 2014). The urban heat-island effect – the increase in mean daily temperature in built-up areas owing to human activities and the reflection of heat by buildings/pavements – will likely worsen as climate change continues (Dubbeling and de Zeeuw 2011).

The literature identifies several pathways through which urban agriculture mitigates the effects of climate change. Enhancing green infrastructure and vegetation cover through such systems can reduce temperatures and provide storm attenuation services (Xiao and McPherson 2002; Gill *et al.* 2007). At the garden level, vegetation can influence the energy loads of buildings (Stewart 2011). In Germany, urban allotment gardens have been found to reduce heat and the use of air conditioning (Drescher, Holmer and Iaquinta 2006). Urban agriculture can also reduce the carbon footprints of foods consumed in cities.

Production and consumption of foods grown in urban areas decrease the amount of energy used in long-distance transport and in cooling and storage (Lwasa *et al.* 2014). Mbow *et al.* (2019) found that urban agriculture has a limited effect on mitigating climate change but has a high impact on adaptation. For urban agriculture to contribute more effectively to mitigation, it needs to become more resilient to climate change itself. Developing and adapting crop varieties to fight pests, drought and higher temperatures must go together with integrating urban forestry in architecture, to help moderate temperatures.



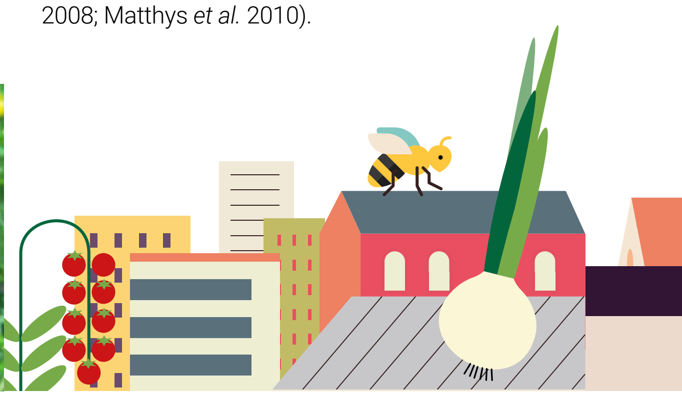
2.3 Urban agriculture and biodiversity

In some Latin American cities, peri-urban agriculture is connected to nearby forest areas that provide important ecosystem services, such as water yield (Instituto Escolhas 2021). Urban agriculture can impede urban encroachment into forest areas and provide an ecological corridor for fauna, thus helping to reduce biodiversity loss. Some local governments have encouraged agriculture in peri-urban areas. For example, São Paulo, Brazil has recognized the importance of urban agriculture in its land-use planning. Rio Branco, in the Brazilian Amazon, has implemented agroforestry systems on degraded pastures (Maciel *et al.* 2018).

Other studies show urban agriculture's contribution to maintaining agrobiodiversity. A survey of 25 urban backyards in Santarém, in Brazil's Amazon, identified 176 species (WinklerPrins and Oliveira 2010). Urban agriculture is also associated with the conservation of pollinating insects (Zhao, Sander and Hendrix 2019).

Empirical research on how urban agriculture interacts with biodiversity is limited, however. Clucas, Parker and Feldpausch-Parker (2018) have noted that more studies are needed to sustain the claim that urban agriculture will have a positive influence on biodiversity in cities. In a systematic review of papers published on urban agriculture and biodiversity between 2000 and 2017, they found that only 18 papers involved urban agriculture and measured biodiversity; of the studies that did measure biodiversity, some showed increases in biodiversity compared to urban vacant lots, while others showed no difference.

Beyond providing beneficial ecosystem services, urban agriculture has the potential to produce some disservices that must be managed properly to avoid damage to ecosystem functions and the health of urban communities. Urban agricultural systems can lead to biological invasions that could harm native species, to greater mosquito-borne disease because of stagnant water from irrigation, and to spill-over of chemicals, leading to soil-, air- or water-based ecological and health risks (Niinemets and Peñuelas 2008; Matthys *et al.* 2010).



2.4 Urban agriculture and other SDGs

Urban agriculture can play a strategic role in feeding cities because of its proximity to consumer centres. While it cannot solve the global demand for food by itself, it can make a difference during times of disruption in urban supply (de Zeeuw, van Veenhuizen and Dubbeling 2011; Corrêa *et al.* 2020). Urban agriculture can also play a strategic role in regions that have high social vulnerability, where fresh and healthy foods are lacking (Mougeot ed. 2005; FAO 2014; McClintock 2014; Lopes, de Menezes and de Araújo 2017; Rekow 2017).

In Latin America, some cities are betting on urban agriculture to promote food security. Teresina, in north-eastern Brazil, has implemented community gardens in vulnerable areas to facilitate access to fresh foods and reduce food imports (Monteiro and Monteiro 2006; Gomes, Gomes and Souza 2019). In Medellín, Colombia, the plan to promote food and nutritional security includes actions to integrate local producers into markets fairly and equitably (Dubbeling *et al.* 2017). In Asia, urban agriculture has been found to contribute to food security by enabling poorer households to consume more nutritious diets (Zezza and Tasciotti 2010).

In low-income developing countries, the role of urban agriculture in providing food security is critical for women (Maxwell 1995). Studies indicate that in such countries, a higher share of women than men are engaged in urban agriculture (to feed their families and generate income) (Maxwell 1995; Slater 2001; Hovorka *et al.* 2009; Hadebe and Mpofu 2013; Orsini *et al.* 2013; Poulsen *et al.* 2015). Urban agriculture provides women with the opportunity to contribute to household food security while taking care of other domestic responsibilities, such as caring for their children (Hovorka *et al.* 2009; Orsini *et al.* 2013; Poulsen *et al.* 2015). Additionally, experiences during the COVID-19 pandemic have shown urban agriculture's ability to respond to stressful situations in the food system, either through coordinated action across municipalities (Friedmann 2020) or through civil society acting alongside urban farmers (Instituto Escolhas and URBEM 2020; Mees 2020).

In developed countries, urban agriculture has not always been about food security, but is increasingly so (Bettencourt *et al.* 2007; Kortright and Wakefield 2011; Pfeiffer, Silva and Colquhoun 2015; Plumer 2016; Santo, Palmer and Kim 2016; Poulsen 2017). Interventions to improve nutrition via household and community gardening (Algert *et al.* 2016; Sickler 2018) were found to increase participants' access to and consumption of fresh produce. Urban agriculture has also supported food security in times of stress, such as during World War II (Andreatta 2015; Opitz *et al.* 2016; Edmondson *et al.* 2020) and the COVID-19 pandemic (Mui *et al.* 2021).

When urban agriculture practices are designed to increase access to fresh and healthy food at fair prices, they contribute directly to the capacity of cities to eliminate poverty and hunger, reduce inequities, increase health and well-being, as well as generate decent work – a key theme of the SDGs. A study of São Paulo, Brazil concluded that enhanced urban agriculture has the potential to supply all 21 million residents of the city with vegetables while generating more than 180,000 jobs (Instituto Escolhas and URBEM 2020).

2 ZERO HUNGER
3 GOOD HEALTH AND WELL BEING
5 GENDER EQUALITY
11 SUSTAINABLE CITIES AND COMMUNITIES
13 CLIMATE ACTION

If practiced sustainably and integrated into a territory's challenges, urban agriculture can be a nature-based solution to address numerous environmental concerns in cities. Changes in urban "grey" infrastructure can simultaneously mitigate and promote adaptation to the climate crisis (SDG 13). Expanding green and sustainably cultivated areas can mitigate the heat-island effect while increasing the uptake of soil water and atmospheric carbon. Urban agriculture can also play a role in flood mitigation. A study in São Paulo showed that urban agriculture based on ecological practices could prevent the erosion of 1 million tons of soil from riverbanks, reduce the average temperature by 0.1 degree Celsius and increase rainfall infiltration in the soil (Instituto Escolhas 2021).

While urban agriculture can stimulate food security for underserved populations, it cannot completely address food insecurity. This is because participation in community agriculture is low compared with household gardening, which is typically dominated by wealthier, food-secure urban residents (National Gardening Association Research Division 2021). During the COVID-19 pandemic, household gardening has increased, especially in developed countries (National Gardening Association Research Division 2021). Some jurisdictions have also experimented with household delivery. For example, the non-profit Food For Free and the City of Cambridge, Massachusetts together initiated the COVID-19 Relief Delivery Program to provide food to people at high risk of food insecurity (Food For Free and City of Cambridge 2021).

Research indicates that certain conditions must be met to realize the long-term food security benefits of urban agriculture. Food must be supplied to the communities where it is grown, must be economically and physically accessible, and must be culturally appropriate; urban agriculture also has to be long-term, free from the uncertainties caused by politics, land-use pressures, zoning and sale (Kortright and Wakefield 2011; Kato 2013; Pfeiffer, Silva and Colquhoun 2015; Santo, Palmer and Kim 2016; Poulsen 2017). More context-sensitive research is needed to determine how best to address food insecurity (Poulsen *et al.* 2015).

2.5 Urban agriculture and health

Studies across the globe point to potential health benefits and risks from urban agriculture, including for certain populations and by gender. Benefits include improved mental health, increased physical activity, consumption of fresher food, better nutrition and dietary diversity, and improved food health literacy, although the magnitude of these benefits varies by context (McCormack *et al.* 2010; Zezza and Tasciotti 2010; Algert *et al.* 2016; Santo, Palmer and Kim 2016; Piorr *et al.* 2018; Sickler 2018; Harada *et al.* 2021). Studies in the United States have highlighted the benefits of urban agriculture for well-being, particularly for people who grow their own food, for low-income groups, for women and for community gardeners (Ambrose *et al.* 2020; Ambrose *et al.* 2021). A study from the US Twin Cities area exploring the well-being implications of gardening found that low-income and female gardeners are associated with higher emotional well-being (Ambrose *et al.* 2020).

Audate *et al.* (2019) reviewed 101 articles on the health benefits and impacts of urban agriculture, with many of the studies focused on North America and Sub-Saharan Africa. Generally, the results revealed positive impacts on food security, nutrition, social capital, physical and mental health outcomes, and well-being. The studies did not find clear evidence of negative impacts of urban agriculture.

However, the promotion of urban agriculture must consider local contexts and conditions to avoid potential health disbenefits. For example, one study found that using untreated or partially treated wastewater for urban agriculture in Hyderabad, India increased health risks as the produce, soil and water become contaminated with pathogens (Miller-Robbie, Ramaswami and Amerasinghe 2017). Studies in the United States point to similar health risks for food grown in urban microclimates, including contamination through soil, urban waste, heavy metals, polluted water and the use of brownfield sites (Kim *et al.* 2014). Exposure to bacterial, viral and parasitic pathogens could occur through contact, inhalation and consumption (Wortman and Lovell 2013). Additionally, pesticide and fertilizer poisoning due to run-off or improper disposal can affect urban farmers, consumers and residents (Brown and Jameton 2000).

