Submission
No 66

FOOD PRODUCTION AND SUPPLY IN NSW

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Food strategies - Localised Alternative Food Networks

‘The potential and limits of urban agriculture as a sustainable food localisation strategy to address the environmental sustainability crisis of the global food system.’

“Many of the greatest current global challenges are related to the food system and the way that land is used and managed”

(Smith et al. 2020, p.1533).

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1. Introduction

1.1 The global food crisis

By 2050, it is estimated we will need to produce 70% more food to feed more than 9 billion people, of whom 67% will be living in large cities (The World Bank 2021). However, the current industrialised food system, based on large-scale rural production in a globalised food economy, is now suffering an environmental sustainability crisis that is threatening food security. Modern agriculture occupies over 40% of the Earth’s ice-free land, and is characterised by widespread deforestation and simplification of ecosystems for the purposes of mechanical and economic efficiency (Campbell et al. 2017), using increasingly intensified production methods to meet food demand from a rapidly growing, urbanising population. Today, the globalised food system relies on a handful of domesticated plant and animal species cultivated in broad-scale monocultures - dependent on synthetic fertilisers, toxic agrochemicals, and often artificial irrigation (Weis 2007). But ironically, these practices are the leading single source of land and environmental degradation (including climate change) that disrupt the external conditions necessary for food cultivation, such as stable climate, fertile soil, and clean water (Chalmer 2021; eds Marsden & Morley 2014). Over 25% of farmland is now highly degraded (e.g., soil erosion, salinity, fertility decline, chemical pollution, loss of biodiversity, depleted freshwater, and desertification) and a further 10% loss is predicted for every 1 degree of global warming (De Clercq et al. 2018), which will seriously impact future agricultural productivity (Figure 1).

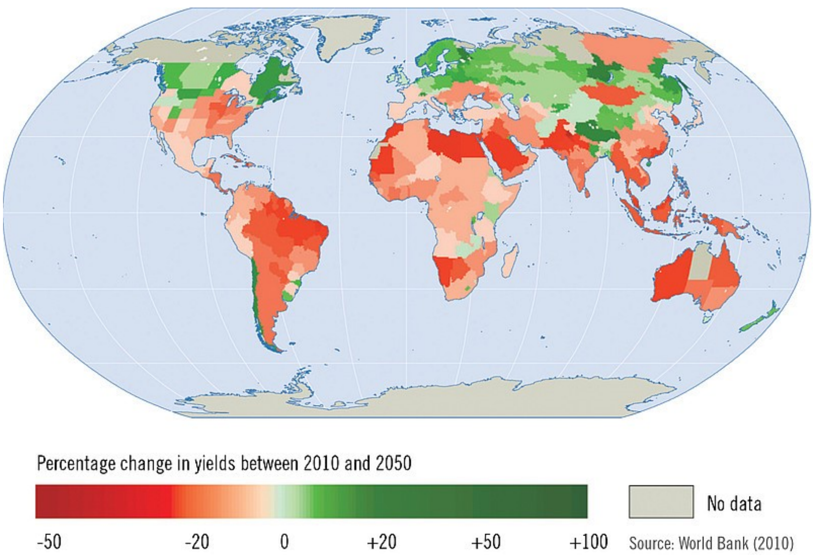

Fig. 1 Expected changes in global agricultural productivity due to climate change
Projected changes in productivity are mapped via region for the 11 major staple foods including: - wheat, rice, maize, millet, field pea, sugar beet, sweet potato, soy bean, peanut, sunflower and rapeseed.
(Source: World Bank 2010)

However, this food crisis goes beyond agricultural methods in rural locations, and is connected to complex geographic and socio-economic factors. The rise of industrialisation and capitalism has created an energy-intensive, linear globalised food system under the control of large transnational corporations (TNCs), whereby urban food is supplied from rural farms hundreds or thousands of kilometres distant, via inefficient and fragile supply chains that involve loss or wastage of one-third of produce (Weis 2007; FAO 2011).

