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VACANT LOTS TO VIBRANT PLOTS

A REVIEW OF THE BENEFITS AND LIMITATIONS OF URBAN AGRICULTURE

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Summary

Urban agriculture has become a popular topic for metropolitan areas to engage in on a program and policy level. It is touted as a means of promoting public health and economic development, building social capital, and repurposing unused land. Food policy councils and other groups that seek to position urban agriculture to policy makers often struggle with how to frame the benefits of and potential problems with urban agriculture. In some cases, the enthusiasm is ahead of the evidence. This review provides an overview of the documented sociocultural, health, environmental, and economic development outcomes of urban agriculture. Demonstrated and potential benefits, as well as risks and limitations, of this growing field will be discussed. We also offer recommendations for further research to strengthen the scholarship on urban agriculture.

Scope

As urban agriculture is a trans-disciplinary topic, this report includes information from both published and grey literature from a variety of academic disciplines, including public health, geography, sociology, urban planning, psychology, sustainability studies, and economics. It focuses on research predominantly from the Global North, as urban agriculture in the Global South has developed under different historical conditions, in different demographic and spatial contexts, and for different reasons.[1,2]

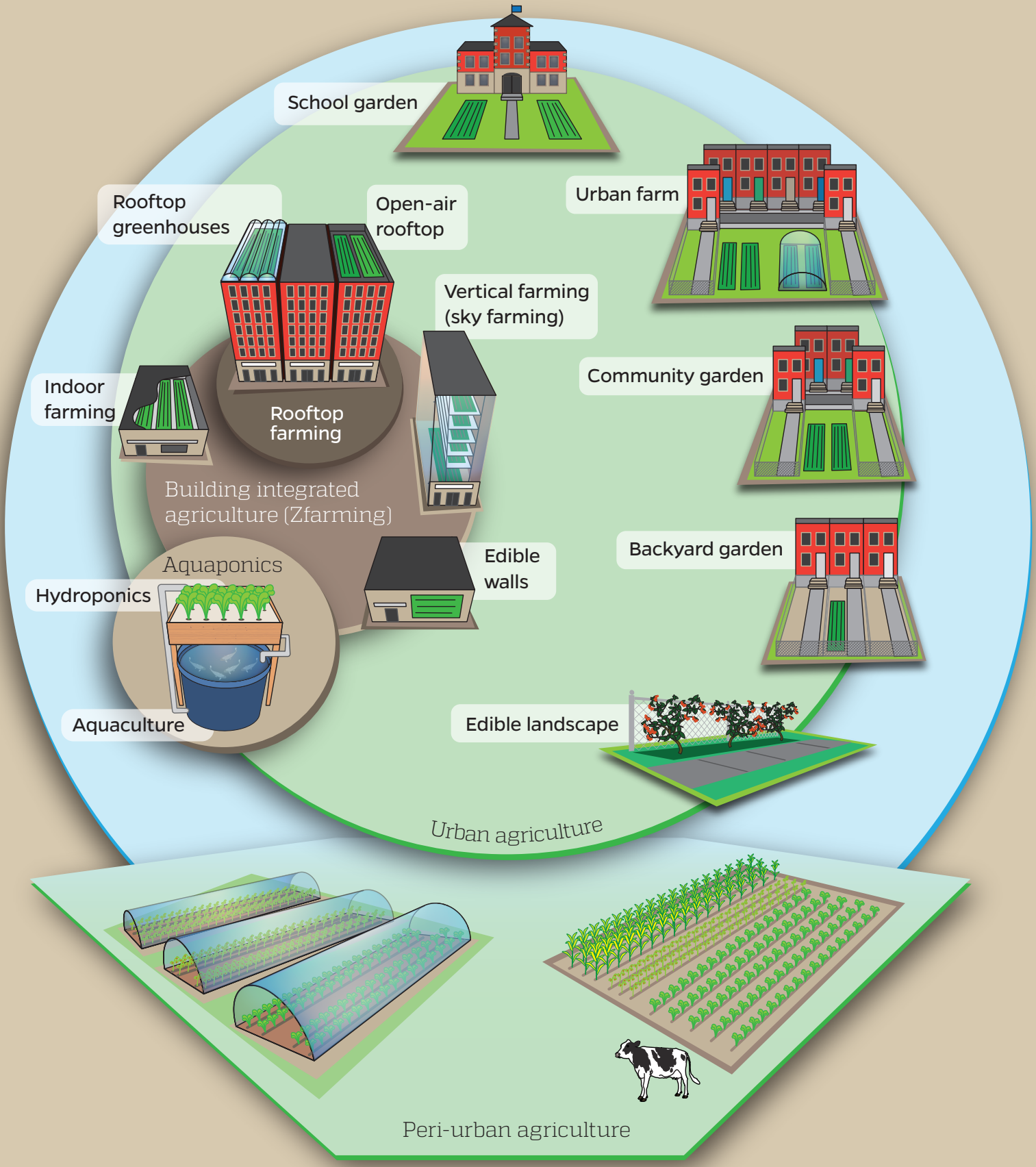
For the purposes of this report, urban agriculture encompasses the production of food and non-food plants, as well as animal husbandry, in urban and peri-urban[i] spaces. Urban agriculture operations may be privately, publically, or commercially owned, and manifest in a number of forms, including household, school, and community gardens; urban farms[ii]; backyard chicken coops and beehives; aquaculture, hydroponics, and aquaponics facilities; and rooftop, vertical, and indoor farms (see Figure 1).

The majority of published literature on urban agriculture comes from research on community gardens.[3] This reflects the fact that gardens remain the dominant form of urban agriculture – involving far more people and growing far more food in volume and value than urban farms.[4,5] More technologically innovative forms of urban agriculture, including rooftop gardens and greenhouses, indoor and vertical farms, edible green walls, and aquaponics facilities, are still in the early stages of research and practice.[6,7] Urban home food gardens have also been under-represented in the literature, though their potential social, ecological, health, and economic contributions can also be significant.[8]

[i] Definitions of peri-urban agriculture abound; this paper considers it to be agriculture at the boundaries of cities, in the transition or "buffer" zones between rural and urban areas. Opitz *et al*. provide a comprehensive review on peri-urban agriculture, and its differences with traditional urban agriculture.[102] It is increasingly difficult to categorize urban agriculture projects by geographical locations, as many have acquired additional land outside the cities in which they are located in order to accommodate their expanded operations.[121]

[ii] Farms are generally distinguished from gardens by the intent to produce goods for sale, though classifying remains an ambiguous task, as some entities such as the USDA's Agricultural Census only consider operations that reach certain sales and size thresholds to be farms.[142]