These hazards are more prominent in low-income, minority communities, which are more susceptible to the health risks of urban agriculture (Lee and Mohai 2012). Cole *et al.* (2006) outlined potential disbenefits from urban agriculture in Sub-Saharan Africa, including physical hazards (*e.g.*, repeated bending, noise from grinding), chemical hazards (*e.g.*, upstream waste discharge, vehicle exhaust), biological hazards (*e.g.*, direct livestock transmission, vector-borne pathogens) and psychosocial hazards (*e.g.*, long hours, fear of theft or assault).

These health risks may be further heightened for women in low-income developing countries, who often rely on urban agriculture as the sole source of food and may be forced to grow food on contaminated sites (*e.g.*, waste dumps) using contaminated water, due to a lack of access to arable land (Nabulo *et al.* 2004; Nabulo, Kiguli and Kiguli 2009). In Kampala, Uganda, women were found to be more vulnerable to health hazards because of the multiple roles they perform. For example, women and children who spend long hours selling food products by the road may be exposed to heavy metal pollutants (Nabulo *et al.* 2004).

2.6 Challenges and business models to enhance the transition to circular urban agriculture

Challenges

Evidence indicates that cities are having difficulties transitioning to circular urban agriculture. Challenges include institutional barriers (such as a lack of defined property rights for biological materials), governance issues related to managing bio-based systems (competition for land and land tenure issues), behavioural barriers (misgivings about using waste as a resource, non-participation in recycling, inadequate incentives) and technical barriers (lack of waste segregation infrastructure or of metrics to measure circularity) (Borrello *et al.* 2016; World Economic Forum 2018). Other barriers include land-use planning and a lack of urban policy directives (Puppim de Oliveira and Ahmed 2021), limited crop types, difficulties in becoming circular (D'Ostuni and Zaffi 2021) and limited supplies of waste.

Gender disparities can exacerbate these challenges for women. A 2011 study found that less than 20 per cent of all land holders were women, even though women represented 43 per cent of the agricultural labour force in 2012 (FAO 2011b; FAO 2011c). In addition, urban agriculture faces challenges related to the disproportionate institutional support by gender. A study in Khartoum State, Sudan found that 94.3 per cent of women felt they lacked institutional support, with only 5.7 per cent being involved in women's organizations (Daoud 2019, p. 30).

In many developing regions, patterns of production, distribution and marketing impede urban agriculture from effectively supporting the transition to a circular economy. At the production level, challenges include the quality of the water and wastewater being used (Box 2), the quality of the available organic compost (Soto and Siura 2008; Rekow 2015), the use of pesticides (Monteiro and Monteiro 2006; Soto and Siura 2008) and the effects of air pollution on food safety (Amato-Lorenço *et al.* 2016). To address these challenges, local governments can provide credit and technical assistance for more regenerative practices. One study found that, through four years of ecological soil management, the share of agricultural inputs can be reduced to 30 per cent or less of the production cost (compared to 40-60 per cent with conventional management), making producers less dependent on inputs and impacting their prices (Instituto Escolhas and URBEM 2020).

BOX 2: Reusing wastewater

In urban centres in developing countries, land and water inputs are scarce and more costly, leading to the use of stormwater, contaminated sewage or grey water for irrigation and freshwater aquaculture (Toze 2006; van Lier and Huibers 2010). Studies have found that, for example, the levels of fecal coliforms in water used for irrigation in urban agriculture do not meet World Health Organization (WHO) standards/guidelines (Amoah *et al.* 2006; WHO 2006; Janeiro *et al.* 2020). Although urban wastewater can be treated for reuse in agriculture, allowing for the recovery of nutrients and alleviating pressures on ecosystems and fresh water (Hyderabad Declaration 2002; Liu *et al.* 2010; Janeiro *et al.* 2020), only a small share of wastewater is currently processed. Less than 5 per cent of the wastewater in Sub-Saharan Africa is treated, while the largest areas irrigated with untreated or diluted wastewater are found in China, India and Mexico (Keraita, Drechsel and Konradsen 2008; Lautze, Cai and Matchaya 2014; Jaramillo and Restrepo 2017; Janeiro *et al.* 2020).

Wastewater aquaculture exists in a few African countries including Ghana, Kenya, Malawi, South Africa and Zimbabwe (Bunting 2004; Magnusson and Bergman eds. 2014). After partially treating the wastewater, the phytoplankton or zooplankton can provide valuable nutrition for fish (Magnusson and Bergman eds. 2014). Reclaimed water is used in China to cultivate vegetables and cereals and in India to farm sugar cane; meanwhile, Mexico uses reclaimed wastewater (typically untreated or partially treated) to grow vegetables, maize and alfalfa (Janeiro *et al.* 2020). The potential social benefits for safe water reclamation in urban agriculture in developing countries are significant, covering the cost of reclamation (Janeiro *et al.* 2020). It is important that developing countries invest adequately when planning urban water and sanitation infrastructure (Janeiro *et al.* 2020).

Long commercialization chains dominate the urban food supply, with several intermediaries operating between the producer and the final consumer. This is the case even in urban agriculture, especially when it is integrated into large-scale supply. On the one hand, intermediaries can help to concentrate the supply and better organize the demand for food; however, they also generate more food loss during transport and reduce the profit margin for producers. Typically, each intermediary adds 100 per cent to the product value, which means that the compensation for products in long chains is typically incompatible with the necessary investments and production costs (Instituto Escolhas and URBEM 2020). Large buyers of horticultural products – such as retail chains and institutional buyers – can play a crucial role in reducing the negative impacts of the supply chain (helping to reduce losses and make local agriculture more profitable) by making direct commitments with producer associations and cooperatives, rather than purchasing from distributors.

The stability of agriculture in urban land use is another critical challenge impeding urban agriculture's contribution to a circular economy. Often, the cost of land is incompatible with the financial returns of urban agriculture, and selling land is more advantageous than keeping cropland. In metropolitan areas, in particular, urban agriculture struggles to compete with residential and commercial land uses. However, agriculture can be practiced in locations where buildings are not allowed, such as under power lines and in other urban interstices. Land distribution policies, such as the one in Rio Branco in the Brazilian Amazon, can aim to prioritize the social or ecological function of non-productive and degraded peri-urban areas.

Local governments should promote land access policies through the regularization of areas that are already occupied and through loans of available public areas. Meanwhile, it is essential that territorial planning instruments and urban land-use regulations officially acknowledge urban agriculture. To this end, the City Region Food Systems (CRFS) approach can be helpful towards strengthening the functional ties of the urban-rural relationship. Since urban food consumption impacts other regions that supply these products and receive their waste, food is an essential link in strategically defining the scope and direction of policies that engage with sustainable development (Dubbeling *et al.* 2017; Lardon *et al.* 2018).

Business models for transitioning to circular urban agriculture

Urban agriculture should be designed to create, deliver and capture value by identifying a viable market for products that have real demand (Dorward *et al.* 2003; Dubbeling, Hoekstra and van Veenhuizen 2010). This includes markets for safe, fresh, and organic produce, which many consumers prefer (Bienabe, Vermeulen and Bramley 2011). Urban consumers are also increasingly (although less so for underserved populations) concerned about environmental and social issues related to food production and distribution (Hinrichs 2000; Haldy 2004; Brown, Dury and Holdsworth 2009). This has given rise to, for example, a vegetable box (social enterprise) subscription model for organic produce (Thom and Conradie 2013), which shortens the link between the farmer and regular consumers of organic produce (Haldy 2004; Thom and Conradie 2013).

There are several reasons to support alternative business models for urban agriculture. First, urban farmers need to adjust their farming to exploit all opportunities and to counter existing constraints (van Huylenbroeck *et al.* 2005). Second, the cultivation, processing and marketing of urban farming products takes place in an environment characterized by the highest levels of demand (McClintock 2010). Third, as observed by Skar *et al.* (2019), cities offer favourable conditions for

creating local and short marketing channels for agricultural products and farming-related services, due to "the potential of nearby and easily accessible large consumer groups, the concentration of particular societal demands and trends, and the innovative milieu in cities".

Urban agriculture business models must distinguish themselves by adapting to cities and shifting away from "mainstream commodity market and global prices mechanisms" (Skar *et al.* 2019). The most-used business models for urban agriculture are product differentiation and enterprise differentiation (Skar *et al.* 2019). Other emerging models include low cost, reclaiming the commons, and experience, as well as agro-tourism (Reed and Kleynhans 2009; Phillip, Hunter and Blackstock 2010). For developed countries, Pölling *et al.* (2017) undertook a comparative analysis of urban agriculture business models in Spain, Italy and Germany. In developing countries, constraints inhibiting urban farmers from accessing niche markets include land tenure insecurity and inadequate finance, as well as the cost and time involved in obtaining organic certification of produce to meet international standards (Bienabe, Vermeulen and Bramley 2011).

2.7 Urban agriculture typologies around the globe

Urban land is usually very expensive and often supports the concentration of commercial and industrial activities in cities. This enables cities to grow rapidly economically and in population, bolstering growth in gross domestic product (Bettencourt *et al.* 2007). Consequently, economic incentives in cities favour high-value activities. Within this fabric, different typologies of urban agriculture – within city boundaries, in peri-urban areas and in even-larger geospatial expanses (local agriculture) – can contribute to the local food system (Table 1). What is considered local varies widely, with some local farms located hundreds of kilometres from the point of consumption (US Congress 2008; Feldmann and Hamm 2015).

With this understanding, studies have shown that the capacity for urban agriculture within city boundaries to meet local needs varies. In-boundary production can range from less than 1 per cent for New York and 10 per cent for Minneapolis in the United States to 5 per cent for Delhi and 40 per cent for Pondicherry in India (Boyer and Ramaswami 2020). For fresh produce, in-boundary production can range from 1.7 per cent in Cleveland, United States and 2.6 per cent in Leicester, United Kingdom to 90 per cent in Accra, Ghana and 76 per cent in Shanghai, China (Lee-Smith and Prain 2006; Grewal and Grewal 2012; Corbould 2013; Edmondson *et al.* 2020). Fresh produce, however, comprises only a small fraction of the weight of food and of the land required for food production, which is dominated by grain. Differences also vary by city type, with Pondicherry and Minneapolis, for example, considered very active in food production and processing.

Higher within-boundary food production in developing countries versus developed countries is not surprising, as existing research and media reports find that the main motivation for urban agriculture in developed countries is not the amount of food you can grow for the whole community, but rather growing food specifically for underserved populations or to support other co-benefits, such as social cohesion, education, civic-engagement, health and well-being (Kortright and Wakefield 2011; Pfeiffer, Silva and Colquhoun 2015; Plumer 2016; Santo, Palmer and Kim 2016; Poulsen 2017).

Other researchers have run scenarios to show how much food could be produced if all available green spaces in urban areas (vacant lots, rooftop gardens, greenhouses, etc.) were utilized (Colasanti and Hamm 2010; Grewal and Grewal 2012). For example, Grewal and Grewal (2012) found that if Cleveland used 80 per cent of every vacant lot, plus 9 per cent of occupied residential lots and 62 per cent of industrial and commercial rooftops, it could meet 46-100 per cent of its fresh produce needs, 94 per cent of its poultry and shell egg needs, and 100 per cent of its honey needs. Nixon and Ramaswami (2018) found that already today, without any expansion of agriculture, 21 per cent of US metropolitan statistical areas could be self-reliant in egg and milk equivalents, 16 per cent in vegetables and 12 per cent in fruits, if food supply chains were oriented to match local production capability. Grain requirements remain challenging, however.