1.2 The role of the globalised food system and conventional agriculture in driving climate change

Agriculture directly contributes a quarter of global greenhouse gases (GHGs), with a further 10% coming from supply chain activities; food transport, processing, packaging, distribution, retail, consumption, and waste disposal (Crippa et al. 2021). With most of the world's population and wealth now centred in cities, urban dwellers (55% of global population) consume 80% of the world's food (FAO 2021), making food a large part of the environmental burden of cities (Goldstein et al. 2016b). Rising affluence has increased demand for resource-intensive foods like meat and dairy, further exacerbating the environmental unsustainability of food production. The impacts are not distributed evenly, and lower income communities in agriculturally marginal areas such as North and West Africa and parts of Asia already suffer increasing poverty levels as crop yields decline or are destroyed by increasingly severe climate shocks (droughts, storms, floods and fires) (Figure 2), while urban dwellers are subjected to food price increases or supply disruptions in times of crisis (Lal 2020; IPCC 2019). But the sheer scale of environmental degradation from industrialised agriculture is contributing to unprecedented destabilisation of the Earth's life support systems, which will affect all future generations everywhere (Campbell et al. 2017; Steffen et al. 2015). Diminishing farmland, depleted resources, and increasingly unfavourable climatic and environmental conditions for food production call for urgent and radical changes in the globalised food system.

Fig. 2 The impact of climate change and rising sea levels on coastal agriculture in Bangladesh
Poor farmers in Bangladesh are losing their crops and livelihoods as climate change drives sea-level rise and increasingly severe storms. While climate change is global in impact, it is often the lower income communities that suffer the worst impacts. (Source: nytimes.com 2014)

1.3 A sustainable solution - urban agriculture as a food localisation strategy

One promising strategy involves increasing sustainable food production within and around cities using urban agriculture (UA) techniques to reduce pressure on degraded rural farmland, create a more efficient and circular food economy, and help to mitigate climate change. Urban farming already produces 15-20% of the world's food supply, especially in developing countries (Lal 2020), with great potential to be scaled up. Defined as "plant cultivation and animal rearing (including aquaculture) within cities and towns or their surrounds" (FAO 2021), UA produces a large variety of food including cereals, legumes, roots and vegetables, fruits, herbs, medicinal plants, ornamentals, and trees, plus livestock e.g., poultry, rabbits, guinea pigs, goats, sheep, cattle, fish, and insects, and animal-based products like eggs, milk, and honey (Orsini et al. 2020). Globally, ~800 million people practice UA to some degree (Khan et al. 2018), ranging from inner-city balconies, backyards, rooftops, urban allotments or community gardens, through to commercial urban farms or totally enclosed high-tech plant factories (Figure 3). As a food localisation strategy, UA can bring consumers and growers closer socially and spatially, and may offer social, economic, and environmental alternatives to food globalisation.

This paper will firstly examine the potential of UA to add diversity to the globalised food system and to mitigate the environmental sustainability crisis of food production. The second section will cover potential limitations of UA, including technical, social, political, and economic barriers to implementation and discuss whether UA can truly contribute to transformative change of the existing food system.

Fig. 3 Some examples of varied types of urban agriculture in different locations
a) Balcony garden in high-rise apartment (www.growveg.com).
b) Backyard chickens produce eggs for family consumption (www.homesteadandchill.com 2021)
c) 'City Farm' Chicago, USA, a highly productive, sustainable community farm (Altieri 2019)
d) Rooftop beehives produce honey in the centre of Sydney (www.urbanbeehive.co.au 2021)
e) Rooftop garden New York City (www.grist.org)
f) Market garden in an African city – provides essential food for urban families, and surplus produce is sold for additional income © Jerry Miner/GlobalHort (www.medium.com)
g) Low-tech outdoor vertical farming using hydroponics in Africa, reduces land and water requirements and overcomes soil infertility or contamination (www.theconversation.com)
h) AeroFarms – the world's largest controlled-environment plant factory in Newark, NJ, USA operates in an old steel mill, and harvests 900,000 kg of leafy greens annually. (www.aerofarms.com)

