Urban Horticulture for Food Security

Subjects: Horticulture

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Sufficient production, consistent food supply, and environmental protection in urban +settings are major global concerns for future sustainable cities. Currently, sustainable food supply is under intense pressure due to exponential population growth, expanding urban dwellings, climate change, and limited natural resources. The recent novel coronavirus 2019 (COVID-19) pandemic crisis has impacted sustainable fresh food supply and has disrupted the food supply chain and prices significantly. Under these circumstances, urban horticulture and crop cultivation have emerged as potential ways to expand to new locations through urban green infrastructure. Therefore, the objective of this study is to review the salient features of contemporary urban horticulture, in addition to illustrating traditional and innovative developments occurring in urban environments. Current urban cropping systems, such as home gardening, community gardens, edible landscape, and indoor planting systems, can be enhanced with new techniques, such as vertical gardening, hydroponics, aeroponics, aquaponics, and rooftop gardening. These modern techniques are eco-friendly, energy-saving, and promise food security through steady supplies of fresh fruits and vegetables to urban neighborhoods. There is a need, in this modern era, to integrate information technology tools in urban horticulture, which could help in maintaining consistent food supply during (and after) a pandemic, as well as make agriculture more sustainable.

Keywords: cropping systems ; ecological sustainability ; hygienic food ; sustainable food supply ; urban horticulture

1. Introduction

Since the advent of the 21st century, phenomenal changes in human civilization have been witnessed throughout the globe. People are opting to live in big cities, where they enjoy diverse amenities. The land around cities is being used for commercial purposes and converted into malls, housing developments, roads, and small and large industrial establishments. This trend of population concentration in urban areas has created problems, such as a reduction of farmable land, increased malnutrition, and increased distances to traditional sites for food production [1]. In addition to these urban problems, the general increase in population, food scarcity, and climate change are emerging concerns of this century, globally [2].

The world population is increasing exponentially, and according to some estimates, it could grow to 9.6 billion by 2050 [3]. In the future, there will be pressure to increase agricultural productivity to fulfill peoples' need for food, while, at the same time, water and land resources are being rapidly depleted. The earth's climate is always changing, and there have been persistent increases in temperature. Under these circumstances, 10% of agriculture land may become uncultivable for farming [4]. The variability in weather due to climate change is threatening food production and distribution systems, and a significant number of people throughout the world are suffering from hunger and malnutrition [2][5]. This scenario varies within (and between) developing and developed countries of the globe. In addition, several anthropogenic activities, such as applications of unbalanced fertilizers, pesticides, inappropriate farming practices, and usage of heavy machinery, have resulted in soil degradation and depletion of fertile land [6]. Besides poverty, the documented migration towards urban areas, lack of resources, natural disasters, and conflict are key constraints of food security. Moreover, the reduced availability of fertile land, crop production, and high market prices of agricultural products have also limited the food supply [7].

Recently, the outbreak of novel coronavirus 2019 (COVID-19) has reached pandemic proportions and has disrupted the food chain in different ways. It has constrained peoples' capability to access food by reducing income and increasing job insecurity. Further, worldwide lockdown strategies have increased transportation interruptions, labor shortages, and limited market access, which has resulted in food loss and waste [8]. Countries with the highest food insecurity levels were less prepared for the COVID-19 outbreak. Globally, governments have implemented lockdown policies to secure their citizens during the epidemic. However, there has been uncertainty in developing countries, regarding feeding their people under these conditions. Moreover, with this pandemic, the major threat for developing countries is hunger, as more people

will die due to hunger, instead of the disease, if lockdowns continue to persist. In effective lockdowns, approximately 40% of a population would be unable to stock food for 14 days, and in just three days, most families would start to suffer from hunger [9]. The current COVID-19 pandemic has emphasized the importance of local food production [10].

Under the above circumstances, ‘‘Urban Horticulture’’ has emerged as a viable concept with the aim to provide sufficient fresh and safe food to cities, to achieve a sustainable food supply and food security. “Urban Horticulture” is the cultivation of fruits, vegetables, mushrooms, herbs, and aromatic and ornamental plants that can grow easily in a city and its surroundings [11]. The current COVID-19 pandemic, and lockdowns, have resulted in advantages to city dwellers who grow fruit and vegetables at homes, providing an opportunity to enhance urban horticulture. People, planners, and governments all are rethinking ways to utilize vacant lands in cities for food production under this dynamic condition [12]. Kitchen gardening is an older term, with a similar concept, in which edible plants are grown in home yards/gardens and rooftops to satisfy some of the home requirements for food. Many horticultural crops are considered ideal in urban agriculture production systems because they occupy a small space, produce more per unit area, have high nutritional value, and short production cycles. For example, diverse vegetable crop species may be grown and harvested within a short period of time (60–90 days) or even less for some herb/leafy crops [13].

