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Vision of Urban Agriculture towards Biodiversity Richness

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Abstract—*Under the current scenario of rapid human population increase, achieving efficient and productive urban agricultural land use leading to biodiversity richness is a global challenge. Urbanization has a negative overall impact on biodiversity in areas under urban sprawl. For decades nature has been forced out of capitals across the globe. Even the United Nations 2020 Strategic Plan for biodiversity does not report features of urban biodiversity. To counter this oversight, a number of public and municipal initiatives have emerged to regenerate biodiversity in urban life.*

Urban agricultural systems can be classified in many forms such as allotment or community gardens, private gardens, easement gardens, roof-top gardens and community orchards. These forms of urban agriculture provide important ecological services exhibit high levels of biodiversity, often exceeding that of other green space areas within the metropolitan. The biodiversity richness of urban agriculture has potentially large societal and environmental benefits for capitals, such as enhanced food security, air quality, and water regulation. Nevertheless insufficient studies have provided knowledge regarding urban agriculture vegetation management impacts on the quantity, quality, and stability of biodiversity provided.

This article presents the investigation of the existing study on the characteristics of urban agriculture management and their potential to deliver biodiversity richness. Specifically, we demonstrate types of urban agriculture and their potential ways for biodiversity richness along with the challenges of promoting urban agriculture systems that support biodiversity richness. Overall, our article reveals that varied vegetative structure, increased native plant diversity, and reduction of urban impermeable surface are key features of urban agriculture systems that contribute significantly to urban biodiversity and provide important ecosystem services such as pollination, pest control, and climate resilience. We conclude with a vision of critical gaps in current investigation and strategies to better understand and support urban agriculture leading to biodiversity richness.

Keywords*: urban agriculture, biodiversity, garden, richness, services, vision.*

1. INTRODUCTION

Rapid urbanization has been recognized as an essentialkey issue for deteriorating the biodiversity richness in urban areas. In 2009more than half the world's population was living in urban areas. Moreover, urban growth is projected to continue in the coming decades, although at a decreasing rate, deserving special attention in order to make life in metropolises more ecologically sustainable [1]. Thus, green spaces found within urban scenes are quickly becoming vital refuges for native biodiversity [2].

Urban agricultural initiatives can reverse biodiversity loss and encourage urban greening and agriculture; they can also provide a way to improve quality of life, nourishment, and the integration of nature into metro life. For instance window farming is practiced all over the world. People across the globe downloaded instructions for building window-farms, growing their own fruits and vegetables, such as strawberries, tomatoes, and peppers, in window openings [3]. Urban farming and gardening is a way to help stop ecological destruction and the loss of biodiversity. JacSmit, founder and past president of The Urban Agriculture Network, pointed out, urban farming "creates green spaces, recycles waste, cuts down on traffic, provides employment, substitutes for imported high-value goods, prevents erosion and is good for the microclimate." [4]However public and scientific awareness in urban agriculture has grown dramatically in the past two decades. Still there are significant challenges for integrating urban agriculture in an increasingly spatially constrained urban landscape. Although there are a number of socioeconomic reflections that affect the development and proliferation of urban agriculture in metropolises, this review will focus on the ecologicalaspects of the urban agriculture system and how they can be designed tomaximize the environmental and health benefits along with biodiversity richness [5].

One way to encourage the integration of urban agriculture is to betterunderst and how planned and associated biodiversity with in these systems contribute to urban ecosystem services. However, there are major gaps in the literature regarding urban agriculture status and impacts that limit our ability to increase its benefits in terms of biodiversity richness. For instance, biodiversity patterns in urban agriculture have only recently been documented and require further investigations [6]. Moreover ecological communities within urban agriculture may provide valuable ecosystem services (e.g., pollination, pest-control, water regulation) [7]; however, the availability of these services has not been well-established.

Finally,little is known about the role of urban agriculture in mediating resilience tomajor threats, specifically climate variability [8].

There are many urban land patches lying vacant today that can be turned into green galaxies. To initiate, local authorities should be required to provide information on land use in urban areas and to adopt favorable urban planning so that people can create new green and diverse spaces leading to biodiversity richness. Considering the potential benefits of urban agriculture forimproved biodiversity fruitfulness, we surveyed different types of urban agriculture and their potential ways for biodiversity abundance and the challenges of promoting urban agriculture systems that support biodiversity richness along with the vision of research in the gaps.

2. URBAN AGRICULTURE: DEFINITION

Urban agriculture is defined as the cultivation ofcrop and livestock goods within cities and towns [9].It is generally integrated into the local urbaneconomic and ecological system which may provide products to the local population[10].Its activities are diverse and can includethe cultivation of vegetables, medicinal plants, spices, mush-rooms, fruit trees, ornamental plants, and other productiveplants, in addition to the keeping of livestock for eggs, milk,meat, wool, and other products [11].This definitionpoints to the fact that it is not solely for food production, butfor a wide range of needs of the local community, includingmedicinal and ornamental plants. The different types of urban agriculture allow for a diverse set of vegetation structures to contribute tothe edible landscape in a range of community types [12], andthis wide range of products means that these systems are highlyheterogeneous in size, form, and function leading to biodiversity fruitfulness.