Figure 1: Scope of urban agriculture



Introduction

People engage in urban agriculture for a wide variety of reasons, such as accessing fresh produce; improving personal health and mental well-being; enhancing socio-ecological relationships; sustaining cultural traditions; and among more radical participants, challenging norms around land use, urban/rural dichotomies, and the global agri-food system.[9-11] Likewise, city agencies, community groups, and other advocates of urban agriculture cite a number of potential benefits, from fostering social interaction, educational opportunities, and community and economic development, to providing important health-promoting and ecosystem services.[12]

These reasons have been used to help acquire and sustain government support for urban agriculture projects. Many municipalities already assist third-party and city-run community gardens through providing land, funding, in-kind supplies, technical assistance, and educational workshops.[13,14] They have also begun supporting urban farms, both for-profit and non-profit, by passing new zoning ordinances and building codes to support urban agriculture efforts.[12] Some have incorporated urban agriculture into municipal food strategies and comprehensive plans.[15,16]

Accurately interpreting and communicating the potential merits of urban agriculture, however, is essential. If its benefits are overstated, or limitations overlooked, this could propel advocates to disproportionally allocate resources to urban agriculture at the expense of other, potentially more effective interventions. And if urban agriculture does not live up to its promises, it may lose the cultural and political support necessary to sustain the benefits it can offer.

This review provides an overview of the documented sociocultural, health, environmental, and economic development outcomes of urban agriculture. Demonstrated and potential benefits, as well as risks and limitations, of this growing field will be discussed. Gaps in current literature on these benefits and limitations, and a summary of recommendations for framing the merits of urban agriculture, are reviewed at the end of this report. While urban agriculture alone will not solve the many dilemmas of our food system, from ecological collapse to inequitable access to healthy food, it can be part of a constellation of interventions needed to reform the food system into one that is more socially just, ecologically sound, and economically viable.

Sociocultural considerations

While difficult to tangibly measure, the preponderance of evidence suggests that urban agriculture's most significant benefits center around its ability to increase social capital, community well-being, and civic engagement with the food system. The majority of literature in this area comes from studies of community gardens, but many urban farms have also established themselves as social enterprises dedicated more to social missions than to profits.[5,17] Some critiques have also been raised about the fact that these social benefits may not extend to all because of complex structural and historical barriers.

Social benefits

Numerous studies have documented how community gardens enhance the social capital of communities through increasing the social bonds and networks among neighbors, among people from more diverse backgrounds, and among those in different positions of power.[18-22] Such connections based on mutual trust and reciprocity offer support during times of crisis, and help communities leverage greater resources, funding, and supportive policies from outside organizations and government. They also bridge gaps, reduce existing tensions, and foster social integration between otherwise segregated groups by bringing people of diverse races/ethnicities, cultures, religions, socioeconomic classes, genders, ages, and educational backgrounds together to participate in shared activities with a common purpose.[19,20,23-27] The strong sociocultural values surrounding food growing, cooking, and sharing help facilitate the role of gardens as a social bridge, and support communities in maintaining and appreciating cultural traditions associated with food.[28]

The physical spaces where urban agriculture projects exist also enrich community well-being. As "third spaces" beyond the home or work, gardens function as gathering places for community members to interact, especially important in areas where open green spaces are rare.[20] As documented in a case study of Latino community gardens in New York City, gardens may serve more as cultural and social neighborhood centers than as agricultural production sites.[25] Another case study of community gardens in Detroit noted their importance as alternative communal, social, learning, and healing safe spaces responding to the needs left by the closing of community centers.[29] Some neighbors of urban farms discuss the community improvement benefits – such as the cleaning up of vacant lots – more frequently and with more enthusiasm than the production of fresh local food.[167] Some argue that through such roles, urban agriculture is challenging traditional boundaries

Table 1: Summary of sociocultural considerations*

Reported Benefits	Reported Limitations
Community cohesion and development	
▪ Provision of opportunities for social interaction, strengthening social ties and facilitating new social connections[18-22] ▪ Catalyst for community organizing and broader community improvement[8,22,25,27,29,45,46] ▪ Gathering places for community members to interact, especially important in areas where open green spaces are rare[20,25,29] ▪ Perceived sense of safety/reduction in crime, and consequent strengthening of residents' pride of place[23,32-34]	▪ UA initiatives are instigated from different organizational structures, e.g., community-led efforts vs. persons or institutions outside the community, which may restrict community development benefits in some instances[19,167]
Cultural integration and preservation	
All of the points in this box come from [19,20,23-27]: ▪ Provision of opportunities for neighborhood residents of diverse backgrounds to interact who otherwise would not have such an impetus ▪ Provision of opportunities for immigrants to develop ties with host and other ethnic communities, expand cultural competencies, and gain a sense of belonging ▪ Provision of opportunities for expression and maintenance of cultural heritage[28] ▪ Provision of opportunities to strengthen inter-generational relationships	▪ UA initiatives have been led by mostly young, white non-residents in predominantly black and/or Latino neighborhoods, unintentionally excluding people of color from participating in or reaping the benefits of such efforts[20,22,30,52-54,167] ▪ Initiatives led by lower-income communities and/or people of color have experienced disparities in access to land, government funding, and political support compared to urban agriculture efforts led by white and middle-class groups[15,55,167]
Education and youth development	
▪ Provision of opportunities to learn about the provenance of food, agricultural processes, nutrition, and sustainability, and to develop new skills[25,35-40,46,145,164,165] ▪ Provision of constructive activity for youth that promotes youth development and as an alternative for youth exposed to drug and crime economies, including wage-earning opportunities[35,39,164,167]	▪ Projects providing comprehensive/intensive education beyond technical farming skills require additional expertise (e.g. in social/moral support and remedial education), which may require more staff time and higher labor costs[42]

*Many of the studies cited in this chart and those following (on pages 9, 13, and 17) are exploratory studies that use qualitative methods, and the quantitative studies rarely measure change before and after implementation of an urban agriculture project, use a control group, or include a large sample. Therefore, these benefits are not "proven" benefits in terms of having been rigorously measured.

between public and private land use.[31] Moreover, urban green spaces, which include but are not limited to vegetable gardens, have been associated with reduced crime rates in socially disadvantaged neighborhoods and the consequent strengthening of residents' pride of place.[23,32-34]