In low income urban areas, the dietary deficiency of micronutrients, such as iron, zinc, iodine, and vitamin A is more common [14]. Horticultural commodities, such as fruits and vegetables, are rich in minerals, fibers, and bioactive compounds (e.g., phenolics and antioxidants), and have the potential to reduce malnutrition. Moreover, when these products are fresh and hygienic, this local food supply can have multiple positive impacts on humans, such as strengthening social cohesion and the local economy [15][16]. It also increases positive attitudes toward nature and natural habitats [17].

In recent years, interest in urban agriculture has increased because of climate change and the desire for a sustainable food supply in urban localities [18][19]. Urban horticulture has furthered its significance during pandemic diseases, such as COVID-19, which, globally, has triggered food insecurity. Moreover, higher poverty rates, malnutrition, stunted growth, and rising populations across the world have enhanced the importance of urban horticulture [13]. To fulfill the food needs of people, vacant spaces in urban areas will be a prime priority in order to compensate for lack of food and urban ecological losses if land is left barren. Growing horticultural food crops in urban landscapes, and open spaces, will improve the sustainability of food and the environment. Urban horticulture is, essentially, a way to mitigate societal social challenges (Figure 1).

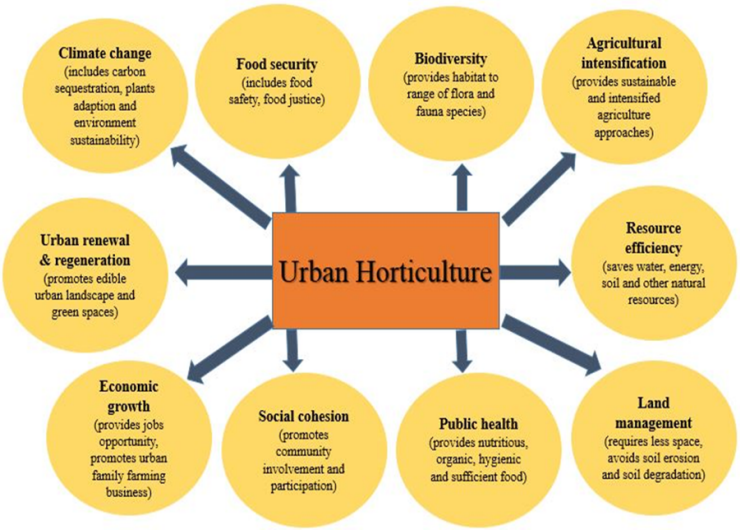

Figure 1. Societal social challenges that can be mitigated through urban horticulture.

2. Significant Features of Urban Horticulture

2.1. Source of Income Generation

In developing countries, poverty is more prevalent and job opportunities are extremely marginal, particularly outside the agriculture sector [20]. Cities are increasing in population, and the demand for healthy and safe food is under intense pressure. Urban horticulture offers a source of local food production and employment generation opportunities for the future, particularly in developing countries [21]. Currently, many from the developing world are using urban horticulture as a direct source of income generation by running their own businesses [22]. In Africa, urban agriculture is becoming an

important source of employment, where roughly 40% of urban citizens are involved in urban agricultural jobs [23]. This was also supported by other researchers, who stated that the agriculture sector has increased urban and rural employment by increasing labor empowerment [24].

In many countries, urban areas are filled with large buildings and the most fertile lands are converted into structures. Under these circumstances, urban agriculture may be limited to low fertile lands on which only selected crops can be grown. For example, growing short duration crops, such as leafy vegetables, is a good option, and gardening practices may help in restoring soil health [25]. There are still some marginal and vacant lands available in or near cities where local people can develop community food gardens. It has been documented that low-income families struggle to get hygienic and affordable food [26]. Such communities could be integrated into urban horticulture activities to improve their livelihoods and ensure food security [27]. Urban horticulture provides work opportunities to those who have the least employment opportunities, and is a way for the unemployed, as well as day-wage earners, to become self-reliant entrepreneurs [28].