3. CLASSIFICATION OF URBAN AGRICULTURE

Descriptions of different categories of urban agriculture are listed inTable 1. Main types of urban agriculture are:

3.1 Community orallotment gardens-denote small-scale, highly-patchy,and qualitatively rich semi-natural bionetworks and areusually located in cities or towns for food production [13].

3.2 Private gardens-Primarily located in residential areas and may be the most predominant form of urban agriculture in cities [14]. These cover anestimated 22–27% of the total urban area in the UK and 36% of urban area in New Zealand [14, 15].

3.3 Easementgardens-Located within private/community properties, butare often regulated by the local government [16]. The main motive to establish these is to improve water quality and erosion control but they can include a wide array of bio-diversity, depending on management type [17].

3.4 Roof-top gardens-Established on theroof of a building and can be both decorative and used for agriculture.

3.5 Urban orchards-Tree-based food farming that can be owned and run privately or by the community. Gradually many schools and hospitals are establishingfruit trees that provide crops, erosion control, shade, and wildlife habitat, while producing food for the local community [18].

4. URBAN AGRICULTURE AND BIODIVERSITY

Urban patches are typically highly simplified with low levels of nativebiodiversity. However, urban greenspaces can provide vegetation andbiodiversity enhancement across fragmented habitats and spatial scales [19]. Just as in agricultural units where more complex agricultural practices have a larger effecton biodiversity and when implemented in simple agriculturalsites than more complex landscapes [20]. Moreover, chemical, water, and animal movement isbi-directional, and strengthened management implemented inbackyards, such as pesticide application, extensive pruning,frequent mowing and other disturbances, can limit the capacity of gardens to maintain rare or sensitive insect species[20]. Thus, it is important to explore the type of biodiversity enhanced in each type of urban agriculture.

4.1 Impacts of Urban farming on biodiversity: Biodiversity is of fundamental importance in order to maintain the variety we want and need from our crops and livestock. It is also the foundation of the ecosystem services that are essential to sustain agriculture and human wellbeing. With increasing urbanization, current agricultural practices are often challenged to provide sufficient locally farmed food to feed growing cities, resulting in ever more industrialized and globalized food production. Urban agriculture isan effectiveapparatus to slow downthe loss of biodiversity. Table 1 indicates the potential ways for biodiversity richness in each type of urban agriculture.

4.2 Path to re-join with nature: Cities all over the world can benefit from urban agricultureasan effective means to build sustainable and more resilient food systems, communities and cities alongwith enhancement in biodiversity services. Byfood production, urban agriculture helps facilitate responsibleconsumption, enhance people to peopleconnection with nature.People grow their own foodand they enjoy interacting with nature, creating newrelationships and connections within their communitiesand are being rewarded with good health and well-being.

Table 1: Classification of urban agriculture and the potential ways for biodiversity richness in each [6].

Urban agriculture Class	Description	Approaches for biodiversity richness

Allotment or community gardens	Allotment gardens- land is sub-divided and parcels are cultivated individually Community gardens- an entire area is tended by a collective group.	•Increased sunlight and floral area lead to bee and butterfly species richness •Farming of local and cultural vegetables as well as medicinal plants can increase the vegetative complexity •Floral diversity and elongated growing seasons support urban pollinators, seed dispersal, and pest regulation •Support for below-ground invertebrates and microbes control soil-dwelling stages of insect pests •Facilitate drainage and reduce urban temperature
Private gardens	Land around the house to meet different physical, social, and economic needs	• Stratified vegetation in home gardens can support large amounts of biodiversity richness • Native plantings can proliferate bird and butterfly diversity • Parasitoid diversity intensifies with floral diversity • Garden size and 3D structure increase mammalian species • Genetic diversity improves threatened and rare species
Easement gardens	Clustered in small patches in unused vegetative patches next to road ways	• Increased vegetation cover can recover water quality and reduce soil erosion • Improves matrix for species movement • Increased vegetation can provide habitat to biodiversity • Urban street trees can contribute to the cooling of buildings • Noise and environmental buffers along rail and highway corridors
Roof-top gardens.	Established on the roof of a building and farming is done using hydroponics, aeroponics or air-dynaponics systems, or container gardens practices	• Provide wildlife habitat for pollination and pest control • Increase air cooling, flood mitigation, and wildlife habitat
Community orchards	Owned and run by the community, some by local authorities with local people.	•Deliver wildlife habitat • Provide condensed tree structure for carbon sequestration in trees and soil • Increased vegetative cover supportive for erosion control and storm attenuation