2. Potential and Limits of Urban Agriculture

A. Potential of Urban Agriculture

i. New capacities for food production through diverse types of urban farming

Urban land is limited but many studies show that UA could provide a major proportion of a city's food needs through intensifying production in existing farms and gardens, utilising vacant land, rooftops and facades, plus indoor spaces that require air conditioning and/or artificial lighting i.e., controlled environment agriculture (CEA) (Taylor 2020). Rooftop greenhouses or vertical farming (VF) (production in vertically stacked layers) offer the best productivity and food security in the face of climate change (Despommier 2011), although large numbers of smaller, low-tech forms of urban farming can occupy a variety of urban spaces and produce a more diverse, and adaptable range of food species. In wealthier nations, CEA is increasingly found on or in city buildings and underground spaces, requiring no extra land - termed "Zero acreage farming" (Specht et al. 2014). The use of hydroponics (soilless plant cultivation in a closed-loop system) or aquaponics (combined fish and hydroponic vegetable production) in CEA gives extremely high yields year-round, independent of local climate variations (Goldstein et al. 2016a; Specht et al. 2014). For example, a San Francisco indoor hydroponic vertical farm (Figure 4) achieves 350 times higher yield per unit area compared to conventional horticulture – using zero pesticides, 99% less land, 95% less water, and greatly reducing food miles and wastage (Engler & Krarti 2021).

Fig. 4. Intensive Indoor vertical farming
Vegetables grown indoors, using closed-loop hydroponics and energy-efficient LED lighting at 'Plenty' farm, San Francisco. (Source: www.plenty.ag)

Many studies demonstrate urban farming's capacity to provide much of a city's food according to location, climate, and urban context, and a surprising amount of urban growing space is available in most cities (Edmonson et al. 2020; Ghosh 2021; Madaleno 2001). For example, 300,000 urban farms in tropical Cuba annually produce half the nation's fresh produce, 216 million eggs and 39,000 tons of meat from small outdoor plots (Figure 5) (Altieri 2019; Woodhouse 2010). In the Global North, city policies often prohibit large livestock, but raising poultry is common, along with fruits and vegetables.

Fig. 5 Urban farming is widespread in Cuba
Nations like Cuba, in the Global South, already have a higher reliance on urban agriculture out of economic necessity, which is likely to increase as global food supplies are impacted climate change. In contrast, the Global North has begun to embrace UA mainly for reasons of city sustainability (e.g. green space, clean air, stormwater management), social benefits, and a short-term individual effort to reduce food supply disruption since the pandemic crisis.
(Photo: www.eduardomartino.com 2021)

In the United States, Grewal and Grewal (2012) calculated potential food self-sufficiency for Cleveland, Ohio (population 380,000), and showed that 94% of poultry/eggs, 100% of honey, and 100% of fresh fruit and vegetables could be produced using 80% of vacant urban land, 9% of residential gardens, and 62% of commercial roof space (using outdoor cultivation, plus CEA during cold winters). Generally, soil-based UA yields are superior to industrial agriculture due to higher-density mixed plantings (McDougall et al. 2019), with wastage greatly reduced by proximity to consumers. Other more innovative forms of UA are increasing worldwide, including growing edible fungi, algae, and invertebrates (crustaceans, molluscs, worms, and insects) for protein in limited urban spaces (Specht et al. 2014).

ii. Global environmental benefits of urban farming

A shift towards localised urban food production could attenuate the overall global environmental burdens from food production and distribution, as summarised in Table 1. Major benefits include elimination of agricultural deforestation and land-use change, and increasing overall biodiversity in urban environments, including a greater diversity of food species (Mahaswa 2021). Climate change mitigation is possible - especially through soilless growing practices with closed loop systems that eliminate nitrous oxide GHG emissions from cultivated soil, and minimise synthetic fertiliser use (whose production requires large fossil fuel inputs) (Shankman 2019). Labour-intensive soil-based UA also reduces CO_2 emissions via minimal mechanisation, nil or short supply chains with little wastage, increased vegetation cover and soil carbon, and encourages a circular economy with recycling of inputs.

iii. Urban sustainability benefits from localised food production

Urban sustainability (economic, societal, and environmental) is also greatly enhanced (Figure 6) (Lal 2020) - advancing many Sustainable Development Goals of the United Nations (UN 2015). A food-enabling city can capitalise on a diversity of cultural knowledge on food practices, and provide opportunities for self-provisioning, alternative local food networks, and urban agricultural employment (e.g., for farmworkers forced to leave unviable rural farming areas) - as well as ensuring food security in times of crisis (Gibson-Graham 2013; Tornaghi 2017). In cities such as New York, urban planning is already integrating localised food systems into the city's material and energy fluxes, termed 'urban symbiosis' (Ackerman et al. 2014; Goldstein et al. 2016a). Widespread adoption of urban agriculture in forms that suit the socio-cultural, economic and geographic needs of each city could make a significant difference to the resilience of the current industrialised food system by reducing pressure on rural farmland and resources, while adapting to and mitigating climate change.

