agriculture

MDPI

Review

Unleashing the Potential of Urban Agroecology to Reach Biodiversity Conservation, Food Security and Climate Resilience

Miguel A. Altieri [1,*], Angel Salazar-Rojas [2,3], Clara I. Nicholls [4] and Andrea Giacomelli [5]

[1] Department of Environmental Science, Policy and Management, University of California, Berkeley, CA 94720, USA
[2] Facultad de Ciencias Agrarias y Forestales, Universidad Católica del Maule, Curicó 7820436, Chile; adsalazar@ucm.cl
[3] Programa Doctorado Medio Ambiente y Sociedad, Universidad Pablo de Olavide, 41013 Seville, Spain
[4] Global Studies, University of California, Berkeley, CA 94720, USA; nicholls@berkeley.edu
[5] Department of Earth and Environmental Sciences, University of Pavia, 27100 Pavia, Italy; andrea.giacomelli02@universitadipavia.it
* Correspondence: agroeco3@berkeley.edu

Abstract: Urban agriculture is considered by many scientists and policymakers as a key strategy to build climate change-resilient communities within cities by strengthening food systems, with positive food security, biodiversity, nutrition and health outcomes. The estimated potential of urban agriculture to provide between 15 and 20% of the global food supply can be enhanced by applying agroecological principles and practices that revitalize urban agriculture cropping systems, thus leading to the design of highly diversified, productive and resilient urban farms on a planet in polycrisis. Two pillars are used in agroecology: (a) restoring spatial and temporal crop combinations that deter pests by enhancing biological control with natural enemies, and (b) increasing soil organic matter through green manures, compost and other organic practices that enhance soil fertility and beneficial microorganisms. In addition to technical and environmental obstacles, there are a series of social, economic and political barriers that limit the scaling-up of urban agriculture. For this reason, it is important to launch policies that establish mechanisms for cities to provide incentives for urban agriculture, including access to land, water, seeds and technical knowledge. The creation of producer–consumer networks around markets with solidarity is critical for local equitable food provision and consumption.

Keywords: agroecology; urban agriculture; climate change; ecosystems services; biodiversity

check for updates

Academic Editors: Moritz von Cossel, Rocío A. Díaz-Chavez and Bastian Winkler

Received: 1 March 2025
Revised: 9 April 2025
Accepted: 16 April 2025
Published: 22 April 2025

Citation: Altieri, M.A.; Salazar-Rojas, A.; Nicholls, C.I.; Giacomelli, A. Unleashing the Potential of Urban Agroecology to Reach Biodiversity Conservation, Food Security and Climate Resilience. *Agriculture* **2025**, *15*, 909. https://doi.org/10.3390/agriculture15090909

Copyright: © 2025 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

It is estimated that by the year 2030, 60% of the world population will live in urban areas, with the number of megacities (>10 million people) increasing from 34 in 2015 to 41. Each city of this size must import around 6000 tons of food per day, which requires enormous amounts of energy and involves the emission of millions of tons of greenhouse gases in traveling 1000 to 1500 km journey to reach the destination [1]. Increasingly, these cities will be vulnerable to significant rises in food prices, and even to food shortages, if failures in industrial agriculture linked to climate change, rising energy costs, armed conflicts, and/or pandemics are aggravated.

By disrupting food systems worldwide, the COVID-19 pandemic affected the food security and nutrition of millions of people, mostly in urban areas, testing the resilience of the global food provisioning system. In addition, food prices peaked worldwide and demand for fresh produce declined, while the consumption of highly processed products

increased, aggravating the incidence of diabetes, obesity, heart disease, and other illnesses related to poor diet, particularly among low-income urban dwellers. Clearly, the pandemic revealed the vulnerability of the food system, highlighting the need to develop more sustainable, equitable and resilient food systems [2]. There is increasing consensus about urban agriculture's potential contribution in improving food security by enhancing crop production and local availability through the sustainable use of plant, soil and water resources and the conservation and regeneration of biodiversity in urban landscapes [3]. There is a great heterogeneity in urban agricultural systems, with practices ranging from high-tech commercial farming to small urban gardens managed conventionally, as well as organically, and some following agroecological practices.

Several studies show that various forms of urban gardens, backyard orchards and market farms featuring fresh vegetables and fruits, and at times animal products, can improve local food security and the nutrition of local consumers [4]. In many cases, however, and for various reasons (lack of technical knowledge, soil limitations, pest and/or climatic stresses, small size of lots, etc.), crop yields are usually low in urban farms, limiting their potential to improve local diets and reduce household food expenditures among marginalized people. In such cases, the improvement of urban cropping systems with practices that make best use of water, seeds, organic waste, etc., is a key strategy [5]. In this regard, the novelty of this paper lies in describing agroecological principles and practices necessary to design biodiverse, productive and resilient urban farms in times of climate change and other challenges. As emphasized herein, the conversion of urban farms to agroecology requires the adoption of two pillars: (a) spatial and temporal crop combinations and (b) the enhancement of soil organic matter and biological activity [6].

2. Urban Agriculture: Dimension and Significance

Urban agriculture (UA), which involves more than 800 million people, is an important but invisible dimension of the global food system. In 2014, it was estimated that globally about 456 million hectares of land were cultivated within a 20 km perimeter of cities [7]. Worldwide, urban food production has doubled in the last 15 years, contributing between 15 and 20% of global food production, with a greater contribution in low- and middle-income countries. Between 1950 and 2005, urban agriculture has expanded in developing countries at an annual rate of 3.6% [8], and in the United States it has spread by more than 30% in the past 30 years. In the period 2007–2011, about 8500 urban farms and gardens were identified in 38 US cities.

The percentage of families engaged in UA ranges from 10% in cities in North America to 80% in smaller cities in Asia. It can be safely affirmed that worldwide, urban food production has doubled in about 15 years [9].