Educational and skill development opportunities

Building on their role as community hubs, gardens and other sites of urban agriculture also serve as sites for education, youth development, and skills/workforce training opportunities. Whether through formal programs or informal exchanges, these places help teach youth about science, environmental stewardship, cultural heritage, and healthy eating, while also offering valuable lessons in interpersonal skills, responsibility, and delayed gratification.[25,35-40] Leadership, project management, marketing, customer service, and other transferable skills gained through working on urban agriculture initiatives can support the job readiness and workforce integration of neighborhood youth, immigrants, differently abled people, and those who were formerly incarcerated,[5,15,40,41] although the spectrum beyond agriculture-specific skills must be emphasized to encourage general job readiness. As Daftary-Steel *et al.* discuss, providing these opportunities to the "least employable" requires additional expertise (e.g., in social/moral support and remedial education) beyond the teaching of technical farming skills, which may require more staff time and higher labor costs.[42] Urban agriculture projects aiming to provide such intensive services, in addition to keeping produce at affordable prices, require greater external financial and political support.[42]

By reconnecting urban consumers to food production and introducing them to new fruits and vegetables, urban agriculture can also help foster agricultural literacy and a "different connection to food."[9] As they shift from being passive consumers of food to becoming co-producers and gain increased control over how their food is produced and distributed, participants become what some scholars refer to as "food citizens."[43,44] This may also catalyze civic engagement in both the broader food and political systems. For instance, the social and political skills gained through gardening, such as community organizing, fundraising, and consensus decision making, can empower residents to begin tackling other issues in their communities and beyond.[8,22,25,27,29,45,46] For instance, as White (p.19) describes, the empowerment and food sovereignty gained by women gardeners in Detroit instigated conversations over how they "might gain control over other aspects of their lives, including access to affordable housing, clean water, community policing, and decent public education."[29] Some scholars[40,47] argue that such efforts in community self-reliance and self-determination ultimately

serve to fill in the gaps (in food security, community centers, etc.) left by government cutbacks – and thereby uphold rather than resist the political and economic system that created the structural inequities, racism, and other issues they seek to address. Others acknowledge this critique, but argue that urban agriculture initiatives can simultaneously fill in the gaps and provide spaces for transformative political resistance.[11,29]

Potential exclusion and marginalization

Urban agriculture projects are not panaceas of social inclusion or equity, however, and critical questions have been raised about who benefits from such efforts. Urban agriculture initiatives are established with different, though often overlapping, aims – whether they seek to supply fresh foods in low-income communities with limited access to full-service grocery retail, achieve more entrepreneurial aims, or provide more educational or community development benefits. They are also instigated from different organizational structures, e.g., community-led efforts vs. persons or institutions outside the community.[19,167] Different meanings around the ideas of community, inclusiveness, and diversity further contribute to the variety of forms that arise among urban agriculture projects.[48]

It is important to understand these various contexts in which urban farms and gardens are situated in order to challenge and prevent exclusionary and discriminatory policies and practices that often manifest in their operations.[49] This is particularly relevant for farms, gardens, and other forms of urban agriculture that are initiated by people or institutions from outside of the neighborhoods in which they are located.[30] It is even more so for commercial ventures where the food produced is not economically or physically accessible to residents.[30] As Draus *et al.* and Hu *et al*. discuss, the systemic racial, socioeconomic, and geographical marginalization of many inner-city populations, especially in relation to urban redevelopment, has left a legacy of distrust among residents of external public or private efforts to "improve" their neighborhoods through urban agriculture.[50,51] A number of case studies have found that urban farms and gardens – both for-profit and non-profit – have been led by mostly young, white non-residents in predominantly black and/or Latino neighborhoods, unintentionally excluding people of color from participating in or reaping the benefits of such efforts.[20,22,30,52-54,167] Other initiatives that have been led by lower-income communities and/or people of color have experienced disparities in access to land, government funding, and political support compared to urban agriculture efforts led by white and middle-class groups.[15,55]

It is essential that the residents of the communities being affected by urban agriculture projects are not just consulted but fully empowered in leadership and decision-making to the greatest extent possible.[15,56] Leaders should understand the historical and social context of the space where their efforts take place (e.g., an urban farm might be located in a community that has experienced a history of racial tensions), and be keenly aware of the participation and power dynamics among people (gardeners/farmers, customers/supporters, and neighboring residents) of different races, socioeconomic classes, genders, ages and educational backgrounds.[52] Successful grassroots efforts that have been led by community members through a culturally directed approach may serve as models for other urban agriculture projects.[28,57]

Environmental sustainability

The vast majority of food consumed in the U.S. today is produced by an industrialized agricultural system that harms the physical environment and lacks the resilience necessary to address rising global challenges of achieving food security in the face of climate change, population pressures, and resource depletion.[58] Given these facts, urban agriculture has been promoted as part of the transition to a more environmentally sustainable and resilient food system. Advocates cite its ecosystem services to urban areas; shorter distance from farm to plate; presumably reduced reliance on petroleum-based energy and embedded greenhouse gas (GHG) emissions needed for farm machinery, pesticide manufacturing, and transportation; and, if widely adopted, reduced pressure on farmland.[6] While some of these proclaimed benefits have been documented in the scientific literature, many have not been critically assessed.

Ecosystem services

Urban green spaces and green roofs offer a number of ecosystem services.[59-66] Vegetation filters certain airborne pollutants such as particulate matter,[67,68] which one study suggests may mitigate morbidity and mortality associated with respiratory illnesses.[69] Plants and trees facilitate temperature moderation, and thus help reduce the urban heat island effect by cooling nearby air through the process of evapotranspiration, offering shade from solar radiation, and diffusing incoming solar radiation.[66] These services are of particular importance in light of the anticipated effects of climate change on heat-related mortality.[70,71] Vegetation also collects and retains precipitation, reducing storm-water runoff into urban waterways.[iii] Gardens, in particular, support local biodiversity by providing habitats and forage for pollinators such as bees and other beneficial organisms.[72] Urban food gardens and farms have been found to help conserve agro-biodiversity, for example, as gardeners and farmers

[iii] Although vegetation captures and infiltrates storm-water, plants may be exposed to contaminated run-off. Buffer strips between urban agriculture operations and parking lots, roads, and industrial sites can help filter out contaminants before reaching edible crop production areas.[99]