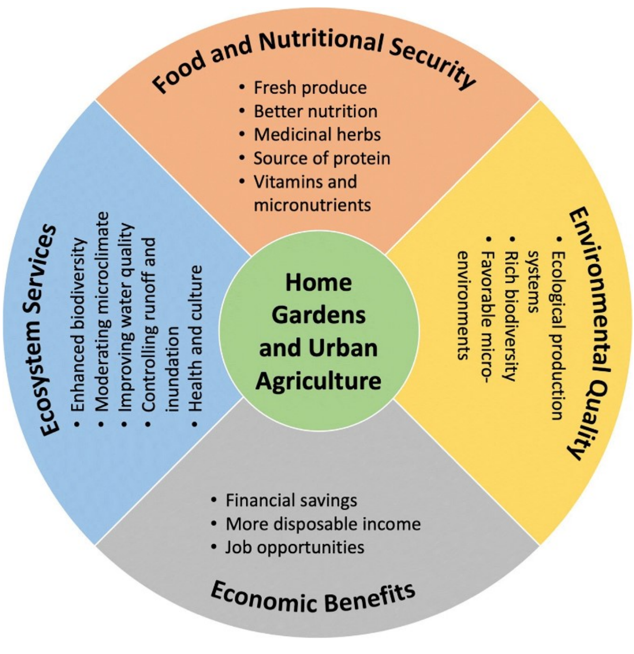

Fig. 6 The benefits of urban agriculture for cities
The well-planned incorporation of urban agriculture into cities can bring multiple social, environmental, and economic benefits.
(Lal 2020, p.874)

Table 1. The environmental benefits and limitations of different types of urban agriculture

Type of UA	Food types	General benefits	Energy/ GHG reductions	Potential limitations	Sources
Residential gardens	- Fruits, vegetables, including fruit trees and heavy crops e.g., roots & tubers, maize, pumpkins - Small livestock e.g., chickens/eggs, rabbits, bees/honey	- organic/ minimal chemicals. - high yields. - urban environment improvements: - i. increased biodiversity. ii. more green space iii. better air quality iv. soil water retention, reduced runoff vi. reduced urban heat island effects - health benefits – exercise, improved access to fresh food.	- Non-mechanised production. - Eliminates supply chain/ food miles - High soil carbon stores. - CO_2 absorbed by vegetation/trees - Composting of food waste - Utilisation of rainwater (saves energy as no municipal water treatment required) - possibly integrate human/animal waste e.g., composting toilets – circular economy.	- High-density urban planning focus – greatly reduces growing space. - may use high embedded-energy resource inputs, inc. potable water. - urban soil contamination, air pollution. - shade from buildings. - subject to weather events and pest losses. - lack of systems for organising growing or distributing produce. - labour-intensive and time consuming. - lack of motivation, cultural dependence on supermarket food types. - legal/urban policy/social - restrictions, conflict, lack of knowledge. - could contribute to urban pollution/ health risks.	(Ghosh 2021; Lal, 2020; Taylor 2020)
Allotment/ Community gardens	As above	As above	As above <u>except</u> - *Reduces* supply chain/ food miles.	As above -possibly vandalism and theft	(Dobson et al. 2021)
Open-air rooftop/balcony gardens	As above	As above plus: - - utilising raised garden beds with new growing medium overcomes issues of contaminated land.	As above plus: - - some symbiotic energy use with buildings – i.e., rooftop garden insulates urban building and utilises waste heat for plant production. - possible re-use of wastewater. - possible use of food waste from building as compost etc.- circular economy. - eliminates land use change	- Structural limits on rooftop e.g. strength, water permeability, drainage, water supply - may require costly modifications. - difficulty in access for set-up and harvest - excess use of potable water. - subject to high winds, temperature extremes, air pollution - subject to weather events and pest losses. - legal/urban policy/social - restrictions or conflict (e.g., building height limits, tenant disagreements, access equity)	(Ackerman et al. 2014)
Commercial urban farms	As above plus: - - Possibly larger livestock e.g., cattle, goats/dairy products	As per Residential gardens	As per Allotment/community gardens plus: - increased resource and energy efficiency with larger scale	- Lack of space, high urban land values, high-density re-development. - may be economically unsustainable - small scale, labour-intensive - urban soil contamination & air pollution. - excess use of potable water. - urban health issues – pesticides, animal waste, diseases etc. - legal/urban policy/social - restrictions or conflict.	(Madaleno 2001; Mok et al. 2014)
Building - integrated greenhouses	- Smaller fruits and vegetables such as tomatoes, berries, salad greens.	- Very high yields with hydroponics - overcomes land contamination. - overcomes weather-related losses. - year-round production. - high food security. - minimises pests, pesticides pollution. - no agricultural nitrogen runoff. - overcomes local climate restrictions. - minimal terrestrial biosphere damage.	- Reduces supply chain/ food miles/mechanisation - urban symbiosis - exploiting CO_2, heat, macronutrients, greywater/blackwater. - solar panels for zero net energy consumption. - biogas from urban waste – feedback to grid. - efficient closed loop water and nutrient systems, minimises synthetic fertilizer use. - soilless farming minimises N_2O GHG emissions. - eliminates land use change/ deforestation	- high cost of urban space - high infrastructure set-up costs - high embedded energy in structure and inputs e.g., fertilisers. - high energy use/GHGs **if** renewables not available - may be limited types of niche-market crops – for economic and technical reasons - high food prices may be inequitable. Legal/urban policy/social - restrictions or conflict.	(Edmonson et al. 2020; Mohareb et al. 2017; Ravishankar et al. 2020; Sanye-Mengual et al. 2015)
Vertical farms	As above - plus: - - aquaponics (fish & vegetables) - cereals - fungi, algae, worms, crustaceans, mussels, insects.	As above plus: - - extremely high yields - can be automated - zero acreage farming = no new land use (e.g., operates in disused buildings, underground tunnels, etc.) - complete climate control allows for wide variety of produce.	As per Building-integrated greenhouses plus: - - reduced water use up to 95%, pesticides by 100%, land use up to 99%. - Computerised technology for energy efficiency (NB: some low-tech vertical farming alternatives exist e.g., hydroponic greenhouses with rotating shelves that require no lighting or heating in tropical climates (Pascual et al. 2018)).	Mostly as for Building-integrated greenhouses, except: - - usually very high start-up costs - usually, high technology requirements - high tech versions may be unaffordable in developing countries	(Asseng et al. 2020; Besthorn 2013; Engler & Krarti 2021; Martin & Molin 2019; Specht et al. 2014)