5. CLIMATE REGULATION

As there is an indication of increased heat waves in metropolitan areas, there has been great interest into the relationship between green infrastructure and mitigation of the urban temperature [21]. Two main approaches have been proposed as solutions to regulate the urban temperature i.e. maintaining more urban green space and reducing resistant surfaces. Increasing the proportion of green space through urban agriculture within the urban matrix can reduce both surface and air temperatures [22]. However, the variety of vegetative infrastructure, management, and plant species within urban farming will vary in their cooling potential. The cooling effect by urban trees in US capitals are a result of vegetation contributing direct cooling of adjacent buildings, and this effect is dependent on tree size, species, maturity, and architecture [23]. At the miniature level, vegetation can influence the energy loads on individual buildings, but how this impacts air temperatures across the wider urban atmosphere is still unclear [24]. However, considering the potential impact that increased vegetation has toward regulating temperatures, there could be big implications on energy use for urban societies. Additionally, gardens located in areas unsuitable for buildings or established as buffer zones along rail corridors and highways, may be supportive in balancing the urban microclimate along with dilution of storm.

Vegetation, trees especially, divert intense precipitation and hold water for the time being within their canopy, thus reducing peak flow and easing demand on storm drains [25]. Urban agriculture may facilitate reduction of impermeable surfaces in urban landscapes, thus increasing the drainage and infiltration potential of precipitation.

6. CHALLENGES IN URBAN AGRICULTURE FOR PROMOTING BIODIVERSITY

There are several challenges that deserve attention so that urban land is better elucidatedand biodiversity can be promoted through the increased integration of urban agriculture in cities. Wepostulate that the three significant challenges in urban agriculture for promoting biodiversity are accessibility of urbanspace, environmental limitations, and lack of awareness.

6.1 Space accessibility: Increased urbanization lead to competition for spaceaccessibility in cities, which further deteriorate to maintain biodiversity supporting habitats. Supplementaryinvestigation is desirable to takeadvantage of the limited space available for urban gardensand maximize biodiversity within these areas.

6.1.1 Private plots: Private plots make up a significant proportion of green space in a city and do not require the acquisition of new space. Small-scale private gardens present multifaceted vegetation assemblywhich can provide appropriate habitatsfor organisms that have difficulty existing in the urban matrix[26]. A number of strategies to increase wildlife-friendly gardening activities are already in process of promotion. InUnited States, the National Audubon Society's "Audubon at Home"project offers several controlling principles to increase birdbiodiversity in backyards,and the

National Wildlife Federation provides documentation for 'wildlife-friendly' gardens [27, 28]. More investigation is needed to understand the efficiency of these incentives to support native biodiversity andfood production as many of the techniques are focused onthe augmentation of ornamental or floral plants rather thanfood crops.

***6.1.2 Accessible public spaces*:** Because greater lodging densityhas been linked to smaller garden sizes, there is a desperate needto better understand how urban agriculture can be supported within publicgreen spaces, such as community gardens and easements toenhance biodiversity richness[29]. Even within small habitat strips, the conservation ofplants known to attract pollinators or pest natural enemiescan provide substantial biodiversity utilizing limited available space, but more informationregarding urban plant–animal interactions needs to be knownin order to best augment such spaces effectively [30].

***6.1.3 Unoccupied lots*:**An unoccupied lot that is vacant lots can provide opportunities to createfunctional green spaces where industrial redevelopment is notlikely to happen [6]. Urban agriculture in these vacant lots can improve biodiversity and provide physical and psychologicalhealth for people in cities [31]. However, we require a better understanding of how to successfully naturalize vacant lots which is need of the hour.Additionally, creating gardens in abandoned lots has implicationson urban land tenure for garden management, and it wouldbe helpful to investigate whether temporary gardens make positive contributions to biodiversity restoration and food production in thesame ways that more permanent gardens do.

6.2 Environmental limitations: A number of environmental fluctuations come with urbanization and affect the agronomic conditions necessary for food production, such as water availability, nutrient supply, soil degradation, and pest pressure [8]. This further damage the available biodiversity of that area leading to severse crisis.

***6.2.1 Pliability to climatic change*:** We need investigationsthat examine how the choice of garden trees, shrubs, andother plants influence air and surface temperatures inthe gardens, and the potential role of garden vegetationto lower energy use and costs in urban environments.Likewise, we need to develop a better knowledge ofthe specific garden plantings that most enhance carbonsequestration in urban agriculture. On the other hand, there is basicallynothing known about how different urban agriculture respond to climatechange or climate extremes, and how the urban environmentin which urban agriculture is embedded may intensify climate effects.Thus, deepexploration is required to understand how plantsin urban agriculture will respond to increasing temperatures, drought,and changes in rainfall amount, nutrient deposition, and weatherextremes.