Some studies estimate that urban agriculture could contribute up to 15 and 20% of the global food supply, while others estimate that UA could feed around 30% of the global urban population. Other researchers claim that UA could generate USD 80–160 billion annually in produce, while providing a series of ecological services such as nitrogen fixation, pollination, soil formation, and the biological control of pests, as well as energy savings and climate regulation [10].

Researchers estimate that if one-third of the world's urban areas were devoted to growing crops, the vegetable demand of the entire global urban population could be met, but data are lacking to evaluate the level of food self-sufficiency that could be reached with UA in each city. A recent survey reports that there is not sufficient land available in 51 countries in order to produce food to meet the nutritional target of 300 g per person per day of fresh vegetables. It is estimated that urban agriculture would require 30% of the total urban area of these countries to meet national vegetable demand. In most cities,

access to land and urban sprawl hinder the availability of the land needed for the required food production [11].

Despite these obstacles, several studies suggest that urban agriculture helps cities achieve a certain level of food self-sufficiency. In Cleveland, researchers estimate that UA has the potential to meet 100% of the honey and fresh vegetable demand and 50% of the poultry and egg needs of the entire population of 400,000 people [12]. Data from urban areas around the world indicate that a significant portion of the local consumption of vegetable and animal products is produced within cities. Studies have reported that UA provides 90% of leafy vegetables in Dar es Salaam, Tanzania. In Dakar, Senegal, UA provides 60% of the vegetables and 65% of the poultry products consumed nationally. In Hanoi, Vietnam, 80% of fresh vegetables, 50% of pork, poultry and fresh-water fish, as well as 40% of eggs, come from urban and peri-urban areas. Shanghai's urban and peri-urban area produces 60% of the vegetables, 50% of the poultry meat, and most of the milk and eggs consumed in the city [8].

3. The Vital Role of Urban Agriculture in Times of Crisis

UA has proven crucial in times of crisis. US households produced enough to meet 40% of the nation's demand for fresh vegetables from "Victory Gardens" during World War II. At that time, there was significant government support helping community gardens to produce food, as most rural men were in the battlefields [13].

After the collapse of the Soviet bloc, in Havana, Cuba, during the so-called "Periodo Especial", more than 26,000 vegetable gardens were deployed in more than 2500 hectares, producing 25,000 tons of food per year, about 50% of the island's fresh produce. Until the 2020s, 300,000 farms and urban gardens were producing 40,000 tons of meat, 7000 L of goat milk and 216 million eggs. UA generated around 300 thousand jobs, 22% occupied by women and 26% by young people [14].

In Rosario, Argentina, during the country's economic crisis in 2002, more than 800 community gardens proliferated in the city, feeding some 40,000 people. Today, urban horticulture is still practiced on 24 hectares where more than 600 gardeners grow vegetables for market and home consumption [15]. As a result of the 2010 crisis, Portugal experienced an exponential increase in urban agriculture, which in Coimbra was considered a key tool to increase food security and promote social integration [16]. Other cases of the proliferation of urban agriculture were reported in post-Katrina New Orleans and in Sarajevo, Bosnia and Herzegovina, two years after the start of the blockade in 1992.

The lack of food supply during the COVID-19 pandemic revealed the vulnerability to food and nutrition insecurity in many cities. Peri-urban and urban farms within cities played a crucial role in the provisioning of fresh vegetables through the development of new producer–consumer linkages, innovative food delivery systems and short-chain commercialization circuits. These urban and peri-urban farms exhibited high production flexibility, allowing them to operate independently from international markets, thus enhancing the food resilience of many cities in the face of COVID-19 [17].

The above examples comprise key lessons for securing local food provisioning in a world facing multiple crises, where citizens are increasingly challenged by price fluctuations and food shortages exacerbated by climate change, rising energy costs, conflicts and pandemics.

4. Environmental and Social Benefits of Urban Agriculture

Producing food through urban agriculture has many positive impacts, such as reducing negative environmental impacts, greening the urban landscape and recycling organic materials [18]. One obvious mitigation effect of UA is that by avoiding the long distance

transportation of food, CO_2 emissions are reduced. Some urban farm and garden designs can create special microclimatic conditions, reducing the urban heat island effect. Local food production and consumption can reduce greenhouse gas emissions and increase rates of carbon sequestration [19]. Based on estimates that urban farms and gardens exhibit a CO_2 sequestration average of about 0.76 kg cm^{-2} [20], researchers calculated that in the cities of Padua and Venice, Italy, an area 774,493 m^2 devoted to UA sequestered an estimated 588,614.9 kg CO_2 year [21].

Urban agriculture is also increasingly being recognized as a form of land use that improves the urban green infrastructure, restoring natural cycles disrupted by urban sprawl and offering water re-utilization solutions, while reducing the impact of storm water runoff and reducing urban flooding associated with extreme hydrological events. In addition, well-planned urban agricultural systems can reduce soil erosion and groundwater contamination [22].

Many studies show that urban farms can strengthen social cohesion, as UA initiatives stimulate community participation and connect people to nature and their food. Farming in low-income neighborhoods can create opportunities to engage in the sustainable production of healthy food, in an equitable manner and respectfully of local culture. Many gardens have become learning platforms that raise community awareness of the importance of accessible locally grown food, as a path to healthy eating habits [23]. The multiple environmental and socio-economic benefits of urban farms managed with agroecological practices are depicted in Figure 1.