Table 2: Summary of environmental sustainability factors

Reported Benefits	Reported Limitations
Local ecosystem services	
▪ Increased biodiversity, including provision of habitat for pollinators[8,73] ▪ Reduced air pollution through filtration of particulates by vegetation[67,68] ▪ Micro-climate regulation (e.g., reduction in the "urban heat island effect") through transpiration processes[66] ▪ Increased rainwater drainage, reducing the risk of flooding, ground water contamination, and depleted groundwater levels[99] ▪ Recycling of organic waste (e.g., through composting)[74]	▪ Soil management and amendment, irrigation, and fertilizer use practices by UA growers may not be ecologically sound[3,8]
Climate change mitigation	
▪ Potential reduction in greenhouse gas (GHG) emissions associated with food transportation, particularly when replacing typically air-freighted produce (e.g., greens, berries)[78] ▪ Carbon sequestration by vegetation and crops[77,78] ▪ Some technological UA operations may reduce the energy and resource inputs – and waste outputs – associated with food production[6,65,75,118] ▪ Urban growing maintains collective memory of food production and protects urban green spaces, upholding cities' capacity to produce food in times of crisis[76]	▪ May increase GHG emissions and water use if plants are grown in energy- or resource-intensive locations[13,75,85-88] ▪ Small-scale, fragmented UA may be less efficient in resource use and transport emissions than conventional agriculture[79] ▪ If UA becomes ubiquitous in cities, it may reduce population density, requiring more driving and GHG emissions than the current system[63,82]

save seeds and grow more traditional crop varieties and wild relatives.[8,73] They also provide sites for composting organic matter for subsequent use as fertilizer, thereby reducing reliance on chemical or mined inputs and keeping waste from landfills.[74]

Some novel forms of building-integrated urban agriculture, including rooftop gardens and greenhouses, indoor and vertical farms, and edible green walls, are also merited for their ability to re-use waste water, waste heat, and organic waste from homes and businesses in limited-input food production systems.[6,59,65] One review on these forms of urban agriculture includes the findings of a few case studies of hydroponic operations that have demonstrated significant reductions in the amount of water needed to produce vegetables compared to conventional farming, as well as studies of building energy savings from the presence of rooftop operations.[6] A multi-country study of

environmental impact factors for integrated[iv] rooftop farming operations in retail parks (e.g., supermarkets) in Europe and South America found that such operations could reduce the carbon dioxide emissions and energy inputs needed to produce tomatoes (compared to non-local conventionally produced ones) and with appropriate rainwater harvesting, could almost universally acquire enough water to avoid additional inputs.[75(Chapter 5)] These potential emissions reductions and energy savings of integrated rooftop operations would be higher in colder climates, as waste energy from the building contributes to reduce energy inputs needed to heat rooftop greenhouses.[75(Chapter 5)] Much of this research is in a nascent stage, and a number of theoretical and practical issues remain before environmental benefits from implementation can be realized in most cases.

Some also argue for the potential of urban agriculture to help cities become resilient in the face of climate change and other environmental challenges, and facilitate the transition to lower-carbon cities. Through an analysis of the role urban gardens have played in history when urban food supply lines were threatened, Barthel *et al*. describe how urban growing maintains the collective memory of food production and protects urban green spaces, thereby enhancing the resilience of cities against food shortages in face of future economic, political, or ecological crises.[76] They argue, however, that external support for intergenerational and multicultural mentorship; experience- and knowledge-exchange; seed sharing and banking; and long-term land tenure for urban green spaces are necessary to uphold cities' capacity to produce food in times of crisis. Others have proposed using urban agriculture for climate change mitigation and adaptation, given the carbon sequestering capacity of vegetation, although this has not been quantified on a large scale.[77] One study that has attempted to quantify an urban agriculture project in the UK found that, while the peri-urban farm under study reduced the community's total diet-related emissions by only 0.4%, it had a greater annual carbon sequestration rate per hectare compared to urban parks and forests.[78]

Environmental limitations

Urban agriculture may not always provide environmental benefits, and could in some cases lead to net negative ecological impacts. For example, indiscriminate fertilizer or compost application may pollute surface water or storm-water runoff with excessive nitrogen, phosphorus, and/or potassium.[8] A number of gaps remain in research related to the practices undertaken at urban gardens and farms, such as the sustainability of their pest management, irrigation, and soil amendment practices, and how and to what extent they foster biodiversity compared to other land use options.[3,8]

One of the main narratives surrounding the environmental benefits of urban agriculture centers on its purported ability to reduce inputs, greenhouse gas emissions, and costs associated with food's production and transportation. Such statements may not consider the loss of economies of scale that come with larger production, processing, storage, and distribution systems, nor regional variances that may actually have net negative environmental outcomes. For instance, the smaller-scale and fragmented nature of urban agriculture tends to be less efficient than larger operations in the use of water, fertilizer, and other resources.[79]

Advocates tout that producing food closer to consumers can reduce "food miles" traveled – that is, the distance the food traveled from where it was produced to where it is consumed – and thus trans-

[iv] Note that there is a difference between integrated rooftop greenhouses (which exchange energy flows with the buildings they are on) and isolated ones, which require energy inputs and are thus not environmentally beneficial in colder climates.[75(Chapter 5)]

portation-related emissions. Yet the vast majority of GHG emissions attributed to foods are from the production phase.[80] In most cases, changing the *types* of foods people eat (e.g., eating less beef and fewer dairy products) and *how* those foods are produced (e.g., input-intensive operations) are more important in reducing foods' associated emissions than reducing *how far* they travel.[80,81] That said, environmental benefits may arise if produce grown in urban areas replaced produce that was typically air-freighted (e.g., greens, berries).[78] Some experts have further argued that if urban agriculture becomes ubiquitous in cities, it may reduce population density and thus require more driving and greenhouse gas emissions than the current system.[63,82]

Some proponents purport that urban agriculture could reduce the soil degradation associated with industrial agriculture by allowing some rural land to be taken out of production.[83,v] But the studies modeling the potential of urban and peri-urban agriculture (see community and municipal food security section on page 14) demonstrate that a significant need will remain for rural food production, where foods that comprise the majority of kilocalories in diets – especially grains – can be produced.[84]

Moreover, producing food in urban settings may increase GHG emissions and water use if plants are grown in energy- and resource-intensive operations, such as indoor/vertical farming, greenhouses, hydroponics (soilless crop production), or aquaculture (the cultivation of aquatic animals or plants for food) facilities in cold or water-scarce regions.[75] A hydroponic farm in Buffalo, New York, for example, shut its doors in 2002 and moved its operations (and over 150 jobs) to southwest Texas due to high energy costs.[13] An aquaponics farm (integrates hydroponics with aquaculture to produce edible plants and fish) in Baltimore, Maryland, found that while the system produced food without antibiotics, synthetic pesticides, or chemical fertilizers, the winter energy use was extremely high – so much so that the tilapia produced a net economic loss if one compared the input costs to market prices.[85] In this case, the aquaponics facility was located in a region with adequate rainwater to supply its operations, but as 90% of global aquaponics operations use drinking water as an input, similar operations could put a further strain on resources in water-scarce regions. Others have critiqued the environmental sustainability of artificially-lit vertical farms in particular, which are notably energy-intensive compared to solar-powered greenhouse and hoophouse systems.[86-88] If appropriate crops and growing methods are chosen, however, there is still the potential for urban agriculture projects to reduce diet-related GHG emissions compared to conventional food production.[75,78]

Public health and food security

Urban agriculture has been promoted for a number of potential health benefits: to those who participate in the actual gardening/farming activities, to community members who may benefit from improved access to the food produced, as well as to city residents on the whole for its potential contribution to food security and resilience, if scaled up strategically and adequately. The strongest evidence of health benefits comes from the first of these categories.