6.2.2 Water consumption:Exploration of environmental constraints relatedto water consumption is also needed in urban agriculture, as irrigation is oftenrequired to provide water necessary for urban farming,especially in waterless environments. Rainwater can be used for garden irrigation, and it is cheaper and attimes more available than potable water-based irrigation, but urban agriculture gardeners must be aware of the potential pathogens andheavy metal contaminants that can cause human and environmental health problems, especiallywith water run-off from these sites[32].

***6.2.3 Soil ecology*:**Urban soils are usually compressed, have lowlevels of organic matter, altered soil moisture features,and sometimes have lead or other heavy metal contamination due to urban environmental processes. A number of methods, such as cover cropping,mulching, producing in raised beds, and changing subsurface drainage through piping, can improve soil ecologyto support food production [6]. However, more investigation must be done to understand how tosustainably assimilate urban soils. The use of both organicand inorganic fertilizers in combination with nutrient-richwastewater can lead to surplus nutrients for urban agriculture to flourish [35]. Alternative methods,such as "organoponics", where organic compost is used as agrowing medium instead of existing soils, need to be furtherexplored area to develop farming approaches that are successful inthe urban environment [18].

6.3 Lack of awareness: Two mainobstacles to wildlife gardening are the lack ofinformation to alter gardening methodologies for improvedbiodiversity richness and the ineffective transfer of awareness toimprove the sustainability of urban gardens [34].

6.3.1 Methodologies for biodiversity richness:There is a large set of data on patterns of biodiversity loss in urbanareas and the factors that positively correlate with thediversity of plants, arthropods, and vertebrates in urbanlandscapes. The time is ripe for a quantitative review ormeta-analysis of those specific habitat and landscape featuresof urban habitats (including gardens) that correlate withincreases in species richness and abundance of biodiversityin general, and beneficial organisms in particular along with climate scenario in present hour. For instance urban gardens can increasepredator or parasitoid diversity [6],but we still lack exploration that documents the garden features that enhance the specific act of predation by ants, spiders,birds, or other predators. Very little investigation has been focused onhow management intensity in urban agriculture systems will affect biodiversity richnessin prevailing environmental atmosphere. Moreover, landscape level urban agriculture connectivity is importantfor the creation of networked biodiversity sanctuaries and for theimprovement of matrix permeability for organisms. Thereis a lack of information in understanding how the movementof species between landscape elements can allow organismsto carry out functions at different points in space and timeand maintain services that would otherwise be isolated [35] and how urban agriculture fits into the present environmental pattern taking account of different aspects. More research to understand the effects ofgarden management on landscape-

wide biodiversity andmovement will be necessary to determine the most critical executive practices for promoting current landscapeconnectivity.

***6.3.2 Information transfer*:**Increasing our understanding of urban agriculture management practices and information spread may be themost vital area of investigation if we are to promote gardensthat support biodiversity richness. We need to determine which types of urban agriculture contribute disproportionately to food production under different geographic, weather, and socio-economic conditions so that urban gardeners can cultivate specific plants species best suited for their locality. Local ecological awareness is generally low among urban residents; however,discussion between community members may encouragebiodiversity-friendly gardening, either through neighborhoodor community interactions for information transfer[36]. More investigation is essential to understandhow to identify the information most useful to urban gardeners and how to most effectively communicate this awareness.

7. CONCLUSION

Urbanization has a negative overall impact on biodiversity and especially on native flora and fauna in areas under urban sprawl.Urban agricultureoffers anextensive, varied, and undervalued resource for enhancingurban biodiversity and improving connectivity across thelarger plots. Farming and gardening in the city are effective ways of supporting well-being by reconnecting people with nature, supporting biodiversity, enhancing ecosystem services, and increasing food security and the resilience of cities. The assumption that urban agriculture has a role to play in sustainable development of modern cities is more difficult to address. At the metropolitan scale, urban agriculture cleans the air and returns carbon to the soil. It restores microclimates, conserves urban water resources in some cases, but degrades them in others, and maintains a penetrable surface between air and land. Urban agriculture is the conservator and generator of biodiversity in today'sscenario. Classification of urban agriculture and the potential ways for biodiversity richness in each has been studied. Farming in our own back yards and city parks does not require genetically modified crops to be economically viable. Urban agriculture produces food and energy crops close to the market demand, some within the neighborhood. This proximity of production to consumption reduces traffic, storage, and packaging as sources of the pollution that erodes biodiversity. Based on this study, we suggest that the challenges of space accessibility, environmental limitations and lack of awareness in urban agriculture for promoting biodiversity should be further explored to develop methods that incorporate biodiversity richness in urban farming and identify management methods that maximize fruitful biodiversity across expanding urban areas.

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