B. Limitations of Urban Agriculture

i. Economic and political barriers to change

Despite its obvious benefits, UA is as yet only rarely considered a viable food production alternative to rural-based industrial agriculture, and many economic, political, social, and physical barriers often exist to farming the city (see 'Potential Limitations' Table 1). Broadly speaking, the primary functions of cities (highly profitable housing, industry, and trade) are given priority over agriculture, which is thought to 'belong' in the rural space - and international, national, and local policies and attitudes often reflect this division (Ghosh 2020; Mok et al. 2014; Dixon & Richards 2016). Industrial agriculture is firmly locked into the capitalist global food system (Hailwel 2002), with international trade agreements, and most government policy and funding directed primarily towards economic rather than environmental sustainability. Modern agricultural science and technology are still widely expected to overcome environmental issues through 'sustainable intensification', i.e., production of more food from the same area of land through more efficient use of resources (Godfray et al. 2010), such as via genetically modified organisms, precision technologies, and land-use innovations (Federoff et al. 2010) - although these methods often still fail to address the serious problems of biodiversity loss, climate shock vulnerability, and supply chain inefficiencies (Goldstein et al. 2016b).

ii. Industrial-scale urban agriculture - transformation of the food system or 'business as usual'?

Most nations seem reluctant to move away from cheap, unsustainable broadacre agriculture practices, especially when industrial-scale urban agriculture projects do incur high setup costs and energy use when artificial lighting is required. For example, a new vertical farm in Berlin (closed-loop aquaponics producing fish and vegetables for 15,000 people) would cost 200 million euros, with annual electricity consumption of 3.5 GWh, plus high embodied energy in structural components and inputs of synthetic nutrients and potable water (Banerjee & Adenaeuer 2014). However, when renewable energy is used, urban closed environment agriculture (CEA) can provide better environmental sustainability than conventional agriculture due to higher productivity, supply chain reductions, and circular economy (Mohareb et al. 2017; Sanye-Mengual et al. 2015). Nowadays, semi-transparent solar cells in greenhouse surfaces create net-zero energy operations, or even feed excess energy back into the grid (Ravishankar et al. 2020). High-tech CEA is increasingly found in wealthier cities in the USA, Europe, UAE, and Asia - but commercial viability constrains production to high-value produce (Figure 7), reinforcing some aspects of 'business as usual' e.g., inequities of urban food provision (Specht et al. 2019), lack of food diversity, and corporate control.