Individual health impacts

Gardening/farming supports public health efforts by providing physical activity to its participants, especially helpful for older people.[22,27,45,89-91] Gardening can support mental health and well-be-

[v] As Cox argues, such lines of thought also ignore the well-being of rural communities, which disproportionately suffer from the worst food insecurity and would likely benefit from increased support from urban consumers.[143]

ing through reducing stress, providing purposeful activity, improving self esteem and a sense of accomplishment, aiding physical and emotional healing, and strengthening people's relationships with nature.[27,45,66,74,91-96] Some of the ecosystem services previously mentioned (on page 8), such as air filtration and temperature moderation, have downstream benefits to the health of urban residents. The increased social support and sense of belonging offered by community gardening (described on page 4) may also empower communities to overcome structural disadvantages they face and improve their access to health-promoting resources such as education, transportation, and medical services.[97]

Urban agriculture may, however, present health risks to food growers, consumers, and the surrounding community if preventive measures are not taken or implemented properly. Local residents could be at risk if garden inputs such as fertilizers and pesticides are used or disposed of improperly.[74] Sources of pollution, such as industrial activity, heavily trafficked areas, and waste dumps, tend to be located in or near urban areas; consequently, urban soils may be contaminated with heavy metals (including lead, cadmium, and arsenic), petroleum products, asbestos, and other hazards.[98] Some urban agriculture projects use treated wastewater for irrigation and biological wastes as fertilizer, which may may introduce bacterial, viral, or parasitic pathogens if not properly treated.[6,99]

Urban food growers may be exposed to soil contaminants (e.g., via accidental ingestion during gardening activities), while persons who consume food grown in contaminated soil may ingest pollutants on the surface of produce and, in some cases, in the tissues of the plant (particularly root vegetables).[99] Exposure to these contaminants can lead to a number of negative health impacts including nervous system damage and certain cancers, which are of special concern for children, pregnant women, and those with compromised immune systems.[98] These sources of pollution and environmental hazards are more likely to be located in lower-income, predominantly black and/or Latino neighborhoods,[166] thus these communities have a higher risk of exposure to contaminants when undertaking urban agriculture projects.[100]

The Center for a Livable Future's *Soil safety resource guide for urban food growers* offers a number of recommendations to educate and support urban growers in taking appropriate measures to avoid contamination.[101] These include conducting site histories, testing soil for contaminants, and following best practices to minimize exposure to any contaminants that may be present (e.g., maintaining a minimum distance between growing sites and roads; appropriately washing and peeling produce before consumption; and using raised beds). The use of buffer strips may reduce the exposure of edible crops to airborne pollutants, contaminated storm-water, and drying winds.[99] Certain cultivation methods, such as indoor or soil-free hydroponics operations, may

Table 3: Summary of public health and food security implications

Reported Benefits	Reported Limitations
Food access and security	
▪ Greater access to fresh, organic, and/or culturally appropriate produce by gardeners[27,37,41,45,106,144,145] ▪ Greater access to fresh food within the larger community (e.g., via donations by gardeners)[37,39,105,110,144,146] ▪ Cost savings on groceries and access to foods otherwise unaffordable in supermarkets[25,27,89,107,147,148] ▪ In some cases, a significant proportion of community/municipal fresh produce needs could be met through urban and (especially) peri-urban agriculture, particularly through the use of intensive forms of production such as hoophouse and rooftop farming[63,102,116-119,124]	▪ UA projects may not be supplying food to communities in which they are located[52,167] ▪ Food may not be economically or physically accessible to local residents[52,167] ▪ Potential to supply produce demand depends on interest/support among urban dwellers to participate in food growing and, in some cases, to adopt more restricted seasonal eating patterns[84] ▪ Modeled municipal food production scenarios rarely account for practical constraints (e.g., current land uses and suitability for food production, property values, infrastructure limitations, zoning regulations, or public accessibility)[121]
Fruit and vegetable consumption	
▪ Greater fruit and vegetable consumption by gardening households[108-112,148-150]* ▪ Increased preference for, consumption of, or willingness to try fruits and vegetables by youth participating in gardening programs[151-162]	▪ Increased produce consumption by gardeners does not represent a significant effect overall on community food security or dietary quality[113,114] ▪ Food may not be culturally appropriate or desired by local residents[52,167]
General health and wellbeing	
▪ Source of physical activity[22,27,45,89-91,150] ▪ Mental health/therapeutic benefits, including: stress reduction, providing purposeful activity, cognitive stimulation, creating a sense of pride and accomplishment, and provision of a connection to nature, a retreat from the urban environment and a way to spend time outdoors[27,45,66,74,91-96,146] ▪ Some ecosystem services provided by UA (e.g., air filtration and temperature moderation) have downstream benefits to the health of urban residents[66,69]	▪ Health risks to growers, consumers, and community from soil contaminants and airborne pollutants if adequate preventative measures to reduce exposures not taken[6,74,98,99]

***Without longitudinal studies, it cannot be determined whether participation in urban agriculture increases fruit and vegetable intake or whether individuals who prefer these foods seek out gardening opportunities.**

also be used to avoid contaminant exposure.[4,102] Government support for conducting, interpreting, and funding such efforts could help ensure that the most vulnerable are not exposed to these risks and associated poor health outcomes, which could undermine other benefits achieved through urban agriculture projects.