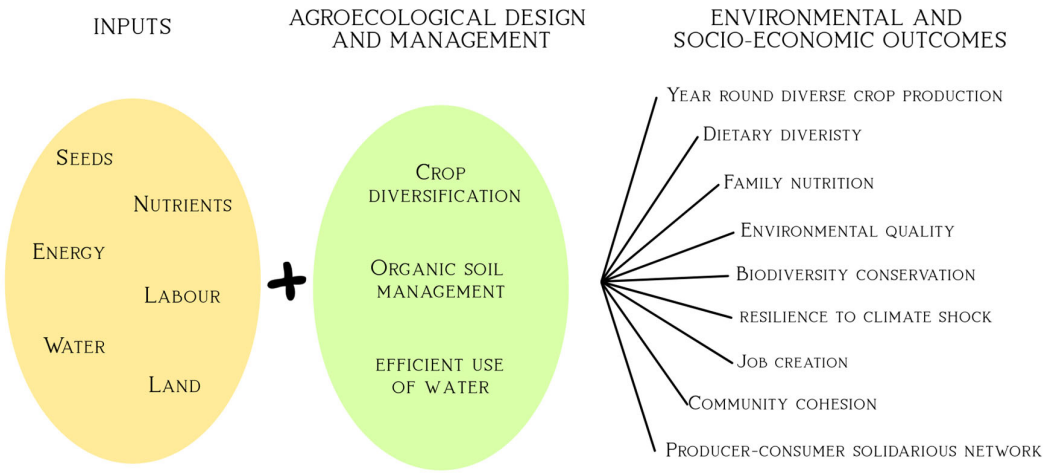


Figure 1. The multiple environmental and socio-economic benefits of urban farms managed and designed following agroecological principles.

5. Urban Agriculture, Biodiversity and Ecosystem Services

Urban agriculture provides multiple ecosystem services globally, estimated at USD 33 billion annually. These services include food production (from 100 to 180 million tons), energy savings (about 15 billion kilowatt hours), the retention of up to 170,000 tons of nitrogen that does not leach into groundwater, and the prevention of stormwater runoff, preventing the yearly loss of 45 to 57 billion cubic meters of water [24].

An essential ecosystem service of UA is the conservation and promotion of biodiversity in cities. By providing habitat, food and shelter, urban green spaces enhance the preservation of bird and butterfly species. UA plots exhibiting a rich plant variety attract and harbor soil biota, insects, birds, reptiles, and other animals, therefore rapidly becoming important refuges for native biodiversity [25].

Several studies show increased biodiversity in lots with diversified gardens compared to urban vacant lots. Urban farms with a high percentage of surrounding green spaces (a rich landscape matrix) can offset the negative impacts of impervious surfaces on insect and bird abundance and diversity. In cities experiencing a dry season, when green vegetation, flowers, prey resources, or water are unavailable in the surrounding landscape, UA spaces act as a refuge for several beneficial insect species. It is not uncommon to find more than 40 plant species in a 200–400 m^2 garden, where local vegetables (cabbage, tomatoes, peppers, lettuce, eggplants, etc.) coexist with a variety of medicinal, culinary, ornamental and some native species blooming throughout the year. Such diverse plant assemblages support a rich entomofauna. In particular, the abundance of flowering plants provides a season-long nectar supply, which in turn supports a higher diversity and abundance of pollinating insects (bees, bumblebees, wasps, and butterflies) as well as predators and parasitoids of insect pests [26].

Despite their ecological benefits, UA systems can be negatively affected by environmental factors such as soil contamination, atmospheric pollutants and water pollution sources [27]. Studies conducted in various US cities found high soil lead (Pb) concentrations (>400 mg kg^{-1}), potentially threatening the quality of vegetables for human consumption. However, some researchers claim that food coming from urban agriculture will unlikely increase the levels of blood Pb in humans. Soil organic management reduces the bioavailability of soil Pb, and the uptake of Pb by most crops is usually low [28].

6. Productive Potential of Urban Agriculture

The extent to which urban gardens can impact food security in a city depends necessarily on the amount and variety of produce grown. Garden yields vary according to soil quality, crop species and varieties grown, weather conditions, the availability of water and organic amendments, and farmers' skills. Despite variability in such factors, researchers have observed that some urban farmers can obtain from small plots reasonable yield levels. It is not uncommon to observe that a 10 by 10 m plot can produce enough to supply 50% of the yearly vegetable needs of a family, furnishing significant amounts of vitamins A, B and C, and iron [29].

Assessments of the productivity of urban farms in various US cities have revealed interesting trends. For example, 226 community gardens and orchards on lots in Philadelphia produced approximately 907,000 kg of vegetables and herbs worth USD 4.9 million. Added Value Farm, which occupies about an acre in Brooklyn, funnels 20,000 kg of fruits and vegetables to Red Hook, a low-income neighborhood. Camden, New Jersey, harvested almost 14,000 kg of vegetables from 44 community gardeners, enough to feed 508 people three vegetable servings a day for 4–6 months. In 2014, Detroit had an urban farming community comprising about 1300 gardens and producing about 181,000 kg of vegetables [12].

A large review of UA-related articles revealed that total harvest expressed as yields varied widely, with a mean of 16 kg/m^2 of fresh weight. Vertical indoor farms exhibited the largest yields, but their energy demands and water use were extremely high. Roof top gardens in Veneto, Italy exhibited an average production value of 5.73 kg m^2 year, while Bologna averaged vegetable yields of 15.2 kg m^2 year [23].

In open-air, soil-based systems, the highest average yields were found for herbs, followed by leafy greens, and tomatoes. Roots and tubers and vegetables exhibited the next highest yields, with fruits, grains, and legumes exhibiting the lowest yields [30].