Typologies of urban agriculture vary across continents and nations. In a literature review, Cilliers *et al.* (2020) identified 27 different urban agriculture practices across the globe based on the rationale for establishment. In developed countries, production is undertaken for recreational or aesthetic purposes besides household food supply and security, and tends to occur on rooftops, balconies, vacant lots and parks (McClintock 2010). In developing countries, however, the focus is on food security and nutritional needs as well as on household income generation, and activities take place on undeveloped lands, marginal lands and community plots (Box 3) (McClintock 2010; Gray, Elgert and WinklerPrins 2020).

Given the diversity of urban agricultural systems, several authors have attempted to provide typologies that suit their context. The typologies are classified by scale of production (Gray *et al.* 2014), ownership structure (Pulighe and Lupia 2019; Nicholls *et al.* 2020) and level of technology and innovation (Ayambire *et al.* 2019; Orsini *et al.* 2020). Table 2 presents an adaption of typologies that are practiced in cities of developed and developing countries and that have the potential to promote sustainable development.

BOX 3: Urban agriculture in Accra, Ghana

Accra, the capital city of Ghana, has a population of 5.4 million, with around 8.7 per cent engaged in urban agriculture. Urban agriculture takes place within the household space or on private open or publicly available space. Significantly fewer farming activities occur within the homestead than away from home, with plot sizes ranging from 1 square metre to 10 hectares or more, and generally increasing along the urban/peri-urban divide. The main types of low-income agriculture include container gardening, homestead gardening, open-space commercial horticulture, subsistence and commercial livestock, and fish farming – using mainly rainwater and wastewater (World Bank 2013). The main produce are vegetables, maize, cassava and plantain; and the animals are poultry, sheep, goats and fish. The vegetables, maize and a few small livestock are produced within the city, whereas staples like maize, plantain and cassava, and large and small livestock are produced in peri-urban areas.

Table 2: Types of urban agriculture, technology adoption and user types

Typologies	Description	Technology Level	User Type/Scale
Backyard gardens 	Private gardens and balcony or terrace gardening associated with residential food production.	Low ●○○	Farmers (individual growers)
Community gardens 	Self-organized or neighbourhood initiatives producing food for personal or common benefit; members participate in decision processes and share resources such as space, water and tools.	Low ●○○	Society
Allotment gardens 	Legally fixed forms of urban gardens that are tended individually by plot holders and their families (see Box 4).	Low ●○○	Society
Rooftop gardens 	Gardens on top of houses or industrial buildings and representing innovative agricultural production; can be organized collectively or privately.	Medium to high ○●●	Farmers, society
Vertical farms with artificial lighting 	High-tech methods to cultivate plants in soil-less or organic or inorganic substrates, including hydroponics, aeroponics* and aquaponics; advancements in greenhouse and supporting technologies such as multi-racking mechanized systems, recycling systems, LED lighting, and solar and wind power.	Medium to high ○●●	Farmers, society
Alternative farms** 	Microgreens, urban beekeeping.	Low to high ●●●	Farmers, society

* *The growing of plants and crops without the use of soil wherein the plant's roots are suspended in the air and are misted with water on a regular basis.*

** *Farms where the production method is not energy- and chemical-intensive.*
Adapted from Ayambire et al. 2019 and Orsini et al. 2020.

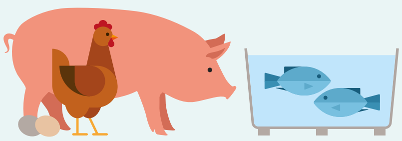
BOX 4:
Allotment gardens and their ability to feed urban populations: Leicester, United Kingdom

An analysis by Edmondson *et al.* (2020) estimated the fruit and vegetable production in 46 allotment garden sites in Leicester, United Kingdom, 45 of them owned by the city council. The sites comprised 3,200 individual plots and accounted for 1.3 per cent of the city's land. The researchers found that the average plot spanned 264 square metres and that around 52 per cent of the plot area was cultivated on average, with as many as 72 different crops being grown. The plots produced more than 1,200 tons of fruit and vegetables and 200 tons of potatoes annually, meeting the fruit and vegetable needs of some 8,500 people (2.6 per cent of city residents). The researchers estimated that cultivating the 13 per cent of plots that remained uncultivated could add 200 tons of fruits and vegetables and 100 tons of potatoes annually, feeding another 1,500 people (bringing the total to 3 per cent of residents).

The case study highlights that food grown on allotment plots can make a modest but important contribution to feeding urban populations. The authors point to the focus on urban agriculture that has occurred in the United States, Canada and the United Kingdom during or following times of emergency rather than on a continuing basis (Ambrose *et al.* 2020; Ambrose *et al.* 2021). Examples from World War II include the Dig for Victory and Victory Garden campaigns (Ambrose *et al.* 2021). In Leicester, in the 1950s, allotment gardens were meeting the fruit and vegetable needs of more than 45,000 residents, compared to less than 10,000 in 2012 (Rydin *et al.* 2012). This pattern seems to persist, with urban agriculture in the United States increasing during the COVID-19 pandemic (Nixon and Ramaswami 2018). This highlights the need for long-term policy support for urban agriculture and for protecting cultivated urban land from development to allow urban agriculture to reach its full potential.

The typologies presented in Table 2 emphasize technology adoption and the nature of the social structure that supports sustainable urban agriculture. However, urban agriculture typologies can also be classified in terms of umbrella typologies and sub-typologies, as well as urban locational characteristics (Table 3). The typologies in Table 3 highlight the distinction in urban agriculture in developing countries, which focuses mainly on providing food security and nutritional needs as well as household income generation.

Table 3: Agriculture systems in urban agriculture

Typologies	Sub-typologies	Description
Horticulture 	Patchwork horticulture (food crops)	Small farms (mainly vegetables) on unused public lands (including reserved land on sides of highways).
		Private and public nurseries producing fast-maturing fruit seedlings (coconuts, mangoes, oranges, etc.) to be sold from trucks in city centres.
	Patchwork horticulture (ornamental)	Ornamental plant nurseries, packaging and sales points located along busy roads.
	Controlled-environment farms	Greenhouse farms producing mainly vegetables.
Livestock 	Animal husbandry	Poultry (for meat and eggs); urban and suburban ranching and piggery operations.
	Fish farming	Tank farms located deep in urban centres, often in private homes.
Backyard mixed farms 	Backyard mixed farms	Pond/Cage farms, mainly in suburban areas, supplying urban areas.

* *The growing of plants and crops without the use of soil wherein the plant's roots are suspended in the air and are misted with water on a regular basis.*

** *Farms where the production method is not energy- and chemical-intensive.*
Adapted from Ayambire et al. 2019 and Orsini et al. 2020.

2.8 Benefits of urban agriculture

In this section, we examine the potential benefits of urban agriculture with specific attention to its contribution to the resilience of food systems – that is, the capacity to quickly respond to impacts on food supply, access to nutritious food and healthy diets, and sustainable food consumption.

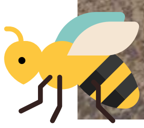
Environmental benefits

The expansion of green areas in cities can potentially contribute to climate change mitigation and adaptation, heat and flood mitigation, erosion reduction and carbon capture. It can also contribute to the maintenance of agricultural biodiversity and related knowledge, the increased presence of pollinators and the consequent reduction in biodiversity loss. Agricultural areas on city fringes can serve as essential transition zones between urban land use and forests, ensuring the maintenance of ecosystem services. However, such benefits can only be achieved when urban agriculture is circular (using regenerative practices, eliminating pollutants, recycling waste and maximizing exploitation of the inputs used) and is fair and equitable for producers and consumers.

Besides providing food and fibre, highly efficient and integrated urban agriculture systems generate other environmental benefits. Drip irrigation and hydroponics can greatly impact crop water yield. Agricultural irrigation represents around 85 per cent of global water use, and drip irrigation can increase yields up to 90 per cent (Rufí-Salís *et al.* 2020; Langemeyer *et al.* 2021). Urban agriculture can benefit ecosystems by preventing erosion, supporting pollination and seed dispersion, and regulating the microclimate (Smith and Roebber 2011; Santamouris 2014; Zupancic, Westmacott and Bulthuis 2015; Vasquez *et al.* 2019).

By using organic waste as fertilizer, urban agriculture can mitigate the environmental impacts of mineral fertilizers as well as the emissions from landfilling. Worldwide, an estimated 30-50 per cent of produce is lost due to lack of cold storage and inadequate infrastructure (FAO 2011a), with fruits and vegetables recording the highest losses. Although per capita food waste is much higher in Europe and North America than in Asia and Africa, food losses in developed and developing countries are the same. In developing countries, they occur mainly during post-harvest and processing, whereas in developed countries they occur at the retail and consumer levels (FAO 2011a). Urban agriculture's proximity to markets can potentially reduce emissions as well as food loss during transport. However, studies and data are lacking.

Despite the potential benefits of urban agriculture, few studies have looked at the multiple environmental benefits and disbenefits of different types of agriculture. In agreement with other literature, Boyer and Ramaswami (2020) explored the water, energy/emissions and land impacts of urban food actions across two cities each in the United States and India and found that the biggest levers for reducing greenhouse gases (and mitigating other impacts in some cases) were dietary change and food waste management (Weber and Matthews 2008; Avetsyan, Hertel and Sampson 2014; Santo, Palmer and Kim 2016).



Overall, urban agriculture's contribution to reducing the environmental impacts from food systems remains limited for several reasons. First, a relatively small amount of land in urban areas is used in agriculture, and rooftop and high-tech vertical farming are still a niche. Second, only a few crops can be grown economically in cities or in controlled indoor environments, and those crops (vegetables, herbs, fruits) are not the biggest contributors to the food system's environmental impact. Studies on urban agriculture's impacts on reducing food waste and transport emissions are limited. Third, many studies have noted that increasing urban agriculture in cities can increase environmental stresses, including fertilizer pollution, water/energy use, and growing on contaminated land (The Economist 2010; Yu, Zhu and Li 2012; Kozai 2013; Love, Uhl and Genello 2015; Miller-Robbie, Ramaswami and Amerasinghe 2017).

Decision makers who want to promote urban agriculture with positive effects on the environment should consider impacts on energy, land and water use, and the potential effects of pollution on food quality.

Social and nutritional benefits

Urban agriculture's most significant contribution is to promote food and nutritional security in cities by expanding the supply of fresh and healthy food at fair prices. A few studies exploring nutrition outcomes of urban agriculture reported positive effects on fruit and vegetable intake, the nutritional status of children and food diversity (Audate *et al.* 2019). Policies that promote urban agriculture have great potential to make urban food systems more resilient in times of shortage, reduce impacts of price fluctuations, improve food access for socially vulnerable populations and reduce social inequality (Maciel *et al.* 2018).

Urban agriculture also has the potential to enhance local food culture. Increasing the supply of local products and maintaining traditional farmers on their land enhance traditional knowledge, customs and the preservation of agrobiodiversity.