Community and municipal food security

Urban agriculture has been promoted as a means for fostering community and municipal food security. Few, if any, urban agriculture projects, however, are intended to replace traditional food retail or would claim to lead to food self-sufficiency for individuals or for cities. The criticism that cities cannot meet year-round food needs through urban agriculture underappreciates the benefits of this approach as one part of the mix of solutions to reform the food system.[103,104]

Urban agriculture, most notably household and community gardening, adds to the tapestry of food sources available in communities across the country that can improve household food security.[105] Gardening enables participants, their households, and occasionally neighbors and friends to access to a diverse array of culturally appropriate foods to supplement their diet, and save money for other essential purchases.[27,37,106] In one study of a home-gardening support program for low-income, working poor and long-term unemployed residents in San Jose, California, 88% of participants reported saving over $240/year/household (with 25% reporting over $720 in savings).[89] A study of community gardens in San Jose, CA found gardeners saved $435 per plot over the season.[107] An Extension specialist from New York City quoted in Saldivar-Tanaka & Kransy (p. 410) offered similar figures: an average 10x20 foot garden plot could produce $500-700 per season.[25] Gardeners are also more likely than non-gardeners to consume the recommended servings of fruits and vegetables a day.[108-112] However, experts contend that this increased produce consumption does not represent a significant effect overall on community food security or dietary quality.[113,114]

Municipal governments may promote urban agriculture as a solution to improving food access in food deserts. While a macro-level quantitative study of the potential in terms of land availability shows that it would be feasible to grow the basic daily vegetable needs for the urban poor in the United States,[115] current evidence from urban farms located within lower-income communities shows that such farms are not necessarily feeding the communities in which they are located.[52,167] A number of factors may account for such discrepancies, but they center around some key critiques that have been raised about urban agriculture (see sociocultural section, p. 4). For farms and gardens aimed at addressing food equity issues, efforts must be made to make the food affordable, physically accessible (location, transportation, hours), cultur-

ally appropriate, and desired by the community members.

The ability of urban agriculture to improve food security on the municipal level is even less demonstrated than on the individual or household scale. A few studies have modeled the potential for food self-reliance in specific cities and found that, in some cases, a significant proportion of fresh produce needs could theoretically be met through widespread implementation of urban agriculture, particularly through the use of intensive forms of production such as rooftop operations. One study found if 80% of every vacant lot, 62% of industrial and commercial rooftops, and 9% of every occupied residential lot in Cleveland, Ohio – a city which has a large amount of vacant land – is used for food production, between 46-100% of Cleveland's fresh produce needs, 94% of poultry and shell eggs, and 100% of honey could be met (between 4.2-17.7% of total food and beverage consumption by weight and 1.8%-7.3% by expenditure).[116] In Detroit, another city with low population density, assuming appropriate postharvest management and storage methods are used, less than half of non-recreational, publicly owned vacant land (~1,800 acres) could provide 65% of fresh vegetables and 39% of fresh non-tropical fruit *currently* consumed by Detroit residents at low productivity levels, or the same percentages of *recommended* consumption levels at high productivity levels.[117] Even greater proportions of food could be produced with significant investments in season-extension techniques (e.g. hoophouses).[117] Another analysis found that if all suitable vacant land in New York City were dedicated entirely to food production, the produce needs of between 103,000 and 160,000 people (out of the city's 8.4 million residents) could be met, although this potential could be significantly increased by including rooftop and greenhouse farming.[118] Cities may be more likely to meet the needs for certain food items, as demonstrated by one study which found that Burlington, Vermont, could meet 108% of its daily recommended fruit intake (albeit in limited varieties compared to the diversity offered by the global market) through an ambitious urban food forestry planting scheme.[119] One multi-country comparative analysis found that less than 10% of urban land in the U.S. would be required to produce the recommended consumption of vegetables by urban dwellers,[120] though its macro-level scale required a number of simplifications that could not account for practical constraints such as current land uses and suitability for food production (e.g., sunlight exposure, water access), property values and competing land uses, infrastructure limitations, zoning regulations, public accessibility, etc.[121] Nevertheless, these are all modeled scenarios with significant barriers for implementation, and would depend on significant interest/support among urban dwellers to participate in food growing and, in some cases, to adopt more restricted seasonal eating patterns.[84]

Some efforts have proposed increasing the production capacity of urban agriculture through creative means such as vertical farming.[83,122,123] There is little evidence, however, indicating that these efforts would substantially increase its contribution to food security, especially for lower-income residents constrained by the higher prices typically associated with such operations.[4] More promising evidence comes from studies of peri-urban agriculture, which produces substantial amounts of food on a relatively small amount of land.[102,124] In Australia, peri-urban agriculture produces 25% of the country's total gross value of agricultural production on less than 3% of agricultural land, and some metropolitan regions meet over 90% of certain fruit and vegetable needs.[63] The aforementioned report on New York found that if all the peri-urban agricultural land in the metropolitan region surrounding the city were dedicated to food production, it could support between 58-89% of

the region's fruit and vegetable needs (excluding warm-weather fruits).[59]

Ultimately, food security is not a primary goal for most participants and supporters of community gardens and urban farms[125,167] and should not be promoted as such. While it can supplement household, community and municipal food security, urban agriculture has more to offer, and be judged on, than its potential outputs in terms of food production.

Economic development

Urban agriculture has been embraced by many cities as a means through which to repurpose vacant lots; increase property values and, consequently, capital investment and redevelopment in distressed areas; and add jobs to the local economy. This framing permeates the literature of municipal planning documents and policies in support of such efforts, however economic outcomes are the "least documented aspect of urban agriculture."[12]

Potential economic development opportunities

As described in the sociocultural section, community gardens are associated with improved neighborhood aesthetics, reduced crime, and community cohesion. Such factors contribute to the finding that community gardens, particularly in economically disadvantaged neighborhoods, are linked to higher home property values and tax revenues in their 1,000-foot radius.[126] In a review of published research on community gardens, Guitart *et al*. found that all 13 of the studies which examined property values (15% of the total studies in the literature review) reported increased property values associated with the presence of the community garden.[3] A report (not peer-reviewed) of 54 community gardens in St. Louis, Missouri, found that their presence was associated with increased home values, rents, owner occupancy (a proxy for homeownership), and socioeconomic diversity amongst renters in the areas within a radius of 0.3 miles surrounding community gardens.[127] These improved indicators were relative to the larger Census Tracts in which they were located and to the city as a whole during a ten-year period.[127]