2.2. Control of Environmental Pollution and Waste Management

Urban horticulture can help mitigate ever-increasing environmental pollution because of the ability of plants to absorb air and soil pollutants. Cities are becoming denser due to rapid urbanization, the increase in the numbers of structures, and the addition of industry. Heavy transportation pressure on roads results in vehicles that emit harmful gases, such as CO_2, CO, SO_2, etc., which are harmful to urban inhabitants and contribute to global warming. Edible urban horticulture plants can help alleviate environmental pollutants. Plants absorb CO_2 and in return exhale O_2 during photosynthesis. This phenomenon is important for all living organisms, both rural and urban. When vegetable and fruit crops are grown near city boundaries, the city will become the site of agricultural production. In cities, green vegetation reduces air pollution, dust particles, and nitrogen dioxide [29]. If enough food can be produced locally, urban horticulture can contribute to the reduction of the transport flow on roads, which ultimately reduces smoke and harmful gases from vehicles. The other advantage is reduced transportation costs and closer market access from which fresh food is easily available [17]. Moreover, high-tech urban horticulture produces more year-round production of food as compared to traditional methods, and reduces CO_2 emissions generated though transportation [30].

Currently, at international levels, several strategies are being adopted to reduce food loss and waste [31]. In the last few years, awareness has been created among the public to reduce food waste, and, it has been observed that this gradual change depends on cultural, political, geographical, economic, and social drivers [32]. Waste management is another serious hazard that can be minimized, to some extent, by integrating horticultural plants into the urban landscape. Inorganic waste, such as plastic bottles, rubber tires, plastic water tanks, baskets, and polythene bags can be used as pots and hanging baskets by filling them with potting substrate and plants. In some places, these materials were used successfully as roofing material for plants and soilless cultivation [33][34]. However, household inorganic materials, such as bottles and cans of motor oil, paint, and pesticides should be avoided, as they are hazardous. In addition, during reuse and recycling of inorganic products, batteries and mercury thermometers should be avoided, as they are enriched with heavy metals [35].

Daily household organic waste, such as papers, tissues, fruits peels, vegetable peels, and plant remains can be recycled into compost (Figure 2). Other organic household waste that can be recycled include wood, cardboard, other biodegradable packaging, natural fiber clothing, newspapers, furniture, food scraps, and grass clippings. Organic waste is normally defined as plant and animal-based organic material that is degradable into carbon. This type of material is normally kept separate from other material and is used for composting. Composting is a positive initiative to keep the urban environment clean and can be used as a natural soil amendment for fresh food production [36]. Compost from organic materials is ecofriendly and reduces consumption of chemical fertilizers. The extracts prepared from organic compost are also used to control plant diseases in Togo and Senegal [37]. Organic composts and other biosolids have been shown to improve the quality of urban soils [38], and the use of compost also reduces lead uptake in vegetable crops on contaminated sites, resulting in crops that are safe to eat [39].

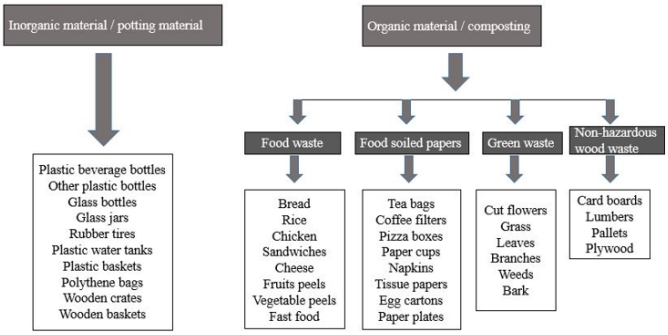

Figure 2. Inorganic and organic house waste items that can be recycled or reused in urban horticulture.

2.3. Ensures Food Supply and Sustainability in the Era of COVID-19 and beyond

Consistent food supply is at high-risk due to natural disasters, climate change, conflicts between countries, the refugee crisis, and worsening inequality. According to the Food and Agriculture Organization (FAO), 820 million people are suffering from hunger, out of which, 113 million are at risk (concerning their lives and livelihood). In addition, the outbreak of the COVID-19 virus has further threatened the lives of 820 million people. Due to the COVID-19 virus, urban food systems are highly disrupted. Worldwide, lockdown polices are being adopted to cope with this problem, which has impacted food commodity production, processing, supply, marketing, and transportation, significantly. Due to lockdowns and food supply restrictions, the cost of food items are being inflated, and there is food scarcity, especially in urban areas. Poor urban residents are not able to purchase food due to increased prices. Moreover, borders are closed worldwide, and there are overall restrictions in food exports and imports. The World Food Program has claimed that, at the end of 2020, there will be severe food insecurity due to COVID-19, and the number of people affected by food insecurity will be doubled, particularly people having limited resources and who work for daily wages.