Different types of urban agriculture, such as institutional, backyard, and community gardens, can promote mental and physical health, offer opportunities to socialize, and help establish networks to exchange inputs and knowledge.

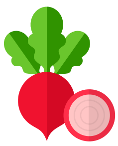
The social and nutritional benefits of urban agriculture are amplified for women in low-income developing countries, particularly as they seek to improve household food security, health and financial security (Anosike and Fasona 2004; Hovorka 2006). Even in cases where the economic potential of urban agriculture is limited, it helps socially empower women through social networks, creating a greater sense of community, engagement in community development and financial independence (Maxwell 1995; Slater 2001; Hovorka 2006; Buechler 2009; Ponce and Donoso 2009; Orsini *et al.* 2013).

In a study conducted in Bulawayo, Zimbabwe, Hadebe and Mpofu (2013) found that 68.3 per cent of women were engaged in urban agriculture, compared to 31 per cent of men, with 54 per cent of women making the decisions on what to plant and grow. Further, 76.2 per cent of women agreed that this food production resulted in improved nutrition for their families compared to purchased food items. Concurrently, a study in Cape Town, South Africa found that both men and women who engaged in urban agricultural activities experienced the same benefits in terms of food security and health benefits, with women demonstrating that engaging in urban agriculture provided stress relief (Robertson 2013).

Economic benefits

In principle, commercial urban agriculture has the potential to generate employment and income and to boost the local economy. Technical assistance aimed at commercialization and scaling-up, as well as policies for accessing land to credit, are therefore essential (Maciel *et al.* 2018; Escolhas and URBEM 2020). Urban agriculture also promotes the development of high technology and green industry.

Non-commercial (subsistence) urban agriculture, such as household and community gardens, also plays a vital role in the economy, helping to reduce food costs for participants. Particularly in low-income developing countries in Asia and Africa, social, cultural and gender norms often result in women having lower levels of education, limited autonomy, greater domestic responsibilities, and limited access to finances and well-paying employment (Anosike and Fasona 2004; Hovorka 2006; Hadebe and Mpofu 2013). In such cases, urban agriculture provides women with the opportunity to engage in income-generating activity with minimal capital investment while taking care of other household responsibilities (Obuobie *et al.* 2004; Buechler 2009; Hovorka, Zeeuw and Njenga eds. 2009; Orsini *et al.* 2013).



A study conducted in the western suburbs of Bulawayo, Zimbabwe showed that women opt to grow crops that enhance household food security rather than purchase food items for their family needs (Hadebe and Mpofu 2013). In Sogamoso, Colombia, 83 per cent of peri-urban agriculturalists consume at least some of the animal or vegetable products that they produce, contributing to increased food security and access to healthy diets (Feola *et al.* 2020). Urban agriculture makes urban food systems more resilient to supply crises, especially when inserted into solid commercialization networks featuring fair and solidary trade. Additionally, a study conducted in Khartoum State, Sudan demonstrated that 32 per cent of women improved their income (alongside improved food security) by engaging in urban agriculture (Daoud 2019, p. 28).

Conventional land-based urban agriculture is relatively low-paying (Brown and Getz 2008; Gray 2013; Holmes 2013). It is often practiced as a hobby or by groups that face food insecurity, more so in developing, low-income countries where it is used mainly for household consumption (Zezza and Tasciotti 2010; Poulsen *et al.* 2015). The economic benefits of such operations have been found to vary based on agriculture type and process, crops grown, farmer income level, gender, etc. (Poulsen *et al.* 2015). Zezza and Tasciotti (2010) found that urban agriculture constituted a sizable portion of the incomes of poorer households in some developing countries in Africa and Asia but not in Latin America and Eastern Europe.

The dynamics of urban and rural settings differ due to the institutional and societal dynamics in cities and rural areas which can create more polarization (Hovorka, Zeeuw and Njenga eds. 2009, p. 2). As articulated above, women can not only enhance family food security through urban farming, but also generate income through selling excess products (Hovorka, Zeeuw and Njenga eds. 2009, p. 2). Soto *et al.* (2009) note that urban farming empowers women through independence, leadership and capacity-building. Thus, there is value in looking to women to enhance urban agriculture as more of the world's population moves to cities.

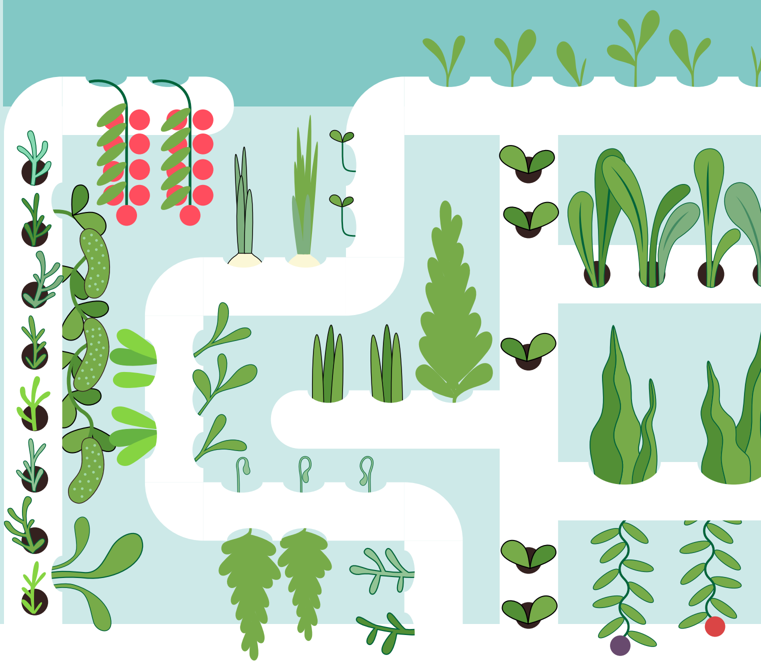
To create value-added products, niche urban farms in controlled indoor environments have developed in some countries, with a focus on products such as herbs that can be grown in soil-less media (Box 5). Research shows significant potential for vertical farming, a market that is expected to reach $7.3 billion globally by 2025 (Markets and Markets 2020; Alterman 2021). Major investments in high-tech urban agriculture have occurred. For example, Gotham Greens grows specialty foods year-round in solar- and wind-powered greenhouses, warehouses and roof farms in six US states (Gotham Greens 2021). With machine learning and artificial intelligence, automation will likely be the next step towards efficiency. The economic benefits and who gets them will depend on whether operations are conventional or high-tech.

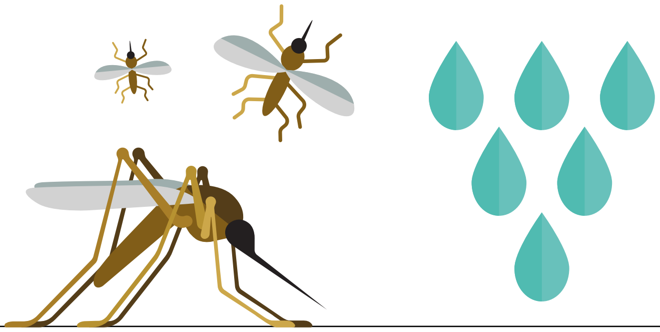
BOX 5: High-tech commercial vertical farming: The case of AeroFarms, United States

AeroFarms, headquartered in New Jersey, United States, has played a prominent role in commercial indoor vertical farming since it started operations in 2004. The company's 6,500 square metre facility in Newark grows more than 900,000 kilograms of produce a year (Birkby 2016; Pandey 2017), using artificial intelligence to control lights, nutrients and temperature. With its automated process, AeroFarms can produce 550 varieties of fruit and vegetables, while achieving 390 times the yield per unit compared to traditional farming and using 95 per cent less water and no pesticides (Birkby 2016; AeroFarms 2021). This efficiency is attributable to a unique closed-loop system that integrates vertical farming with aeroponics and a patented reusable cloth medium for growing. AeroFarms can grow produce in half the time of traditional field operations (Pandey 2017; AeroFarms 2021).

AeroFarms' growing facility. Photo source: AeroFarms 2021

AeroFarms focuses on the sustainability of food systems and boasts a business model designed to address 12 of the 17 Sustainable Development Goals. It integrates with local distribution systems to meet urban food needs and, in the process, creates year-round employment for communities (Pandey 2017; AeroFarms 2021). In addition, AeroFarms partners with the city and schools to educate communities about vertical farming and to fight local food insecurity (Vyawahare 2016; Baer 2021). As a Certified B Corporation, it meets the "highest standards" of verified social and environmental performance, transparency and legal accountability (Certified B Corporation 2017). Plans include expanding to grow additional leafy products and berries, incorporating autonomous systems and machine learning technologies, and new facilities in Abu Dhabi and Virginia (Klein 2021).



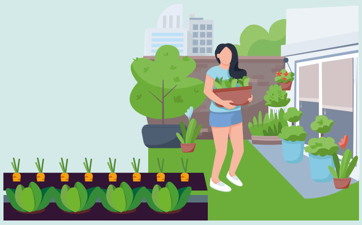


Benefits and trade-offs of urban agriculture typologies

While the different typologies of urban agriculture provide economic, social and environmental benefits to urban communities (Mougeot 2000; Mougeot ed. 2005), they also generate environmental, productivity and related trade-offs (Table 4). The optimum benefits lie at some appropriate balance between the production from urban agriculture and the externalities that it generates (Lin, Philpott and Jha 2015).

Changes in food production can conflict with other Sustainable Development Goals, such as protecting land resources and mitigating climate change. Decision makers need to understand potential trade-offs between these goals and find a balance between human needs and environmental impacts. For urban agriculture to generate net social benefits, it must be highly efficient and be an integrated production system. It should have lower environmental impacts than conventional agriculture, with production based on efficient water use and fertile soils and integrated into urban land-use planning, which can also help mitigate climate change (Bren d'Amour *et al.* 2017; Langemeyer *et al.* 2021). Modern technologies such as controlled-environment agriculture (vertical or greenhouse farming, hydroponics, aeroponics, aquaculture, aquaponics) should be explored.

Table 4: Benefits and trade-offs of urban agriculture typologies

Typology	Benefits	Trade-offs
Backyard gardens 	***Economic:*** provide fresh, safe and hygienic foods; save income spent on food commodities. ***Social:*** source of exercise; enhance well-being. ***Environmental:*** recycling of household organic wastes into compost; reduce pressure on landfills.	Mosquito breeding; use of drinking water for irrigation; health and environmental implications of improper management of wastes.
Community gardens 	***Economic:*** promote food security for the poor. ***Social:*** promote intercultural communications; green the city; educate people; strengthen communities. ***Environmental:*** storm attenuation services; reduce temperature and greenhouse gases.	Competition for space for urban infrastructure, *e.g.*, housing; demands for drinking water for irrigation.
Allotment gardens 	***Economic:*** enhance self-sufficiency of lower-income residents. ***Social:*** encourage community participation. ***Environmental:*** improve biodiversity and ecosystem services.	Competition for space for urban infrastructure, *e.g.*, housing; spill-over of chemical nutrients to natural systems.
Rooftop gardens; greenhouses 	***Economic:*** increase organic fruit and vegetable production; create employment opportunities; enhance property value. ***Social:*** improve aesthetics; provide education; enhance community participation. ***Environmental:*** increase biodiversity; reduce heat and energy use; recycle organic waste.	Mosquito breeding; demands for drinking water for irrigation.
Vertical farming 	***Economic:*** reduces energy, packaging and fuel to transport food; turns waste into an asset; offers greater yields; creates jobs. ***Social:*** improves air quality, the environment and health; supplies fresher local foods; saves time for productive and socially rewarding activities; enhances well-being; encourages higher education and skilled jobs; availability of potable water. ***Environmental:*** reduces air pollution and need for landfills; requires less space; increases biodiversity; reduces surface water run-off.	Demands for drinking water for irrigation; introduction of pest and pathogens into natural environment.