Few studies have compared the crop yields of conventional versus agroecological farms. In Cleaveland, Ohio, research conducted in 10 m^2 plots with a growing season of 130 days indicated that conventionally managed UA exhibited low yields (1.20–1.35 kg/m^2 per year), and implied higher land requirements than agroecologically

based UA, which achieved yield levels on average of 6.20 kg/m^2 per year, with lower land requirements [11]. In Cuba, agroecological urban farms achieved an average yield of 15–20 kg/m^2 per year, while in Central Chile, 11 m^2 urban agroecological gardens containing 15 intercropped plant species produced a total of 177.4 kg per year, or 16 kg/m^2 per year [31].

In the city of Queretaro, Mexico, highly diverse urban gardens (about 86 plant species and varieties) achieved yields between 5 to 7.5 kg/m^2. Gardens with an area of approximately 200 m^2 with high levels of agrobiodiversity reached the highest productivity values. The evaluated urban gardens covered a total of 6984 m^2, producing approximately 36,000 kg of edible biomass per season. Authors of the study estimated that this production was equivalent to the nutritional intake of 6050 kg of proteins, 161,487.19 Kcal of energy, 957.41 kg of carbohydrates and 5428.382 kg of fats [32]. There are few studies available that compare productivity levels of conventional urban farms (vertical and greenhouse farming, hydroponics, rooftops, etc.) and agroecologically managed UA farms. This is corroborated by a bibliometric study examining 376 agroecology related publications published between 1981 and 2024 [33]. Nevertheless, based on a set of existing solid studies, it is possible to suggest certain differences, as illustrated by the qualitative trends described in Table 1. The suggested trends indicate that in addition to yields, conventional and agroecological UA systems exhibit differences in several agronomic and ecological features, highlighting the advantages of agroecological UA systems in terms of crop and nutritional diversity, water use, the recycling of waste, resilience, and lower dependence on external inputs.

Table 1. Comparison of various agronomic and ecological features of agroecological and conventional-based UA (urban agriculture) systems (derived from data contained in [12] and references cited therein). L = low, L–M = low–medium, M = medium, M–H = medium–high, H = high (qualitative values assigned to each feature are based on information derived from references [4,6,7,11,12,14,23].

Features	Agroecological UA System	Conventional UA System
Crop diversity	H	L
Soil organic matter	M–H	L
Chemical inputs	L	M–H
Water use	L–M	M–H
Flower diversity	H	L
Pollinator presence	M–H	L
Natural enemy abundance	M–H	L
Use of local resources	M–H	L–M
Labor demand	M–H	L–M
Total edible biomass output	M–H	M–H
Nutritional quality (vitamins, minerals, etc.)	M–H	M
Resilience to stress	M–H	L–M

7. Agroecological Pillars for the Design of Urban Farms

Agroecological principles have evolved in the last decade to include social, cultural, economic and political dimensions of food systems, in addition to those related to agricultural practice at the farm level [34]. These same principles can be applied to the design of diversified urban farms with the purpose of increasing soil fertility and enhancing biological pest control without the need for external inputs, but that are also socially and

economically viable [35]. In diversified urban farming systems, the health and production of crop plants is a consequence of mutualistic above- and below-ground relationships between plants, insects, and soil microbial communities. Exploiting the synergies between greater plant diversity and enhanced microbial activity generates conditions for the establishment of a diverse and active beneficial arthropod and microbial community above and below ground, which is essential for provisioning insect pest, weed and disease regulation, as well as soil fertility [36].

From a practical standpoint, the approach involves two pillars: (a) restoring spatial and temporal crop combinations that deter pests by enhancing biological control with natural enemies, and (b) increasing soil fertility and biological activity via the addition of organic matter through green manures, compost and other organic practices [6]. As indicated in Figure 2, the integration of agroecological practices constitutes a proven approach for enhancing soil quality, plant health, and crop productivity in urban farms, based on the interactions between soils, crops and beneficial biota, without depending on external resources or inputs.

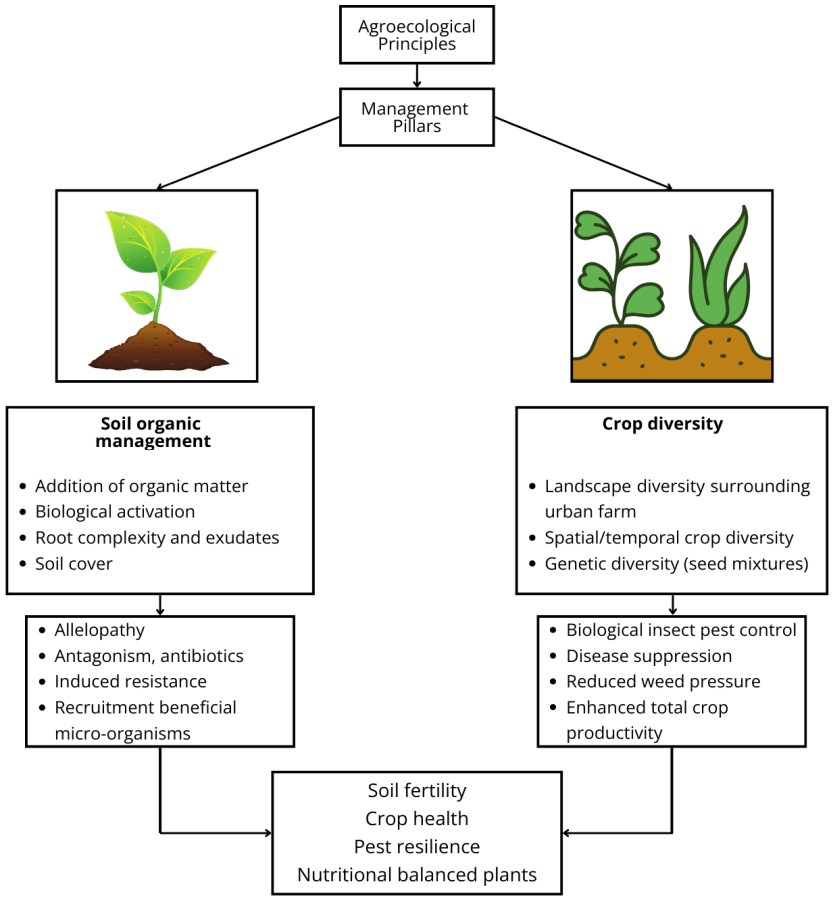


Figure 2. Agroecological pillars for the design and management of diversified and resilient urban farms (agroecological principles described in references [6,34,36].