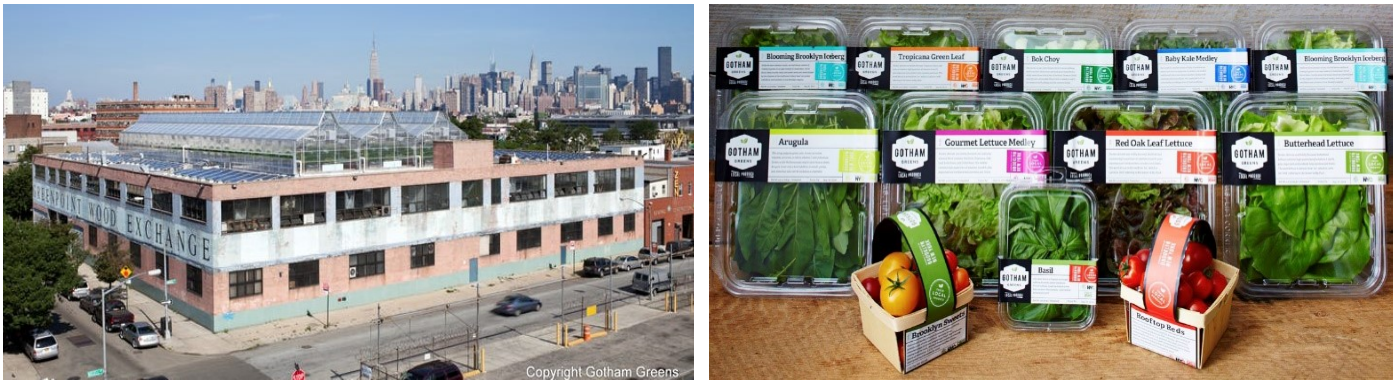

Fig. 7 Rooftop commercial greenhouse in New York City, 'Gotham Greens' and its premium products
Gotham Greens rooftop greenhouse in Brooklyn cost several million dollars to set-up on top of an existing warehouse building, and incorporates solar panels to power air-conditioning, lighting, water pumps, etc. Food is produced via closed-loop hydroponics with no pesticides, offering environmental sustainability benefits, and is sold on-site or locally with minimal food miles and wastage. Only a limited range of salad greens and gourmet tomatoes are grown, and highly packaged to sell at premium prices (e.g., USD $3.99 each in 2011). The company has expanded its commercial operations into several U.S. cities (Zeveloff 2011). (Photos: www.gothamgreens.com)

iii. Small-scale urban agriculture limitations

In contrast, small-scale UA such as home or community gardens offer more diversity in food types and creative ways of growing/sharing/trading food, but better grower education, regulation, and organisation of urban farming will be needed to ensure food safety and efficient distribution of increased volumes of produce. Urban growing spaces may also suffer polluted air, water and soils but these can be overcome with a variety of techniques (Table 2). Other major constraints to upscaling UA include limited access to land/space, non-supportive city policies, and the unsuitability of time-consuming and labour-intensive food growing for busy urban residents (Tornaghi 2017).

Table 2. Strategies for reduced contamination risk in urban grown vegetables (Orsini et al. 2020, p. 10)