Adapted from Khan et al. 2020 and Nicholls et al. 2020.

3. Policies to Support Urban Agriculture

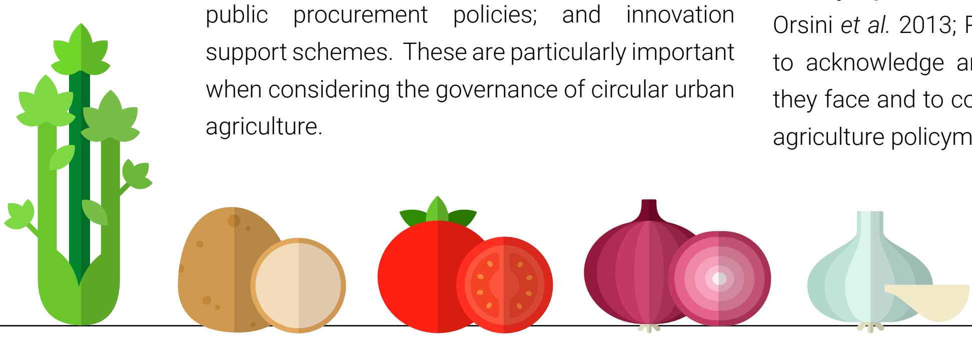
Promoting urban agriculture within the context of a food systems approach calls for actions not only from the agricultural sector but also from the urban planning sector. This is critical for integrating urban agriculture into the urban economic and ecological system (Mougeot 2000). The success of urban agriculture depends on a supportive and conducive policy environment. Appropriate policies will, among others, create awareness of the socioeconomic and environmental role of urban agriculture, delineate the responsibility of governments and city planners, integrate urban agriculture in city planning and land-use planning processes, identify the type of resources (financial and technical) needed, provide formal and informal institutional support, and take steps to address the potential disbenefits of urban agriculture.

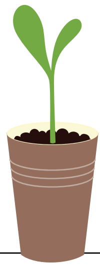
Circular urban agriculture aims to make maximum use of resources through recycling and reuse. However, the transition to circular urban agriculture faces institutional, behavioural and technical barriers as well as governance challenges. Policies to support circular urban agriculture should be designed and developed within this context. Ekins *et al.* (2019) suggest five areas of policy interventions for a circular economy, which may also apply to circular urban agriculture. These are: regulatory frameworks; fiscal frameworks; education, information and awareness creation; public procurement policies; and innovation support schemes. These are particularly important when considering the governance of circular urban agriculture.

3.1 Types of policies for urban agriculture

Clear policies in many areas are needed to support urban agriculture. These include defining land tenure and property rights, providing tax and fiscal incentives to landowners, providing incentives for procurement (*e.g.*, for acquiring waste segregation equipment) and creating public awareness and education (Mougeot 2000; Simatele and Binns 2008).

Additionally, case studies from Africa, Asia and South America indicate that women in low-income developing countries often face unique or heightened barriers to participating in urban agriculture compared with their male counterparts. These barriers relate to land access, land security, the availability of capital and credit, the supply of agricultural inputs, agricultural education/information, water scarcity, and access to markets for sales and connections with institutions and local governments (Anosike and Fasona 2004; Ba Diao 2004; Obuobie *et al.* 2004; Sapkota 2004; Hovorka, Zeeuw and Njenga eds. 2009; Devi and Buechler 2009; Nabulo, Kiguli and Kiguli 2009; Arce, Prain and Maldonado 2009; Buechler 2009; Gaye and Touré 2009; Hope *et al.* 2009; Ishani 2009). Given that women constitute a majority of those engaged in urban agriculture in many countries (Maxwell 1995; Slater 2001; Hovorka, Zeeuw and Njenga eds. 2009; Hadebe and Mpofu 2013; Orsini *et al.* 2013; Poulsen *et al.* 2015), it is critical to acknowledge and assess the unique barriers they face and to consider gender equality in urban agriculture policymaking.





Proposed policy guidelines to strengthen urban agriculture include the following (Hagey, Rice and Flournoy 2012; Instituto Escolhas and URBEM 2020):

- Financing and technical assistance policies for transitioning food production towards more sustainable models without pesticides and with soil regeneration and sustainable use of water.
- Land access policies, through institutional regularization of areas already occupied by productive farmers and land-use agreements in available public areas.
- Recognition of urban agriculture and peri-urban policies in master plans, urban zoning and instruments for territorial planning and land-use regulation.
- Policies for more sustainable water use and access, such as infrastructure investment in cisterns, wells and irrigation systems that avoid using treated water for human consumption.
- Policies to oversee organic waste composting and urban planning for local food production.
- Policies to strengthen public markets for local producers.
- Public procurement policies that privilege local producers when possible (*e.g.*, school meals).
- Policies that support research and data collection on food systems and related challenges.

Among the numerous actions needed in the urban agriculture sector are creating partnerships to develop multi-level urban-regional agricultural policy, clarifying the purpose of urban food actions, and developing tailored policy guidelines for food and nutritional security, social equity (including gender) and well-being, environmental sustainability, resource circularity and economic development. Table 5 provides examples of existing policies that support urban agriculture in different regions. The first four are national-level policies, which are critical in creating a conducive environment for sub-national policies.

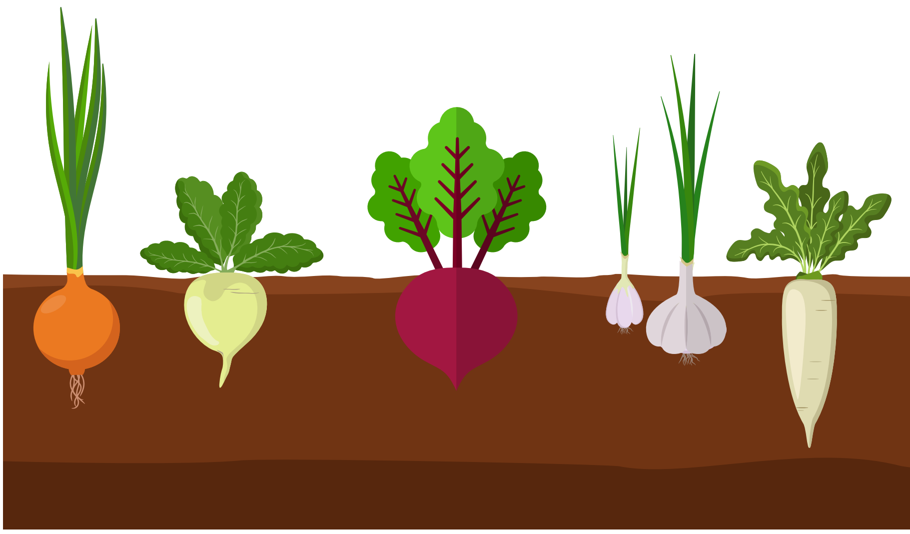


Table 5: Examples of existing policies to support urban agriculture

City and/or Country	Policy description
Brazil	The National Policy on Agroecology and Organic Production (Política Nacional de Agroecologia e Produção Orgânica – PNAPO), launched in 2012, institutionalizes different policies and public actions to promote food and nutritional security. A key instrument is the Agroecology and Organic Production National Plan, which includes urban agriculture as a target. The two editions of the Plan strengthened the relationship between public and private agents around agroecology, helping to incorporate the theme in policy planning and implementation (FAO n.d.; Giacchè and Porto 2015). http://www.planalto.gov.br/ccivil_03/_ato2011-2014/2012/decreto/d7794.htm https://www.in.gov.br/materia/-/asset_publisher/Kujrw0TZC2Mb/content/id/44100949/do1-2018-10-05-portaria-interministerial-n-1-107-de-4-de-outubro-de-2018-44100743
Brazil	The Urban and Peri-urban Agriculture National Program (Programa Nacional de Agricultura Urbana e Periurbana), implemented in 2018, aims to encourage agroecological food production in cities, healthy eating habits, and agricultural production for educational purposes, especially in socially vulnerable regions. Through the programme, it is possible to support initiatives such as implementing vegetable gardens and seedling nurseries, and promoting technical assistance. https://www.gov.br/cidadania/pt-br/acoes-e-programas/inclusao-produtiva-urbana/agricultura-urbana/agricultura-urbana-1
Brazil	The Pedagogical Gardens Project (Projeto Hortas Pedagógicas) is an initiative of the Ministry of Citizenship to integrate scientific knowledge and food and nutritional security. It targets public schools, which can obtain training to promote gardens to increase access to nutritious food (Brasil 2020). Four schools were selected in two north-eastern states. In 2020, during the COVID-19 lockdown, the vegetable gardens contributed to the food security of the schools' communities (Brasil 2020). The project also offers a free online course for public managers. https://www.gov.br/cidadania/pt-br/acoes-e-programas/inclusao-produtiva-urbana/agricultura-urbana/projeto-hortas-pedagogicas
China	The Urban Master Plan 2005-2020 makes provision to preserve farmland and green space and to designate green areas in city fringes and corridors. It also promotes wastewater recycling and rain and flood water harvesting, protects forest areas and subsidizes energy-saving production.
Bandung City, West Java, Indonesia	The Bandung Food and Agriculture Office facilitates the local farming programme with attention to gender mainstreaming. It directly supports the participation of women farmer groups in urban farming through training, education and monitoring by the government. In addition, it provides these groups with access to city land for farming, seeding homes, nurseries and fishponds (Safitri, Abdoellah and Gunawan 2021).
Bobo-Dioulasso, Burkina Faso	A policy promotes open urban lots (greenways) while protecting peri-urban forests and acknowledges agroforestry and gardening as urban land uses. The greenways are planted with different fruit-bearing tree species, and space is provided for recreation. Participating households have increased their consumption of fresh vegetables and reduced their food expenditures.
Bogota, Colombia	The Huertas Urbanas en Espacios Públicos de Bogotá (Urban gardens in public spaces in Bogota), project is led by the Department of Public Space Advocacy and a range of public institutions. The objective is to transform public spaces through urban agriculture to counteract the effects of climate change while allowing environmental education and promoting food security (Bogotá 2020). Currently, the regulation covers seven different community gardens in public areas. https://www.dadep.gov.co/transparencia/marco-legal/resoluciones-producidas-la-entidad/resolucion-361-del-30-diciembre-2020
Bulawayo City, Zimbabwe	The city promotes gender mainstreaming by including gender and social inclusion as key areas in its Urban Agriculture Policy. The plan calls for the equitable allocation of land for urban agriculture to women and men (Policy 6.2.1 C/). https://foodsystemsplanning.ap.buffalo.edu/gsfp-policy/urban-agriculture-policy-bulawayo-zimbabwe