7.1. Crop Diversification

Agroecology promotes the diversification of urban farms via crop rotations and intercropping arrangements that may include fruit trees and/or small animals. In general, mixtures of annual crops favor arthropods and microorganisms involved in improved nutrient cycling, soil fertility, and pest regulation. Intercropping systems involving legumes improve soil organic matter input, biological soil activity, and water retention capacity. Crop diversity also bolsters the resilience of farms to climatic variability [37].

Good crop combinations include plants that use soil, water and sunlight more efficiently by including crops with different root systems and different foliage architectures, leading to increased productivity due to facilitation and synergistic processes [38]. The diversification of urban farms can create habitats for generalist predators, often leading to reductions in pest abundance and crop damage [39]. Many hymenoptera wasps are parasitoids of several lepidopteran pests, and their diversity and abundance is increased in intercropping systems that include floral resources [40].

The overall productivity of intercrops is measured using the Land Equivalent Ratio (LER), which captures how efficiently crop mixtures use nutrients, water and sunlight resources compared to monocultures. When the LER value is higher than 1, polycultures over-yield. An LER of 1.3 means that a monoculture requires 1.3 ha of land to obtain the same yield as 1 ha of polyculture. Several UA experiments have reported LER values > 1.3 from combinations of various vegetable crops [6].

Temporal diversification involves rotations of different crop species (legumes, root crops, fruit crops, and leaf crops) on the same land during various seasons. Rotations can improve soil fertility, break the life cycles of soil-dwelling insect pests and soilborne pathogens, and increase yields. It is important to alternate legumes and cereals, avoid planting crops of the same family year after year, and follow crops with deep roots with crops of shallow roots. Including legumes in crop rotations reduces the need for external nitrogen inputs as legume species fix N, which can then be utilized by subsequent crops [41].

7.2. Organic Soil Management

Agroecological practices such as green manuring and compost applications enhance SOM, maintain soil cover, enhance soil available water, lower compaction, permit nutrient availability, and promote microorganisms that produce growth-promoting substances [42]. Such practices can lead to disease control caused by soilborne pathogens by enhancing antagonists that produce antibiotics, or elevating antagonism and other mechanisms responsible for disease suppression by antagonistic microbes [43].

In more dry or arid environments, adding soil organic matter enhances the soil's moisture-holding capacity, leading to higher available water for plants. Increasing SOM by 1% can enable soil to store 1.5 L of water per square meter [44]. SOM-rich soils usually harbor arbuscular mycorrhizal (VAM) fungi, which biologically extend crop root systems, increasing their water use efficiency [45]. Mulching helps to conserve soil moisture by reducing evaporation, allowing more moisture accessibility near the plant roots, extending crops' time available to absorb water [46].

Many urban farmers do not have access to animal manure to make compost or apply directly to the soil, which can lead to a shortage of available N and may greatly reduce crop yields. Some cities do not allow animal-raising, further limiting nutrient availability. In such cases, leguminous green manures can serve as a viable alternative to increase N supply for crops. Depending on the legume species, a green manure incorporated into the soil can add between 112 and 224 kg N/ha, part of it available for the next crop. Yields of most vegetable crops are dependent on N inputs and are sensitive to C/N ratios of green manure biomass higher than 20:1, as this may lead to N "hunger". One important aspect to consider is to avoid overfertilization with compost and manure inputs beyond the mean crop N, P and K demands, because nutrient surpluses can lead to the contamination of water supplies, as well as reducing soil quality [47].

8. Overcoming Barriers to Scale Up Urban Agriculture

The biggest challenge to scaling UA is access to land. More than 79% of the state's urban farmers in California do not own the land where they farm. In cities such as Oakland,

California, it is estimated that there are more than 500 hectares of abandoned public land that could be used for community gardens, but for various reasons most of this land is not available for farming [48]. One solution for cities with similar problems would be to establish mechanisms for people to use vacant and unused public land through low-cost multi-year leases. In the city of Rosario, Argentina, about 1800 residents practice horticulture on private land, whose owners receive tax exemptions for allowing people to use it for urban agriculture [16].

Achieving high levels of production, such as those achieved in Cuba in urban gardens, is not immediately feasible for all urban farmers in other parts of the world. The majority of urban farmers lack knowledge and practical skills related to organic horticulture, so municipal agricultural services, local universities or NGOs would have to provide agroecological training modules and information to urban farmers on organic farming practices, and how to secure access to seeds and water, while supporting the creation of decentralized composting facilities and/or bio factories. It will also be necessary to promote participatory research processes to find environmentally sound solutions to soil, pest and other problems faced by urban horticulturists.

Overall, most obstacles to scaling up urban agriculture are political, not technical. It is important to create and implement policies that establish mechanisms for cities to provide incentives for urban agriculture, including access to land, water, seeds and knowledge. Switching subsidies from agrochemical inputs to composting activities, and the promotion of natural fertilizers and biopesticides, are important steps. Like in Cuba, local governments could provide a small parcel of land (200 m^2 or more) to people interested in engaging in UA. One condition could be, for example, that between 10% and 20% of the harvest is donated to schools, hospitals, or senior centers, while the rest can be sold in solidarity markets that allow gardeners to directly market their products to the public at accessible prices.