Commercial urban agriculture projects have been particularly encouraged in economic development goals, especially given their potential to attract capital to and provide jobs in economically disadvantaged neighborhoods. A 15-year-old report by Kaufman & Bailey assessed the feasibility, potential benefits of, and barriers related to for-profit urban agriculture in the United States.[128] They found (at the time of publication) 71 entrepreneurial urban agriculture sites in U.S. cities, mostly located in lower-income, inner-city neighborhoods. While they found a small number of projects had begun making profits, most were still in their infancy and not yet demonstrating significant economic returns. More recent market research focusing specifically on the vertical farming sector of urban agriculture models that the global vertical farming market will be worth 3.88 billion by 2020 (up from 1.01 billion in 2015), with the fastest growing segment of this sector from hydroponics.[129] It should be noted that the methods behind this research are behind a paywall so they cannot be verified independently.[129]

Limitations of economic development framework

Some important questions have been raised about the economic development narrative surrounding urban agriculture. For one, concerns abound over the potential for gentrification and displacement of residents (usually lower-income, people of color) as property values in neighborhoods rise following

Table 4: Summary of economic development outcomes

Reported Benefits	Reported Limitations
Employment opportunities	
▪ Employment and workforce training opportunities, particularly for low-income and socially excluded populations[5,15,40,41,167]	▪ UA not likely to provide significant number of livable wage jobs[5,7,17] ▪ UA projects offering opportunities to the "least employable" require additional expertise beyond technical farming skills, which may require more staff time and higher labor costs[42]
Increased property values	
▪ Increased property values surrounding community gardens, particularly in economically disadvantaged neighborhoods[3,126,127]	▪ Possibility of displacing/marginalizing low-income residents[49,130]
Redevelopment	
▪ Entrepreneurial UA may attract capital and create profitable business opportunities, particularly in distressed areas[128,129]	▪ Lack of long-term land tenure makes UA projects vulnerable to redevelopment or competition with other uses of the land/building[3,4,25,27,54,121,130-132] ▪ For commercial operations, long-term economic viability or profitability unproven, especially for technological UA concepts[6,17,63,65,134] ▪ UA requires financial and political support; most projects cannot survive on profits from produce, especially when incorporating other social missions[17,42,167]

the improvement of vacant lots. As Hoover (p.112) asks, "Is urban agriculture just another form of urban renewal, displacing underprivileged communities in the process, or is it an inclusive practice that works with marginalized people in the remediation of 'their' land?"[49] In practice, this question is not necessarily a binary one, as outcomes from different urban agriculture initiatives fall along a continuum. In order for the revitalization associated with urban agriculture efforts to support the wellbeing of its immediate neighbors – and to avoid reproducing injustices they already experience – urban agriculture and related economic redevelopment projects must be designed with the priorities of the most vulnerable residents in mind, and, if possible, their presence at the decision-making table.[130] See page 7-8 for a discussion of inclusive community engagement strategies.

The community garden literature in particular has noted the vulnerability of gardens to redevelopment. As cities provide temporary leases of vacant lots to community groups, or incentivize private landowners with lower tax rates if they allow their land to be used for urban agriculture, issues surrounding long-term land tenure arise.[25,27,130,131] Some operations on city-owned land have been granted land under the agreement that no permanent changes to the site may be made, thereby restricting the long-term scalability, efficiency, and sustainability of urban agriculture.[121] Lawson[131] and Schmelzkopf[54,132] document specific cases – reflective of a broader trend experienced by many

gardens across the country[3] – in which gardens have been cleared once the property of the land they occupy assumes economic value attractive to real estate developers. These actions literally uprooted years of invested labor, material, and social networks embedded in urban green spaces. Such studies underscore the necessity for cities to recognize the public goods that urban agriculture projects provide, and encourage them by granting long-term leases, incorporating them into public park infrastructure, or supporting the use of land trusts to secure garden locations.

Land-use competition affects more than just community gardens. Rooftop, vertical, and other forms of indoor farming do not compete with land constraints associated with land-based urban agriculture projects, but they may face competition from other forms of building use, such as rooftop solar energy systems.[4] While peri-urban agriculture is generally operated by professionals and is more economically-motivated than urban agriculture, development pressures from urban sprawl increase land prices in surrounding areas and thus significantly threaten the long-term economic viability of such operations, too.[102,133]

Urban agriculture projects themselves face a number of barriers that challenge their economic viability, especially for commercial efforts aiming to make a profit.[65] In their literature review on "Zero-acreage farming," Specht *et al*. note that the high capital costs required to retrofit existing buildings or build new facilities for high-yielding, space-efficient forms of urban agriculture such as large-scale rooftop greenhouses prevent many such operations from moving past design or pilot stages.[6] The challenge of quantifying social and environmental benefits such as resource recycling further complicates their economic case. In a case study of a rooftop greenhouse system in Barcelona, Spain, the structure itself was 2.8 times more expensive than conventional multi-tunnel greenhouses, and the operation faced uncertain crop yields, threatening its economic competitiveness and environmental benefits.[134] Similarly, Mok *et al.* discuss the large gap of research on the long-term economic feasibility of more technological urban agriculture concepts, such as vertical farming.[63]

Farm labor is one of the most exploitative, lowest paying industries in the U.S. today.[135-137] As urban agriculture commentator Angotti points out (p. 339), "Who is to say that urban farms, whether public or private, won't follow the same pattern?... Who will do the work, how much will they be paid, and will they be paid at all?"[138] In an evaluation of urban farms and gardens in six U.S. cities, Vitiello & Wolf-Powers point out the reality that urban agriculture will not likely provide a significant amount of livable wage jobs.[5] They argue that to expect anything otherwise would ignore the nature of the food system and its reliance on low-wage labor, government subsidies, and economies of scale. Most urban agriculture projects are sustained through public funds, grants, donations, and volunteer labor, not food sales (which account for 2-30% of the operational costs for three urban agriculture operations – including the U.S.'s most prominent urban farm, Growing Power in Milwaukee[42]). While many for-profit farms include social goals such as improving food security in their missions,[17] the few profitable operations tend to be those selling to high-end restaurants and consumers, not to lower-income residents.[5]

Corroborating these findings, a 2012 survey of 370 urban farmers in the U.S. found average sales from urban farms were about $54,000 a year (though this average was skewed by a small percentage of high-earning hydroponic operations; the median level of sales were $5,000).[17] Respondents identified profitability and financing as the top challenges they face.[139] One-third of urban farmers

reported earning a living from the farm, though the survey did not delve further into what kind of lifestyle these jobs were able to support.[17] Non-profit farms were more likely to provide a salary for the primary farmer than for-profit ones, likely because of additional revenues from donations, grants, and educational fees, as well as the support of volunteer labor.[17]

A survey of aquaponics facilities across the world (81 percent were based in the U.S.) found similar prospects: on average, these operations supported only two full-time jobs and one part-time job, while depending on another six unpaid workers.[7] In addition, fewer than one-third of the 257 respondents had profited in the previous year. While many of them were new businesses who anticipated becoming profitable in the near future, those outcomes must be measured before any economic successes can be stated.