City and/or Country	Policy description
Freetown, Sierra Leone	Zoning of wetlands and low-lying valleys for urban agriculture aims to promote urban agriculture for food supply and job creation, while increasing water infiltration, reducing flooding and keeping flood zones free from legal and illegal construction.
Kathmandu, Nepal	The city promotes rooftop gardens as well as recycling of household and urban waste. It trained more than 500 households in rooftop gardening and formulated a rooftop garden policy.
Kesbewa, Sri Lanka; Rosario, Argentina	The cities promote the preservation and protection of green and productive areas on stream banks to reduce flood risks.
Rosario, Argentina	Fiscal and tax incentives are provided to landowners who lease vacant private land to groups of urban poor willing to work on the land. Cities can also make municipal land available to groups of urban poor for gardening purposes, either through lease arrangements or by providing occupancy licences. These contracts often include conditions regarding "safe and sustainable land".
São Paulo and Rio de Janeiro, Brazil	The Urban and Peri-urban Agriculture Program in São Paulo (Programa de Agricultura Urbana e Periurbana – PROAURP) and the Carioca Community Gardens Program (Hortas Cariocas) in Rio de Janeiro integrate urban agriculture into social housing and slum upgrading programmes. Space was created for home gardens, community gardens (see Box 6), and street trees for shade and fruit. https://www.prefeitura.sp.gov.br/cidade/secretarias/meio_ambiente/servicos/proaurp/index.php?p=30091 https://www.rio.rj.gov.br/web/smac/hortas-cariocas
São Paulo, Brazil	The Urban Master Plan, 2014-2030 stipulated a Municipal Plan of Conservation and Recuperation of Ecosystem Services Provider Areas. Specific zoning promotes peri-urban agriculture, aiming for its sustainable transition and permanence to contain urban sprawl in spring water areas. The main policy tool is Payments for Environmental Services, also considering urban agriculture (São Paulo 2019). https://gestaourbana.prefeitura.sp.gov.br/marco-regulatorio/plano-diretor/texto-da-lei-ilustrado
Various cities, United States*	• Cleveland (Ohio), Hartford (Connecticut) and Washington, D.C. collect and maintain inventories of public or private vacant land suitable for gardens. Cleveland's water department allows urban farmers to use fire hydrants for urban farms based on a predetermined rate. • Minneapolis (Minnesota) helps provide access to water and compost for local community gardeners. The city also adopted a resolution that aims to expand the consumption, production, and distribution of local, sustainably produced and healthy foods. • Philadelphia (Pennsylvania) created a food policy council and released the Philadelphia Food Charter, which includes a focus on urban agriculture.
Various cities, Europe	• During the COVID-19 pandemic, Novi Grad Sarajevo in Bosnia and Herzegovina allocated public land for urban agriculture at no cost and provided free seeds (Custovic and Ljusa 2020). • In Barcelona, Spain, the city council's L'Hort al terrat ("garden on the roof") programme promotes rooftop gardening, often on unused municipal facilities. Some of the produce is delivered to soup kitchens and food banks (Barcelona City Council 2018). • As part of its Climate Action Plan, Paris, France committed to creating 100 hectares of green roofs and walls, with a third of this allocated to urban agriculture projects (City of Paris 2018). • In Leicester, United Kingdom, the city council actively promotes allotment gardening at 43 locations with more than 3,000 plots. The Council directly manages and maintains 11 allotment garden locations (Leicester City Council 2021). • Ghent, Belgium was one of the first European cities to launch its own urban food policy, Gent en Garde, in 2013, with strategic goals to create a sustainable food system. Awarded a United Nations Global Climate Action Award in 2019, the policy calls for a greater focus on urban agriculture incorporating programmes such as locally grown school lunches and exploring innovative business models to promote urban agriculture (City of Ghent 2016).

** For more examples of US policies to support urban agriculture in the United States, see Hagey, Rice and Flournoy (2012). Compiled from various sources including Hagey, Rice and Flournoy (2012) and Dubbeling, van Veenhuizen and Halliday (2019).*

BOX 6: Manguinhos Community Garden, Rio de Janeiro, Brazil

The Manguinhos Community Garden is the most extensive horticultural garden in Latin America. It is located in the Maré Complex, which covers 11 slums in Rio de Janeiro and has one of the city's lowest levels of quality of life (O'Reilly 2014). The Carioca Community Gardens Program launched the garden in 2013 as part of a policy to boost economic dynamism with low environmental impact. To develop the garden, 700 truckloads of waste were removed, the ground was adapted for food crops, and several nurseries, greenhouses and water tanks were built. Every month, 2 tons of organic food are distributed to 800 households at no cost. The agroecological practices use organic compost prepared by the city organic waste treatment company (O'Reilly 2014). As of 2021, the garden directly employed 22 people who receive assistance from the municipality (Lichterbeck 2021; Souza 2021).

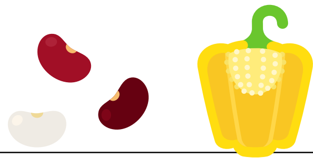
The Carioca Community Gardens Program is supported by the Rio de Janeiro City Hall. As of 2021, it included some 49 community gardens, of which 25 are at schools and 24 in vulnerable neighbourhoods. The organic production supplies around 80 tons of fresh vegetables annually, with half of the production donated to nearby public shelters, nursing homes and schools, and the rest sold to provide income for participants (Rio de Janeiro n.d.). Together, the gardens employ around 180 people. The initiative also strengthens the sustainable occupation of underused lands and integrates the United Nations' Partnership for SDG online platform (UN 2020b).

View of the Manguinhos Community Garden, Ian Cheibub.
Photo source: Lichterbeck 2021

3.2 Governance of urban agriculture

Urban agriculture brings together a range of actors, including city planners, farm managers, the underserved urban population, state institutions, and non-governmental and civil society organizations. In developed countries, food policy councils have emerged that adopt collaborative governance approaches to work alongside or partner with other actors (Haysom 2020). In developing countries, particularly in Africa, the conditions for adequate urban food governance are just emerging. Often, urban agriculture is perceived as a rural activity that is "inappropriate and detracts from the modern image of the city" (Simatele and Binns 2008).

In Africa, the governance of urban food systems is complex, encompassing a range of actors with competing agendas. This impacts food production, distribution, retail, and safety and impedes participatory governance, contributing to food and nutritional insecurity (Smit 2016; Nchanji 2017). Weak governance exacerbates the challenges facing urban agriculture, such as land competition, land tenure decisions, unfair land-use planning and lack of policy directives (Puppim de Oliveira and Ahmed 2021). Nonetheless, some successful mechanisms to govern urban agriculture in Africa have emerged (Box 7).



BOX 7: Food labs and systems in Sub-Saharan Africa

Zambia developed food labs under the Sustainable Diets for All programme in 2015 to promote healthy, diverse, nutritious and sustainable food systems. Local-level Food Change Lab interventions included capacity-building to reduce deforestation, food festivals, food dialogue meetings and radio programmes to promote diverse food consumption. Nationally, the Zambian Food Change Lab identifies opportunities for changes in food production, consumption, processing, and access, involving institutional actors, technical experts and community members.

In **Uganda**, a Food Change Lab began in 2015 to advocate for a more conducive policy environment and to improve diets and the productivity of local food systems. The Lab engaged citizens and community leaders in activities aimed at improving food quality and nutrition. The key challenges considered were the lack of local capacity to process food and natural resources, resulting in high levels of export of primary produce, malnutrition in children, consumption of high-starch foods with low proteins and micronutrients, and declining production of nutritious traditional crops. The programme promoted household awareness through, for example, cooking demonstrations, food fests and mobilizing small farmers to learn basic food processing methods. Programme results included greater household consumption of indigenous foods and vegetables planted in gardens.

Arusha, **Tanzania** has joined nine other cities in six Eastern and Southern African countries for a City-to-City Food Systems Forum. A key focus area of this multi-stakeholder mechanism is the governance of urban food systems. Arusha is developing and implementing a city-region food system policy that fits into its overall master plan.

In **Kenya**, the Nairobi and Environs Food Security, Agriculture and Livestock Forum (NEFSALF), a network of urban and peri-urban farmers that involves the private, public, and community sectors, was founded in 2003. The farmers, mainly youth, receive training in food systems input and policy thinking. Network members form hubs to undertake self-organized activities. The women's hub has been most successful and has lasted longer than its male counterpart. The women learn financial management, adding value to food products to help grow their businesses.

Source: RUAF 2019

3.3 Urban agriculture and multi-stakeholder governance mechanisms

The urban agriculture sector involves diverse issues of land, land use and tenure, access, food and ecosystem health (Corcoran and Calvin 2015). The starting point for the governance of urban agriculture is establishing a multi-stakeholder forum or mechanism that addresses these issues and the integration of related public policies in a coordinated and holistic way. Evidence shows that such fora can provide fertile ground for an integrative and systemic approach and create platforms for collaboration among key food system actors (UNEP 2019; Biodiversity International *et al.* 2021). See Boxes 8 and 9 for examples.

BOX 8: Connect the Dots Project and Sampa+Rural Seal: São Paulo, Brazil

In 2016, the municipal government of São Paulo won the Mayors Challenge in Latin America and the Caribbean Prize for its Connect the Dots Project. The initiative has created actions to integrate public policies and different actors involved in the food system, with a focus on strengthening urban agriculture by democratizing access to fresh and quality food, containing urbanization in watershed areas and reducing waste generation in the food system (São Paulo 2018; São Paulo 2020). The project has two fronts: 1) creating tools to collect farmers' data on production and marketing and to feed a digital platform to support technical assistance activities and the agricultural value chain; and 2) based on the identified demands and needs, supporting a group of technicians in the field to promote agroecological practices, through different institutional partnerships.

The Sampa+Rural Seal was created to increase visibility and value and strengthen the network of initiatives directly linked to urban agriculture in São Paulo. Of the two types of seals, the Production Seal is intended specifically for traders of local agricultural products, while the Presence Seal is aimed at the set of actors that the digital platform has mapped, from farmers and civil society initiatives to markets and tourism establishments (São Paulo n.d.). As of 2021, 56 commercial establishments and 110 farmers were certified with the Production Seal (São Paulo n.d.). Another 2,359 places, mapped through the platform, can receive one of the two seals at no cost.

BOX 9: Online Vegetable Gardens, Peru

The Urban Masterplan (2001-2010) of the District of María Del Triunfo, in Peru's Metropolitan Region, included urban agriculture as a strategy to tackle food insecurity and poverty (Kohn, Schvimer and Delgado 2019). Strategy implementation included efforts by the local community, the municipality, and several private and non-governmental organizations. One activity, the Huertos en Línea (Online Vegetable Gardens) project, carried out by the electric power company Red de Energía del Perú (REP), promotes existing community gardens and also recovers degraded areas assigned to REP (including under power lines) and occupies them with urban agriculture.