Prevention strategy		Contamination source	Experimental evidence	References
Location	Distance from roads	Air	Main contamination from road is limited within 25 m	García and Millán, 1994; Reinirkens, 1996; Charlesworth et al., 2011; Vittori Antisari et al., 2015
	Rooftop cultivation	Air, soil	Reduced contamination risk in rooftop grown vegetables due to height and distance from roads	Vittori Antisari et al., 2015; Liu et al., 2016
	Adoption of hazard indexes	Air, soil, water	Importance of site-specific risk assessment to reduce the risk of contamination	Hough et al., 2004
	Adoption of tree barriers	Air	Vegetated barriers between roads and gardens allowed to reduce contamination	Vittori Antisari et al., 2015
	Identification of past land use	Soil	Contamination is higher in areas that hosted refineries, petrochemical processing, timber and textile processing or mining sites	El Hamiani et al., 2010; Hursthouse and Leitão, 2016
	Background geology	Soil	Heavy metal contamination may also result from paedogenesis (e.g., As, Pb)	Jean-Soro et al., 2014
Genotype	Crop selection	Air, soil, water	Breeding and cultivar/species selection reduce risks posed by heavy metal contamination	Grant et al., 2008; Ghosh et al., 2012; Ding et al., 2013
	Crop genetic engineering	Air, soil, water	Plants can be genetically engineered to increase tolerance to heavy metals	Edelstein and Ben-Hur, 2018
Agricultural practices	Grafting	Soil, water	Herbaceous grafting can enhance tolerance to heavy metals in vegetables	Edelstein and Ben-Hur, 2018
	Bioremediation	Soil	Use of plants with elevate accumulation capacity allow to clean-up target contaminants in soils	Cunningham et al., 1995; Austruy et al., 2014
	Soilless cultivation	Soil	Reduced contamination when soilless system is used as compared to soil	Pennisi et al., 2016, 2017
	Agrochemicals management	Soil	Overuse of fertilizers or pesticides may result in heavy metal contamination	Hursthouse and Leitão, 2016; Pennisi et al., 2016
	Irrigation	Water, soil	Water quality and both its distribution strategy and applied volumes may modify contaminant presence in soil	Hursthouse and Kowalczyk, 2009
Soil amendments	Manure and compost	Soil	Modify heavy metal phyto-availability and their immobilization	Janoš et al., 2010; Pérez-Esteban et al., 2014
	Zeolites	Soil	Allow to remediate plant uptake of heavy metal in highly contaminated soil	Li H. et al., 2009
	Biochar	Soil, water	Can increase soil pH and contribute to immobilization of heavy metals (Cd, Cu, Pb)	Tang et al., 2013; Zhang et al., 2013
	Soil liming material	Soil, water	Allow to increase pH decreasing heavy metal availability	Abd El-Azeem et al., 2013
	Ashes	Soil	Fly ash increase phyto-stabilization of heavy metal-contaminated agricultural lands	Ukwattage et al., 2013
	Mycorrhizae inoculation	Soil, water	May influence heavy metal availability and uptake by plants in the rhizosphere	Edelstein and Ben-Hur, 2018

iv. Particular limitations on Urban Agriculture in developing countries

In developing countries, high-tech UA projects are often deemed unaffordable, and incapable of producing enough food to replace the broadacre cereal crops that provide 63% of global calories (Hunter et al. 2017; Specht et al. 2014). But basic UA already supplies concentrated starches and protein through grains, roots, tubers, nuts, and legumes (Madaleno 2001), so production could be scaled up with government or NGO support, e.g., low-tech vertical farming in Uganda (Capron 2016), or the Philippines (Pascual et al. 2018) (Figure 8 a, b). However, cultural shifts towards urban production and consumption of a greater diversity of food types will require fundamental adjustments in individual food choices and lifestyles, laws, regulations, city policies, and corporate activities (Halweil 2002).