Daftary-Steel *et al.* argue that urban agriculture operations aiming to provide produce at affordable prices, and offer livable wage jobs and workforce training opportunities for marginalized people, will never be profitable from produce sales alone, and advocates, funders, and policymakers should not promote such expectations.[42] Many urban agriculture projects select crops and make other organizational decisions based on their social goals, rather than factors such as production efficiency or profitability.[121] Urban agriculture projects providing these valuable and multidimensional social services will need substantial long-term external financial and political support to survive.[42] Dimitri *et al.* concur, and suggest that the grant-supported non-profit model may be the most viable option for ensuring the longevity of socially-driven urban farms.[17] In addition, many urban growers would benefit from more accessible and relevant technical assistance and research to support their operations.[121]

This discussion does not aim to discredit the role that urban agriculture projects play in providing workforce training and supplemental income generation, as well as the host of other benefits described in the previous sections. However, it indicates that the rhetoric and expectations of urban agriculture efforts should revolve more around the social, health and environmental values they hold, with supplementary incomes and food provisions as additional benefits, rather than the other way around.

Research gaps

This literature review has revealed a number of research gaps that could be further explored. These include:

Social

- A review of the various models of urban agriculture projects and their effectiveness in meeting the needs of the community, working with the community, and fostering leadership within the community
- More research on the development and use of indicators to evaluate community impacts (see Beilin & Hunter[140] and Cohen *et al*.[141] as examples)
- Research on how urban and peri-urban agriculture influence seasonal eating practices, food waste rates, support for rural farmers (through increased appreciation of full value of food), and other consumption patterns and how these patterns differ across populations (e.g., participants, community members)
- Further research into how participants in urban agriculture projects apply newly gained social and political skills to other issues that affect their communities

Environmental

- Case studies of environmental practices (e.g., soil management and amendment, irrigation, and fertilizer use practices by food growers), crop yields, supply chain losses, lifecycle impacts of foods produced, and other outcomes associated with urban agriculture projects
- Comparisons of the above outcomes across types of operations (e.g., rooftop, vertical farming, community gardens), levels of urbanization (e.g., urban, peri-urban), regions, and climates
- Comparisons of the above outcomes to conventional rural agriculture
- City-level quantitative analyses of the potential carbon sequestration, air quality improvement, and stormwater run-off mitigation benefits specific to the land use and plant species associated with urban agriculture projects (most research to date concentrates on urban forests[66])
- More research on the long-term environmental sustainability and economic feasibility of technology-based urban agriculture concepts, such as artificially-lit vertical farming
- Research on how agricultural easements and preservation programs can be tailored for peri-urban and urban settings

Public health and food security

- More research on potential exposures to soil contaminants (e.g., in garden soils, in crop tissues, and on the surfaces of produce), and the effectiveness and feasibility of various soil remediation techniques
- A multi-site study comparing potential exposures to airborne pollutants (e.g., via inhalation and deposition of contaminants on soil and produce surfaces) across ground-based, rooftop, and indoor operations
- Additional research on the potential health hazards associated with urban livestock production on participants, consumers, and neighboring residents (e.g., odors and air-borne pollutants, concentration of toxicants in eggs and meat)
- Research on if/how the availability of vacant land influences urban agriculture's food output and contributions to food security
- More research on if/how climate and the length of growing seasons influence urban agriculture's food output and contributions to food security
- Further studies assessing the feasibility of urban and peri-urban agriculture to meet the produce demands of different metropolitan regions, with special emphasis on modeling realistic estimates based on costs of implementation, available infrastructure, market demand, etc.

Economic

- Research to identify more holistic measures of economic outputs and outcomes of urban agriculture projects, differentiating between profit-driven initiatives and those with other social and environmental aims
- A long-term study assessing the employment status and job readiness of people who received workforce training in urban agriculture projects, examining the market for newly acquired skills and whether such experiences lead to other opportunities in communities where underemployment and unemployment may be the norm
- Further longitudinal studies on the effect of urban agriculture initiatives on neighborhood indicators (e.g., rents, property values, owner occupancy rates), and the downstream effects on residents (e.g., displacement as a result of higher rent)
- A review of how loans, grants, and other forms of financial and administrative support from government, foundations, investors, and other external entities impact the economic feasibility of urban agriculture initiatives across the U.S.
- Research on the profitability of commercial urban agriculture projects across the U.S.

More research into the topics discussed above could enhance the collective understanding of the potential benefits and limitations from encouraging urban agriculture initiatives. Case studies of how food policy councils, public institutions, and local governments use such information to support urban agriculture efforts (e.g., through preferential procurement programs, changing zoning ordinances) as well as evaluations of their impacts (e.g., in increasing/sustaining projects long-term) could further complement this analysis.

Recommendations for framing the merits of urban agriculture

Urban agriculture should be evaluated for the multifaceted nature of its outcomes – social, health, environmental, and economic – and not merely for its potential outputs in terms of food production or economic development measures. The list below offers a number of evidence-based talking points for advocates seeking to advance urban agriculture policy and programs:

1) Urban agriculture's most significant benefits center around its ability to increase social capital, community well-being, and civic engagement with the food system.

2) The most successful urban agriculture efforts require sensitivity to the historical and current racial, socioeconomic, geographical, and cultural dynamics in highly diverse urban areas.

3) Urban agriculture offers a number of ecosystem services to urban areas, some of which also offer downstream benefits to the health of urban residents.

4) Urban food growing can support participants' physical and psychosocial health, though special precautions should be taken to minimize health risks associated with contaminated soils.

5) Urban agriculture supplements household, community and municipal food security with seasonal and culturally-appropriate foods, and if knowledge sharing and long-term land tenure are adequately supported, may offer resilience in the face of temporary future food shortages.

6) The presence of community gardens has been associated with increased property values, though special attention should be paid to ensure that community residents are given a voice in decision-making around urban agriculture and economic development issues pertaining to their neighborhoods.

7) While large-scale job creation potential has not been demonstrated, urban agriculture projects offer valuable opportunities for skills development, workforce training, and supplemental income generation. These may be particularly helpful for neighborhood youth, immigrants, the differently abled, and the formerly-incarcerated, though external financial support will likely be necessary to support the extra time and expertise needed to operate such initiatives.

8) Many of the demonstrated benefits of urban agriculture efforts will only be achieved with adequate local, state, and federal governments' long-term commitment of support.

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