With the local community and government, REP manages 15 different gardens in Peru, impacting more than 720 inhabitants (REP 2019). Most of the gardens are in María Del Triunfo, where individuals or families cultivate vegetables for self-consumption and commercial purposes. REP offers tools and materials, including seeds and irrigation infrastructure, which it replaces every three years. Local community leaders coordinate the programme, which also promotes technical assistance and access to local markets (Kohn, Schvimer and Delgado 2019).

Available literature on food policy councils and similar structures shows that urban agriculture has been an important catalyst for the emergence of multi-stakeholder initiatives that support more inclusive and holistic governance of food systems (RUAF 2019; Biodiversity International *et al.* 2021). In 2011, Antananarivo, Madagascar launched an urban agriculture initiative to promote micro-gardens in vulnerable neighbourhoods to boost food security and incomes. In 2014, a multi-actor platform was created to connect these activities, and two years later, with the signing of the Milan Urban Food Policy Pact, the idea emerged of creating a food policy committee to strengthen food governance. Thus, the Antananarivo Food Policy Council was born from a pre-existing platform of food actors who moved from focusing on urban agriculture to having a systemic vision of the food chain (Andrianarisoa *et al.* 2019).

A recent study analysed seven outstanding multi-stakeholder mechanisms for urban food systems and found that, in all cases, urban agriculture was a priority topic (Biodiversity International *et al.* 2021). Consequently, urban agriculture features prominently in the food policy documents associated with these structures. For example, the Los Angeles Food Policy Council supported the development of the Urban Agriculture Incentive Zone Policy, which incentivizes urban agriculture in California by offering a reduction in property tax assessments in exchange for converting vacant or unimproved property to agricultural use (City of Los Angeles 2018). Similarly, in 2018, the Municipal Food Security Committee of La Paz, Bolivia formulated the Municipal Law for the Promotion of Urban Gardens and a policy proposal on Urban and Peri-urban Agriculture for the Cities of Tomorrow (City of La Paz 2018; Fundación Alternativas 2018).

Beyond policy development, the studied multi-stakeholder mechanisms show on-the-ground results related to promoting urban agriculture. In Antananarivo, within the framework of the urban agriculture programme, an experimental micro-gardening site was developed where stakeholders and citizens can receive free training on urban agriculture, including on topics ranging from food production and consumption to composting. The initiative now operates in all six districts of the municipality, in 24 neighbourhoods and in more than 36 schools and social centres, reaching over 18,000 beneficiaries (mainly women and children) (Andrianarisoa *et al.* 2019, cited in Biodiversity International *et al.* 2021). In 2017, the programme won the Milan Urban Food Policy Pact prize (Milan Urban Food Policy Pact 2017).

Since 2014, more than 42 schools in Ghent, Belgium have received training in how to develop community garden beds on their campus, and 240 parents and teachers have participated in these workshops. In London, one of the most concrete achievements of the London Food Board is Capital Growth, the city's largest food growing network, which helps community gardens, schools, allotments and home growers gain skills and grow food through training, advice and networking opportunities. Thirty-one councils are actively involved, and the network has supported more than 2,900 growing spaces across all 33 boroughs since its launch in 2008. Capital Growth has engaged more than 150,000 volunteers in growing food and has harvested over 1 million portions of fruit and vegetables, valued at 600,000 British pounds (€705,543).[7]

7 *All currency conversions were carried out on 22 July 2021.*

4. Conclusions, Recommendations and Further Research Needs

4.1 Conclusions

Urban agriculture will play a critical role in meeting the food needs of the world's burgeoning cities. At the same time, urban expansion has been shown to impact larger-scale rural agriculture occurring around cities (Seto, Güneralp and Hutyra 2012), with impacts on biodiversity, on the release of agricultural carbon pools and on rural livelihoods. An urban-rural regional approach can be complementary to and an important part of urban agricultural policy. Urban agriculture addresses several Sustainable Development Goals, particularly SDG 2 (Zero hunger), SDG 3 (good health and well-being), SDG 8 (decent work and economic growth), SDG 11 (sustainable cities) and SDG 12 (responsible consumption and production). Finally, it is important to understand why policy does not tend to reflect women, despite their active role in urban agriculture, and why it is necessary to create the enabling environment through gender mainstreaming in governance to be able to empower women to have a greater role for inclusivity.

Several conclusions and key messages have emerged from this synthesis, specifically focusing on intra-urban practices of urban agriculture. They are as follows:

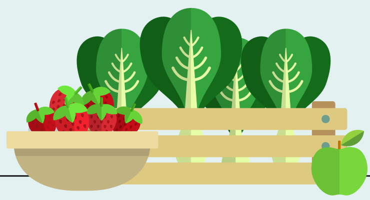
1. **Urban agriculture takes many different forms:** The inputs, outputs, and multiple benefits as well as management to reduce any related risks will vary depending on the technology and business model.
2. **Protecting the natural base:** Urban agriculture must be practiced in a way that does not exert pressure on the natural resource base. Circular urban agriculture aims to use minimal external inputs, to close nutrient loops and to reduce negative discharges into the environment. Urban agriculture will play a role in transitioning the global economy to circularity, as resources per person tend to be lower in urban areas, while the generation of potentially reusable waste tends to be larger.
3. **Overall benefits:** Broadly speaking, the potential benefits of urban agriculture will be context dependent and specific to addressing the needs of underserved populations, providing recreational benefits and providing opportunities for high-tech agriculture. Hence, local contexts and uncertainties must be considered.
4. **Extent of urban agriculture and potential for urban-rural regional linkages:** It is important to clarify the spatial extent of urban agriculture and to describe it as intra-urban, peri-urban and larger local/regional agriculture that directly serves cities.

5. **Community-wide food provisioning:** The capacity of urban agriculture, within city boundaries, to serve the whole community is low in developed countries and somewhat higher in developing countries. Most data are for fresh produce within urban areas, which can be grown more readily in cities, in contrast to grain which needs a significant amount of land. Additionally, the capacity of local agriculture, which extends well beyond urban boundaries, to serve the whole community is high. Furthermore, women play a crucial role in the provisioning of food in urban areas. It is highly significant to consider the challenges these women face for urban food provisioning.

6. **Supporting underserved populations:** The relevance of urban agriculture to address the food insecurity of specific populations is high, particularly in times of stress such as the COVID-19 pandemic. This holds true particularly for women in low-income developing countries.

7. **Economic benefits:** Land-based urban agriculture can support livelihoods of the poor in developing countries but is limited in much of the developed world. In most cities, it may be more resource efficient to allocate land for higher-value commercial and industrial activities. In this context, high-tech indoor urban farming and controlled-environment agriculture has shown enormous economic potential for commercial operations producing limited, high-end niche products.

8. **Environmental benefits:** Environmental benefits or resource circularity in urban agricultural systems can be positive and negative. It is important to examine both the environmental benefits and disbenefits and potential risks, in the local context and as part of overall food systems. Dietary change and food waste management have higher potential of providing environmental benefits.

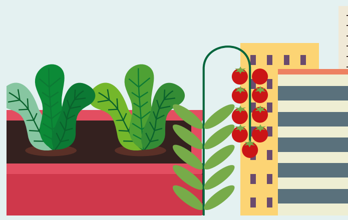


9. **Health benefits, risks and impacts:** There is some evidence of positive health and nutritional outcomes from urban agriculture; however, this is context sensitive. The environmental disbenefits of urban agriculture are the source of health risks: for example, air pollution can impact food quality, and the use of untreated or partially treated wastewater can have significant health disbenefits. Women in low-income developing countries are more susceptible to these risks, due to a lack of land access and arable land to engage in urban agriculture and to a scarcity of clean water.

10. **Resource circularity:** New technologies are facilitating the transition to circular urban agriculture. Examples of circularity include integrated networks and applying by-products of food waste management, such as compost, biochar, and nutrient-rich digestate, to agricultural land. However, much larger agricultural lands will be needed to absorb the nutrients than is available within cities. Resource circularity will have to look at regional, and not necessarily urban or peri-urban, agriculture.

11. **Future data and policy needs:** Among the challenges and bottlenecks that hinder the transition to a circular urban agriculture are fundamental gaps in the potential for resource circularity, as well as institutional barriers, governance problems, behavioural barriers and technical barriers. Further work is needed to develop methodologies to assess urban agriculture and to measure its environmental impacts. Further work is also needed to identify unique barriers to urban agriculture faced by women, particularly in low-income developing countries, and to design policies to address them.

12. **Multi-level governance:** Governments at the local and national levels should provide technical assistance and credit to support the transition to circular urban agriculture, develop programmes to monitor environmental impacts, and connect with larger-scale urban-regional actors to maximize benefits across multiple dimensions.



4.2 Recommendations

Action in the following areas might be useful:

- **Re-visit land-use policies**, specifically for cities, and rethink city planning. This includes limiting sprawl on agricultural rural lands and adopting multi-level urban-regional agricultural policy partnerships.
- **Digitalize and promote data-driven urban agriculture approaches**, particularly for local environmental monitoring and life cycle assessment to ensure sustainability gains and minimize negative impacts.
- **Pursue innovations** to turn waste into wealth and promote circular urban agriculture.
- **Develop programmes** (educational, awareness creation) to promote urban food production.
- In developing countries, **develop frameworks** for urban agriculture governance.
- **Incorporate gender mainstreaming** into urban agriculture policymaking at all levels.
- **Establish and strengthen multi-stakeholder fora** and mechanisms to govern and enhance collaboration in urban food systems. This would require clarifying policies for urban food action plans.

4.3 Knowledge gaps and further research needs

The literature indicates that urban agriculture will play an important role in the transition to a circular economy. However, large knowledge gaps remain. Additional research is needed on the following topics:

- **Identifying contextual factors** that can boost the food security benefits of urban agriculture for specific populations, and comparing its feasibility to other options such as food delivery.
- **Promoting local research** that identifies unique barriers that women face in urban agriculture participation and finding policy solutions to address them (*e.g.*, land ownership, financing, access to urban agriculture inputs).
- **Governance** of urban agriculture, especially in developing countries.
- **Social benefit-cost analysis**, including environmental valuation, of urban agriculture in developing countries.
- **Economic benefits** of conventional land-based urban agriculture, especially in developed countries.
- **Business models** for urban agriculture in developing countries, including research on agro-tourism potentials and social enterprise boxes.
- The **multifunctionality of urban agriculture** and its "relation to green infrastructure and food-productive urban landscapes, circularity debates and discussions of the possible adverse effect of air pollution on…product quality" (Skar et al. 2019).
- Benefits and disadvantages of specific urban agriculture typologies in the **context of their locations**, to help determine the allocation of resources towards urban agriculture versus other interventions.
- **Geospatial data** on non-urban features (small green or empty spaces) within cities, to better identify and understand the potential of these spaces for food production and other ecosystem services.
- **Census data** on non-commercial and small urban agriculture initiatives.
- Comparing the costs and benefits between a concentrated, long-distance **supply chain** and a decentralized, short-distance supply chain, such as for urban agriculture.
- Measuring urban agriculture-related **ecosystem services**.
- **Feasibility and trade-offs for large-scale implementation** of technologies that pave the way for the transition to circular urban agriculture.
- How digital technology can be used to generate **geospatial data**.