Most cities have been unable to address food security issues, as many problems associated with local food systems are determined by economic policies at the national and international level. Municipal governments, local universities, non-governmental and community organizations could form coalitions aimed at strengthening local food systems, establishing policies to ensure access to land and water, as well creating agroecological training programs to enhance the technical capacities of farmers. An important step is to increase public awareness on how urban agriculture can benefit modern cities, in order for consumers to organize and support local urban farmers and their markets. The creation of producer–consumer networks around solidarity-based markets is critical to ensure equitable local food provisioning and consumption [49].

Rapid urban growth and development pose serious challenges to the permanence and expansion of urban agriculture, particularly in cities experiencing scarcity and the fragmentation of urban agricultural land, increased competition for water, and changing food demands. In such cases, urban farmers may concentrate their operations in areas unfit for urban development but with access to water, or expand UA to the city outskirts [50]. The results from studies analyzing the current state of urban agriculture in Dar es Salaam and Copenhagen provide some helpful guidelines for scaling up UA, as they suggest that municipal recognition and institutional support for urban agriculture is key for ensuring the sustainability of UA initiatives, by facilitating bottom-up grassroots involvement and multi-stakeholder processes, the promotion of conducive policies, etc. The role of Municipalities in supporting the conservation and allocation of land is crucial to ensure project permanence and multifuncionality [51].

9. Conclusions

Research shows that urban agricultural systems under different biophysical and socio-economic conditions exhibit a wide range of outcomes for crop yields, biodiversity conservation, water use, and climate change adaptation. The IPPC in its 2023 report suggests with high confidence that enhancing green infrastructure in cities, including UA systems, can substantially contribute to emission reductions by supporting carbon storage and uptake [52]. This is particularly applicable to the more diverse and resilient forms of UA managed under agroecological principles, which in addition appear to deliver more ecological, production and nutritional services than conventional UA systems.

Researchers are increasingly recognizing the potential of urban agriculture to improve urban food security, particularly in a time of inflation, climate change, pandemics, and intensifying social disparities in the food system. Across cities, a major motivation to embrace UA is to address the food insecurity of underserved populations, but additionally it can support other nutritional assistance programs such as school lunch programs, local food banks, etc. Highly diverse urban gardens can use scarce land efficiently and may offer additional economic and environmental gains. For these and other reasons, it is likely that many more people would take up urban farming to put food on their tables, particularly if they were to be supported with knowledge, tools, and access to land, seeds, water and technical support.

A crucial factor to unleash the potential of urban agriculture to ensure adequate access to food and nutrition is to enhance the total productivity levels of urban cropping systems. Agroecology provides the principles to tailor a site-specific strategy to manage agrobiodiversity via crop diversification and soil organic matter additions to reduce dependence on agrochemicals while sustaining productivity and providing resilience to climate change and other stresses. The goal is to enhance food provisioning through agroecological practices aimed at enhancing total food output, but at the same time increasing several ecosystem services including pollination, natural pest control, soil fertility, rainwater capture and organic waste recycling. Making the practice of urban agroecology available to a critical mass of citizens engaged in growing healthy food will require the establishment of supportive policies to ensure access to land, seeds, water, etc., as well as urban agroecological research and extension programs. Policies directed at reducing land tax for UA, or which allocate vacant lands for urban agriculture, protecting them from more profitable development, are key to ensuring UA sustainability.

Producer–consumer networks can expand the provision and consumption of locally produced food, but at the same time scale up the multiple benefits of urban farming beyond the production of food, including social benefits and community values, such as the maintenance of biodiversity, cultural heritage and community cohesion.