Under these circumstances, urban horticulture provides an opportunity to supply healthy and safe food to cities and its surroundings. It will be helpful in stabilizing food prices by reducing the price volatility in markets under COVID-19 pandemic conditions. Growing vegetables in urban horticulture will enable the continuous flow of food with high food safety standards. This strategy was adopted by the Wuhan municipality and they started the project “Vegetable basket”. They have cultivated vegetables (on 20,000 hectares) since February 2020, in order to provide a continuous supply of fresh vegetables [40]. Growing vegetables at homes in (nearby) vacant spaces will fulfil the food needs of poor people, and keep them engaged in positive, healthy activities during lockdown.

Urban horticulture can be helpful in adding resilience to our food systems during the COVID-19 pandemic as it will strengthen markets by supplying food, and prevent supply-chain disruptions. The practice of urban horticulture will be helpful in keeping food systems running smoothly during a crisis, and the innovative techniques used in urban horticulture will protect individual workers from spreading COVID-19. We must show unity in our societies, so that local farmers, and people in general, can continuously produce and sell their crops safely.

2.4. Food Security

Global food security is under intense pressure due to urbanization and industrialization of productive agricultural lands throughout the globe [41]. Due to population increase, it is estimated that, by 2030, world food demand will increase to 43% [42]. Food security requires that every person will have safe, nutritious, affordable, and sufficient food for their health, according to the personal preference of each individual. It is suggested that urban horticulture can meet the challenge of providing safe and abundant fruits and vegetables [43]. Urban horticulture fulfills much of the vegetable demands in Singapore, as 35.5% of vegetables are grown by people on rooftop farms and gardens [44].

However, the sustainability of urban horticulture depends on access to and appropriate management of available spaces, such as vacant lands, rooftops, lawns, and commercial places provided for urban agriculture, as well as individual initiatives and behavior to grow fruits and vegetables [45][46]. Food security can be augmented if urban dwellers opt for self-production of food at home. Using these various methods, urban horticulture has already contributed significantly to food security and livelihoods in developing cities [25].

Because of constant migration towards cities in developing or developed countries, food needs are increased, and there is need to provide local sustainable food [47]. Besides food quantity, quality is becoming one of the major concerns of cities. Urban horticulture has the potential to reduce food pressure and, thus, urban food security can be safeguarded [48]. Throughout the world, urban agriculture has played a significant role in food security, for example, in Japan, after a natural

disaster, it helped with food resiliency [49]. Similarly, Cuba lost a major trading partner after the Soviet Union breakdown, and, at that time, urban agriculture helped Cuba to become food independent, and played a prominent role in food security. Currently, more than 35,000 ha in Havana is used for urban and peri-urban horticulture, and Cuba is one of the leading countries in urban horticulture [50]. Other cities of the world that produce urban horticulture products through efficient land utilization are presented in Table 1. Urban horticulture is not only a source of nutritious food production, but is also a way to secure food supply. In the USA, urban agriculture declined from 2002 to 2007, but there was an increase in small farms, and the most common products were vegetables, eggs, and goats [51].

Table 1. Cities/countries producing urban horticulture products by efficient land utilization.

City/Country	Horticulture Products Grown	Land Utilized	References
Havana/Cuba	Vegetables (beans, tomatoes, lettuce, okra, eggplant) Fruits (Papaya, pineapple, avocado, guava, coconut)	Community gardens, vacant spaces, green spaces, parking, highways, rooftops	[50]
Jakarta/Indonesia	Cabbages, ginger, chilies, pineapples, and mangoes	Vacant land, uneven spaces, riverside, roadside, and coastal lands	[52]
Rubi/Spain	Tomatoes and green houses	Rooftops	[53]
Munich/Germany	White cabbages, grapes, and apples	Green spaces, building facades, rooftops, and car parking	[46]
Boston/USA	Dark green vegetables and fruit trees (according to climate and cultural practices)	Vacant residential areas, vacant commercial areas, and rooftops	[43]
Montreal/Canada	Vegetables (according to climate and consumer preferences)	Vacant spaces, residential gardens and rooftops	[16]
Toronto/Canada	Summer vegetables	Residential gardens and rooftops	[54]
London/UK	Strawberries, lettuce	Farmlands, private gardens, and small plots	[52]
Maputo/Mozambique	Lettuce, kale, cabbages, tomatoes, and carrots	Green belts and small plots	[55]
New Town/Singapore	Vegetables and hydroponic products	Rooftops and public buildings	[44]