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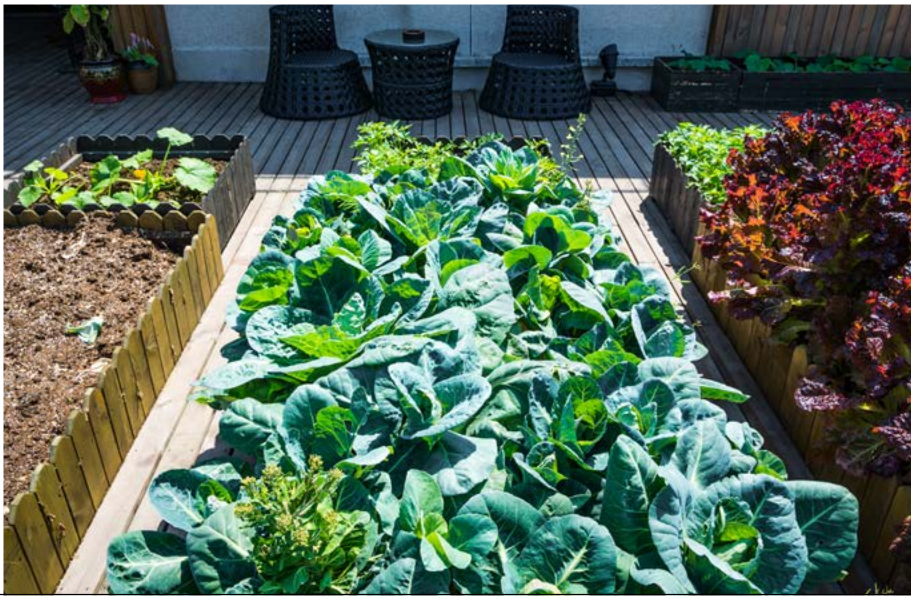
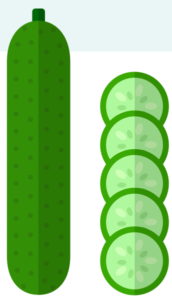


Annex: Definitions of Urban Agriculture

Reference/ Source	Definition	Distinction between urban, peri-urban and "local/direct-to-local"*
FAO 2019	Urban and peri-urban agriculture can be defined as the growing of plants and the raising of animals within and around cities. Urban and peri-urban agriculture provides food products from different types of crops (grains, root crops, vegetables, mushrooms, fruits), animals (poultry, rabbits, goats, sheep, cattle, pigs, guinea pigs, fish, etc.) as well as non-food products (*e.g.*, aromatic and medicinal herbs, ornamental plants, tree products). Urban agriculture includes trees managed for producing fruit and fuelwood, as well as tree systems integrated and managed with crops (agroforestry) and small-scale aquaculture.	Both urban and peri-urban are considered urban agriculture.
Game and Primus 2015	Urban and peri-urban agriculture can be defined as the growing, processing and distribution of food and other products through plant cultivation and (seldom) raising livestock in and around cities for feeding local populations.	Both urban and peri-urban are considered urban agriculture.
Vejre *et al.* 2015	Urban agriculture spans all actors, communities, activities, places and economies that focus on biological production in a spatial context which – according to local standards – is categorized as "urban". Urban agriculture takes place in intra- and peri-urban areas, and one of its key characteristics is that it is more deeply integrated into the urban system compared to other agriculture. Urban agriculture is structurally embedded in the urban fabric; it is integrated into the social and cultural life, economics and the metabolism of the city.	Both urban and peri-urban are considered urban agriculture.
Roggema 2016; McEldowney 2017	Urban agriculture is the growing, processing and distribution of food or livestock within and around urban centres with the goal of generating income.	Both urban and peri-urban are considered urban agriculture.
Smit 1996	Urban agriculture is an industry that produces, processes and markets food and fuel, largely in response to the daily demand of consumers within a town, city or metropolis, on land and water dispersed throughout the urban and peri-urban area, applying intensive production methods, using and reusing natural resources and urban wastes, to yield a diversity of crops and livestock.	Both urban and peri-urban are considered urban agriculture.
Mougeot 2000	Urban agriculture is an industry located within (intra-urban) or on the fringe (peri-urban) of a town, a city or a metropolis, which grows and raises, processes and distributes a diversity of food and nonfood 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.	Both urban and peri-urban are considered urban agriculture.
Simon-Rojo *et al.* 2015	Urban food gardening encompasses agricultural activities with generally low economic dependence on the material outputs while using food production for achieving other, mostly social, goals.	No spatial bounds.

Reference/ Source	Definition	Distinction between urban, peri-urban and “local/direct-to-local”*
Pölling *et al.* 2015	Urban farming refers to intentional business models taking advantage of proximity to the city by offering local or regional agricultural products or services. The importance of the production in proportion to the other societal benefits can vary strongly…. [B]oth, the production-oriented side or the co-benefit-oriented side may prevail depending on the individual practices of an urban farming operation.	Not specific about urban boundaries and includes local and regional, which could be very large.
US Environmental Protection Agency 2021	Urban agriculture is “part of a local food system where food is produced within an urban area and marketed to consumers within that area”. Additionally, “[u]rban farming can also include animal husbandry (*e.g.*, breeding and raising livestock), beekeeping, aquaculture (*e.g.*, fish farming), aquaponics (*e.g.*, integrating fish farming and agriculture), and non-food products such as producing seeds, cultivating seedlings, and growing flowers.”	Urban agriculture is a subset of a larger food system. Urban boundary not specific.
European Parliamentary Research Service 2014	Urban and peri-urban agriculture is “the cultivation of crops and rearing of animals for food and other uses within and surrounding the boundaries of cities, including fisheries and forestry.”	Both urban and peri-urban are considered urban agriculture.
US Department of Agriculture 2021	Urban agriculture can include “city and suburban agriculture [that] takes the form of backyard, roof-top and balcony gardening, community gardening in vacant lots and parks, roadside urban fringe agriculture and livestock grazing in open space”.	Both urban and suburban are considered urban agriculture.
Piorr *et al.* 2018	Urban and peri-urban agriculture is “comprising of food production in and around urban areas, ranging from leisure to commercial activities”.	Both urban and suburban are considered urban agriculture.
Bhat and Paschapur 2020	Urban agriculture is “the practice of cultivating, processing and marketing of food and food products in and around urban localities”. It “also involves animal husbandry, aquaculture, beekeeping and horticulture”.	Not specific about urban boundaries; spatial bounds of “around urban localities” are not specific.
Smit, Ratta and Nasr 1996	Urban agriculture is: “an easy-in, easy-out entrepreneurial activity for people at different levels of income. For the poorest of the poor, it provides good access to food. For the stable poor, it provides a source of income and good-quality food at low cost. For middle-income families, it offers the possibility of savings and a return on their investment in urban property. For small and large entrepreneurs, it is a profitable business.”	No spatial bounds.



** Local/direct-to-local can extend hundreds of kilometres outside of cities.*
Adapted from Skar et al. 2019.

International Resource Panel

About the International Resource Panel

Aim of the Panel

The International Resource Panel was established to provide independent, coherent and authoritative scientific assessments on the use of natural resources and their environmental impacts over the full life cycle. The Panel aims to contribute to a better understanding of how to decouple economic growth from environmental degradation while enhancing well-being. Benefiting from the broad support of governments and scientific communities, the Panel is constituted of eminent scientists and experts from all parts of the world, bringing their multidisciplinary expertise to address resource management issues. The information included in the International Resource Panel's reports is evidence based and policy relevant, it informs policy framing and development, and supports evaluation and monitoring of policy effectiveness.

Outputs of the Panel

Since the International Resource Panel's launch in 2007, more than 30 assessments have been published. The assessments of the Panel to date demonstrate the numerous opportunities for governments, businesses and wider society to work together to create and implement policies that ultimately lead to sustainable resource management, including through better planning, technological innovation, and strategic incentives and investments. Following its establishment, the Panel first devoted much of its research to issues related to the use, stocks and scarcities of individual resources, as well as to the development and application of the perspective of "decoupling" economic growth from natural resource use and environmental degradation. These reports include resource-specific studies on biofuels, water and the use and recycling of metal stocks in society. Building upon this knowledge base, the Panel moved into examining systematic approaches to resource use. These include looking into the direct and indirect impacts of trade on natural resource use; issues of sustainable land and food system management; priority economic sectors and materials for sustainable resource management; benefits, risks and trade-offs of low-carbon technologies; city-level decoupling; and the untapped potential for decoupling resource use and related environmental impacts from economic growth.

Upcoming work

In the forthcoming months, the International Resource Panel will focus on scenario modelling of natural resource use, the socioeconomic implications of resource efficiency and the circular economy, the role of resources in environmental displacement and migration, and the connections between finance and sustainable resource use, among others.

More information about the Panel and its research can be found at:

Website: www.resourcepanel.org

Twitter: https://twitter.com/UNEPIRP

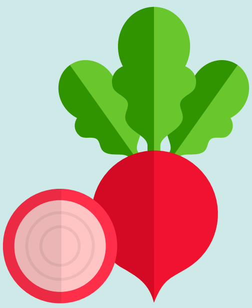
LinkedIn: https://www.linkedin.com/company/resourcepanel

Contact: unep-irpsecretariat@un.org

Cities are now home to more people than are rural areas, with around 55 per cent of the world's population living in urban areas. As urban populations continue to grow, an estimated 80 per cent of food is expected to be consumed in cities by 2050. Feeding burgeoning cities means that food production systems will have to change in significant ways, including bringing food production closer to urban areas.

Urban agriculture has been defined in various ways and can take different forms. Broadly, it refers to the growing of food and raising of animals within and around urban and peri-urban areas. Urban agriculture has been advocated as a strategy to provide food and many other benefits for city dwellers and to address the triple planetary crises of climate change, biodiversity loss and pollution. Urban agriculture encompasses several of the Sustainable Development Goals (SDGs), including eradicating poverty, ending hunger, achieving gender equality, contributing to well-being, promoting sustainable cities and supporting ecosystem services. As urban areas grow, they also displace rural agriculture. Thus, considering urban-rural regional linkages can complement urban agriculture.

This Think Piece examines the multiple sustainability benefits of urban agriculture, taking a systems perspective. It provides a synthesis of the different typologies of urban agriculture practiced worldwide, acknowledges that urban agriculture is not going to address all urban food problems, highlights urban agriculture's potential contributions to promoting sustainable urban food systems and identifies trade-offs associated with urban agriculture. The report also identifies challenges for transitioning to circular urban agriculture. It examines urban agriculture policies from different parts of the world and suggests policy guidelines to support multi-functional urban agriculture. There is an urgent need to develop and strengthen urban food governance structures, especially in developing countries, which lag behind the developed world with respect to developing frameworks for governance of urban food systems.



For more information, contact:
International Resource Panel Secretariat
United Nations Environment Programme
1 rue Miollis – Building VII – 75015 Paris, France

Email: unep-irpsecretariat@un.org

Website: www.resourcepanel.org

Twitter: @UNEPIRP

LinkedIn: www.linkedin.com/company/resourcepanel

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United Nations Avenue, Gigiri
P.O. Box 30552, 00100 Nairobi, Kenya
Tel. +254 20 762 1234
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