Author Contributions: Conceptualization, M.A.A. and C.I.N.; methodology, C.I.N.; software, A.S.-R. and A.G.; validation, C.I.N., A.S.-R. and A.G.; formal analysis, M.A.A. and C.I.N.; investigation, M.A.A., C.I.N., A.S.-R. and A.G.; resources, A.S.-R.; data curation, A.S.-R.; writing—original draft preparation, M.A.A.; writing—review and editing, C.I.N., A.S.-R. and A.G.; visualization, M.A.A.; supervision, M.A.A.; project administration, M.A.A.; funding acquisition, M.A.A. and C.I.N. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Data Availability Statement: Data are available in a publicly accessible repository.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Deelstra, T.; Girardet, H. Urban agriculture and sustainable cities. In *Growing Cities, Growing Food. Urban Agriculture on the Policy Agenda*, 1st ed.; Bakker, N., Dubbeling, M., Gündel, S., Sabel-Koshella, U., de Zeeuw, H., Eds.; Zentralstelle für Ernährung und Landwirtschaft (ZEL): Feldafing, Germany, 2000; pp. 43–66.
2. Altieri, M.A.; Nicholls, C.I. Agroecology and the reconstruction of a post-COVID-19 agriculture. *J. Peasant Stud.* **2020**, *47*, 881–898. [CrossRef]
3. Langemeyer, J.; Madrid-Lopez, C.; Beltran, A.M.; Mendez, G.V. Urban agriculture—A necessary pathway towards urban resilience and global sustainability? *Landsc. Urban Plan.* **2021**, *210*, 104055. [CrossRef]
4. Hamilton, A.J.; Burry, K.; Mok, H.F.; Barker, S.F.; Grove, J.R.; Williamson, V.G. Give peas a chance? Urban agriculture in developing countries. A review. *Agron. Sustain. Dev.* **2014**, *34*, 45–73. [CrossRef]
5. Herrmann, D.L.; Chuang, W.C.; Schwarz, K.; Bowles, T.M.; Garmestani, A.S.; Shuster, W.D.; Allen, C.R. Agroecology for the shrinking city. *Sustainability* **2018**, *10*, 675. [CrossRef] [PubMed]
6. Altieri, M.A.; Nicholls, C.I. Urban agroecology: Designing biodiverse, productive and resilient city farms. *Agro Sur* **2018**, *46*, 49–60. [CrossRef]
7. Thebo, A.L.; Drechsel, P.; Lambin, E.F. Global assessment of urban and peri-urban agriculture: Irrigated and rainfed croplands. *Environ. Res. Lett.* **2014**, *9*, 114002. [CrossRef]
8. Orsini, F.; Kahane, R.; Nono-Womdim, R.; Gianquinto, G. Urban agriculture in the developing world: A review. *Agron. Sustain. Dev.* **2013**, *33*, 695–720. [CrossRef]
9. Lovell, S.T. Multifunctional urban agriculture for sustainable land use planning in the United States. *Sustainability* **2010**, *2*, 2499–2522. [CrossRef]
10. Ferreira, A.J.D.; Guilherme, R.I.M.M.; Ferreira, C.S.S. Urban agriculture, a tool towards more resilient urban communities? *Curr. Opin. Environ. Sci. Health* **2018**, *5*, 93–97. [CrossRef]
11. Martellozzo, F.; Landry, J.S.; Plouffe, D.; Seufert, V.; Rowhani, P.; Ramankutty, N. Urban agriculture: A global analysis of the space constraint to meet urban vegetable demand. *Environ. Res. Lett.* **2014**, *9*, 064025. [CrossRef]
12. Grewal, S.S.; Grewal, P.S. Can cities become self-reliant in food? *Cities* **2011**, *29*, 1–11. [CrossRef]
13. Herrmann, M.M. The modern day "victory garden". *Procedia Eng.* **2015**, *118*, 647–653. [CrossRef]
14. Koont, S. A Cuban success story: Urban agriculture. *Rev. Radic. Political Econ.* **2008**, *40*, 285–291. [CrossRef]
15. Ferreira, A.J.; Pardal, J.; Malta, M.; Ferreira, C.S.; Soares, D.D.; Vilhena, J. Improving urban ecosystems resilience at a city level the Coimbra case study. *Energy Procedia* **2013**, *40*, 6–14. [CrossRef]
16. Dubbeling, M.; Bracalenti, L.; Lagorio, L. Participatory design of public spaces for urban agriculture, Rosario, Argentina. *Open House Int.* **2009**, *34*, 36–49. [CrossRef]
17. Tittonell, P.; Fernandez, M.; El Mujtar, V.E.; Preiss, P.V.; Sarapura, S.; Laborda, L.; Cardoso, I.M. Emerging responses to the COVID-19 crisis from family farming and the agroecology movement in Latin America—A rediscovery of food, farmers and collective action. *Agric. Syst.* **2021**, *190*, 103098. [CrossRef]
18. Hallett, S.; Hoagland, L.; Toner, E. Urban agriculture: Environmental, economic, and social perspectives. *Hortic. Rev.* **2016**, *44*, 65–120. [CrossRef]
19. Lwasa, S.; Mugagga, F.; Wahab, B.; Simon, D.; Connors, J.P.; Griffith, C. A meta-analysis of urban and peri-urban agriculture and forestry in mediating climate change. *Curr. Opin. Environ. Sustain.* **2015**, *13*, 68–73. [CrossRef]
20. Davies, Z.G.; Edmondson, J.L.; Heinemeyer, A.; Leake, J.R.; Gaston, K.J. Mapping an urban ecosystem service: Quantifying above-ground carbon storage at a city-wide scale. *J. Appl. Ecol.* **2011**, *48*, 1125–1134. [CrossRef]
21. Lucertini, G.; Di Giustino, G. Urban and peri-urban agriculture as a tool for food security and climate change mitigation and adaptation: The case of mestre. *Sustainability* **2011**, *13*, 5999. [CrossRef]
22. Mancebo, F. Gardening the city: Addressing sustainability and adapting to global warming through urban agriculture. *Environments* **2018**, *5*, 38. [CrossRef]
23. Nogeire-McRae, T.; Ryan, E.P.; Jablonski, B.B.; Carolan, M.; Arathi, H.S.; Brown, C.S.; Saki, H.H.; McKeen, S.; Lapansky, E.; Schipanski, M.E. The role of urban agriculture in a secure, healthy, and sustainable food system. *BioScience* **2018**, *68*, 748–759. [CrossRef]
24. Aerts, R.; Dewaelheyns, V.; Achten, W.M. Potential ecosystem services of urban agriculture: A review. *PeerJ* **2016**, *4*, e2286v1. [CrossRef]
25. Clucas, B.; Parker, I.D.; Feldpausch-Parker, A.M. A systematic review of the relationship between urban agriculture and biodiversity. *Urban Ecosyst.* **2018**, *21*, 635–643. [CrossRef]
26. Bennett, A.B.; Gratton, C. Local and landscape scale variables impact parasitoid assemblages across an urbanization gradient. *Landsc. Urban Plan.* **2012**, *104*, 26–33. [CrossRef]
27. Wortman, S.E.; Lovell, S.T. Environmental challenges threatening the growth of urban agriculture in the United States. *J. Environ. Qual.* **2013**, *42*, 1283–1294. [CrossRef]