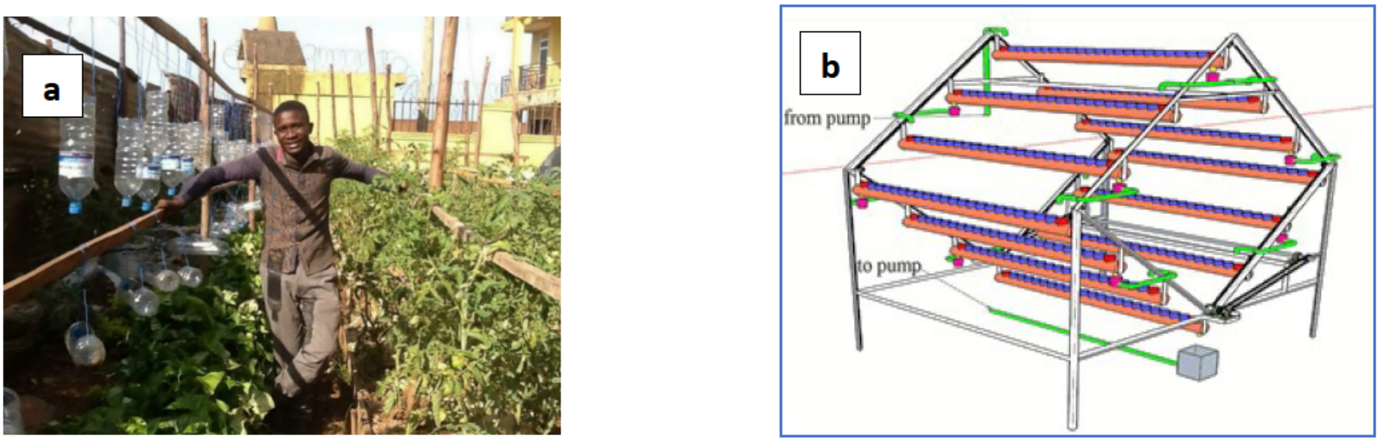

Fig. 8 Examples of cheaper vertical farming techniques for developing countries
a) "Stack farming" in Uganda. Initiated by NGO 'Ideas for Uganda', it uses stacks of wooden crates filled with earthworms to compost waste, in which vegetables are grown using collected rainwater. It requires no fertiliser and uses 75% less land space (Capron 2016).
b) Vertical farming hydroponic system for vegetables in the Philippines. The 9m-high greenhouse has 2.5m long growing troughs, which can be manually rotated. 750 plants can be grown quickly with minimal water and fertiliser, free from pests and adverse weather effects, which are increasing under climate change. However, government loans would be needed for set up (Pascual et al. 2018).

v. Broader issues that limit transformation of the global food system

Urban food production does not need to totally replace rural farming or the globalised food system to mitigate the environmental sustainability crisis. A recent study found vertically-farmed (VF) wheat could be sustainably grown year-round using closed-loop CEA, yielding 220 to 600 times the global yearly average per hectare (Asseng et al. 2020). Although currently uncompetitive with heavily subsidised market prices, VF wheat could stabilise food supplies in times of environmental or political crises, while taking pressure off degraded farmland and halting agricultural expansion. Currently, 87% of global agricultural subsidies (~USD $540 billion a year) incentivize unsustainable agricultural practices and penalize small-scale, diversified production. If current Earth system trends continue, by 2030 global financial support for 'business as usual' agriculture, struggling under climate change, will approach USD $1.8 trillion (FAO, UNDP, and UNEP 2021) - making investment in sustainable UA in all its diverse forms (from home gardening to vertical farms) seem cheap in comparison. One aspect of the environmental sustainability crisis that UA cannot address is the increasing demand for resource-intensive meat and dairy products. This highlights the importance of consumer education/awareness and the responsibilities of food retailers to provide diverse food options in shaping sustainable consumption. In the future, some innovative city-grown protein foods such as insects or seaweed may offer sustainable alternatives (Specht et al. 2019).

3. Conclusion

This paper has clearly shown that urban agriculture is capable of producing large quantities of food with minimal use of land, water, resources, and energy - to create a more efficient and circular local food economy. The diversity of forms and methods of UA, with its large variety of possible food species, allows for adaption to climate change and resilience in the face of crises, such as external supply chain disruptions. There are many social, economic and environmental benefits of UA within the city, plus ex situ benefits of reducing pressure on degraded farmland and resources, halting agricultural deforestation, and mitigating global climate change. However, many barriers exist - especially the overarching dominance of the corporate global food system, limited access to urban space, conflicting land-use priorities, restrictive laws, regulations and policies, and widespread cultural dependence on globalised supermarket food items.

For urban agriculture to be scaled up enough to address the environmentally sustainability crisis of the food system, it needs to be taken seriously as a food production strategy and organised and regulated accordingly to ensure food safety. Additional strategies would include government support - financial, technical, educational, and organisational - at national, state, and local level for both commercial and non-commercial urban farmers, strengthened alternative food networks, and flexibility within the existing food system to incorporate city-grown food. For example, in Australian cities, a community urban farming system could be set up where residential property owners with unutilised garden space could register to share their growing space. The soil would be tested, and trained gardeners would then utilise the residential land for growing fruit and vegetables, with the residents receiving a share of fresh produce, and the excess produce sold or given to the local community to enhance food security and equity. This system would have the potential to be run as an education and employment training scheme, or to provide part-time voluntary work for retired people to build community and improve health and social wellbeing of local residents. The benefits of a localised food system are far reaching, and by finding a balance between urban and conventional farming, global food production can become sustainable not just in terms of yield, but also in preserving a liveable Earth for future generations.

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