28. Brown, S.L.; Chaney, R.L.; Hettiarachchi, G.M. Lead in urban soils: A real or perceived concern for urban agriculture? *J. Environ. Qual.* **2016**, *45*, 26–36. [CrossRef]
29. Brown, K.H.; Jameton, A.L. Public health implications of urban agriculture. *J. Public Health Policy* **2000**, *21*, 20–39. [CrossRef]
30. Dorr, E.; Goldstein, B.; Horvath, A.; Aubry, C.; Gabrielle, B. Environmental impacts and resource use of urban agriculture: A systematic review and meta-analysis. *Environ. Res. Lett.* **2021**, *16*, 093002. [CrossRef]
31. De Bon, H.; Parrot, L.; Moustier, P. Sustainable urban agriculture in developing countries. A review. *Agron. Sustain. Dev.* **2010**, *30*, 21–32. [CrossRef]
32. Villavicencio-Valdez, G.V.; Jacobi, J.; Schneider, M.; Altieri, M.A.; Suzán-Azpiri, H. Urban agroecology enhances agrobiodiversity and resilient, biocultural food systems. The case of the semi-dryland and medium-sized Querétaro City, Mexico. *Front. Sustain. Food Syst.* **2023**, *7*, 1066428. [CrossRef]
33. Chimi, P.M.; Fobane, J.L.; Onguene, E.M.A.; Nkoué, B.B.; Kamdem, M.E.K.; Pokam, E.Y.N.; Mala, A.W. A bibliometric analysis of agroecological practices: Trends, impacts, and future directions. *Environ. Syst. Res.* **2025**, *14*, 4. [CrossRef]
34. Wezel, A.; Herren, B.G.; Kerr, R.B.; Barrios, E.; Gonçalves, A.L.R.; Sinclair, F. Agroecological principles and elements and their implications for transitioning to sustainable food systems. A review. *Agron. Sustain. Dev.* **2020**, *40*, 40. [CrossRef]
35. Dumont, A.M.; Wartenberg, A.C.; Baret, P.V. Bridging the gap between the agroecological ideal and its implementation into practice. A review. *Agron. Sustain. Dev.* **2021**, *41*, 32. [CrossRef]
36. Altieri, M.A.; Nicholls, C.I.; Dinelli, G.; Negri, L. Towards an agroecological approach to crop health: Reducing pest incidence through synergies between plant diversity and soil microbial ecology. *npj Sustain. Agric.* **2024**, *2*, 6. [CrossRef]
37. Lithourgidis, A.S.; Dordas, C.A.; Damalas, C.A.; Vlachostergios, D.N. Annual intercrops: An alternative pathway for sustainable agriculture. *Aust. J. Crop Sci.* **2011**, *5*, 396–410.
38. Woods, M.E.; Ata, R.; Teitel, Z.; Arachchige, N.M.; Yang, Y.; Raychaba, B.E.; Kuhns, J.; Campbell, L.G. Crop diversity and plant–plant interactions in urban allotment gardens. *Renew. Agric. Food Syst.* **2016**, *31*, 540–549. [CrossRef]
39. Morales, H.; Ferguson, B.G.; Marín, L.E.; Gutiérrez, D.N.; Bichier, P.; Philpott, S.M. Agroecological pest management in the city: Experiences from California and Chiapas. *Sustainability* **2018**, *10*, 2068. [CrossRef]
40. Arnold, J.E.; Egerer, M.; Daane, K.M. Local and landscape effects to biological controls in urban agriculture—A review. *Insects* **2019**, *10*, 215. [CrossRef]
41. Nair, A.; Delate, K. Composting, crop rotation, and cover crop practices in organic vegetable production. In *Organic Farming for Sustainable Agriculture*; Springer: Berlin/Heidelberg, Germany, 2016; pp. 231–257. [CrossRef]
42. Magdoff, F.; Weil, R.R. Soil organic matter management strategies. In *Soil Organic Matter in Sustainable Agriculture*; CRC Press: Boca Raton, FL, USA, 2004; pp. 45–65.
43. Bonanomi, G.; Antignani, V.; Capodilupo, M.; Scala, F. Identifying the characteristics of organic soil amendments that suppress soilborne plant diseases. *Soil Biol. Biochem.* **2010**, *42*, 136–144. [CrossRef]
44. Hudson, B.D. Soil organic matter and available water capacity. *J. Soil Water Conserv.* **1994**, *49*, 189–194.
45. Salomon, M.J.; Watts-Williams, S.J.; McLaughlin, M.J.; Cavagnaro, T.R. Urban soil health: A city-wide survey of chemical and biological properties of urban agriculture soils. *J. Clean. Prod.* **2020**, *275*, 122900. [CrossRef] [PubMed]
46. Sharma, R.; Bhardwaj, S. Effect of mulching on soil and water conservation-A review. *Agric. Rev.* **2017**, *38*, 311–315. [CrossRef]
47. Wielemaker, R.; Oenema, O.; Zeeman, G.; Weijma, J. Fertile cities: Nutrient management practices in urban agriculture. *Sci. Total Environ.* **2019**, *668*, 1277–1288. [CrossRef]
48. Siegner, A.B.; Acey, C.; Sowerwine, J. Producing urban agroecology in the East Bay: From soil health to community empowerment. *Agroecol. Sustain. Food Syst.* **2020**, *44*, 566–593. [CrossRef]
49. Wadumestrige Dona, C.G.; Mohan, G.; Fukushi, K. Promoting urban agriculture and its opportunities and challenges—A global review. *Sustainability* **2021**, *13*, 9609. [CrossRef]
50. Follmann, A.; Willkomm, M.; Dannenberg, P. As the city grows, what do farmers do? A systematic review of urban and peri-urban agriculture under rapid urban growth across the Global South. *Landsc. Urban Plan.* **2021**, *215*, 104186. [CrossRef]
51. Halloran, A.; Magid, J. The role of local government in promoting sustainable urban agriculture in Dar es Salaam and Copenhagen. *Geogr. Tidsskr.-Dan. J. Geogr.* **2013**, *113*, 121–132. [CrossRef]
52. IPCC. 2023: Summary for Policymakers. In *Climate Change: Synthesis Report*; Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change; Core Writing Team, Lee, H., Romero, J., Eds.; IPCC: Geneva, Switzerland, 2023; pp. 1–34. [CrossRef]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.