2.5. Improvement of Climate and Microclimate

In recent years, many people have developed an interest in urban agriculture due to concerns about climate change and sustainable food supply in urban areas [18][19]. Worldwide, urbanization has negatively impacted the climate. Moreover, deforestation, greenhouse gases, heat and smoke emissions from vehicles, industries, and homes have raised pollution levels, and the temperature of the earth. Modern facilities and home appliances, such as air conditioning and refrigerators, are also prime reasons for the temperature increase. The effects of climate change, particularly rising temperatures and erratic rainfall patterns, are notable in reducing crop yields and environmental growing conditions [17][56]. Extreme climatic

conditions have a negative impact on all living creatures. Cities are being polluted with transportation, industries, and domestic activities [50]. Planned, well organized vegetation can change the urban microclimate, as well as reduce temperature and greenhouses gases significantly [57].

In cities, vacant and neglected places can be used for green vegetation. Trees and shrubs can be planted along roadsides, highways, and even the center of wide streets. Vegetation assists in decreasing solar radiation and dust particles, and increasing atmospheric humidity, which will modify the microclimate of a place. Moreover, the strategy of planting aromatic plants can help in mitigating bad odors from polluted cities. Urban horticultural plants have played an important role in making cities more natural, greener, and beautiful. For example, in the town of Sofia, Bulgaria, increased vegetation in vacant spaces has resulted in milder temperatures [58]. The use of tall trees, green shrubs, grasses, and mulches in urban settings has been shown to have a cooling effect [59].

2.6. Conservation of Biodiversity

Another benefit of urban horticulture is that it makes a major contribution to balancing the ecosystem by maintaining biodiversity. In urban areas, human activities have disturbed the biological ecosystem, including the habitat of several flora and fauna species. It has changed ecological patterns, increased environmental pollution, and changed natural cycles and processes [60]. The diversity of flora and fauna are greatly reduced in urban areas compared to rural areas [61]. The reduction in biodiversity results in decreased natural resources and disturbed nutrients and water cycling [62][63]. However, research on urban agriculture shows that cities still have the potential to support biodiversity, and the conservation of endangered and threatened species [64]. Green spaces in urban areas offer important refuge sites and natural habitats [65].

Urban landscape practices in cities contribute to the conservation of biodiversity, and can be even better in some ways, as compared to natural or non-urban landscape. It has been observed that urban landscapes are richer in flora and fauna species compared to rural landscapes [58]. In urban horticulture, there is usually less use of fertilizers, pesticides, and fungicides, which helps with the coexistence of other components of the ecosystem. In urban horticulture, mostly organic and natural materials are used to produce crops, which saves the growers and consumers from the hazardous effects of pesticides. Organic farming in urban horticulture is considered an essential tool in enhancing the biodiversity of urban areas because the flora and fauna survive better in these natural habitats [21].

2.7. Source of Recreation and Reduction of Gender Inequality

A trend for more urban horticulture in developed countries is increasing significantly. People frequently practice horticulture on small areas of private land, home gardens, school gardens, and even on leased lands [22]. Along with food production, people are doing urban horticulture as a hobby or recreational activity. Gardening promotes social association and cultural activity among people. In urban horticulture, older people are also able to participate and keep themselves engaged in gardening. It has been shown helpful in reducing mental stress. Urban horticulture is also helpful in the reduction of gender inequalities. Both males and females work together at the same place and in a good environment. In developed countries, more than 65% of participants in urban horticulture are women [25]. The involvement of women in urban horticulture empowers them to become independent [27]. It is also observed that home gardening has positive effects on mothers and children [13].

2.8. Self-Reliance and Land Management of Cities

Urban horticulture is a way to increase the self-reliance of cities. It can lead to cities that are self-sufficient and independent. They can strive to produce enough fruits and vegetables for their residents. It is argued that, if cities are sustainable, then the world would be sustainable [58]. Several cities are independent and self-sufficient in horticulture, while some are self-sufficient up to a certain limit [26]. In Berlin, urban horticulture was of utmost importance as it provided fruits and vegetables during a crisis of limited food [66].

To meet the food demands of an urban population, land in and round the cities, such as green belts, land adjacent to sidewalks, vacant plots, community gardens, botanical gardens, and rooftops should be used efficiently. A recent case study from Sheffield, UK, showed that there are large potential spaces available to produce more than enough fruits and vegetables to fulfill the needs of urban inhabitants [67]. Cleveland, Ohio, a city of 400,000 inhabitants, has the potential to fulfill resident demands by growing fresh vegetables on rooftops and conducting vertical gardening in vacant spaces [68]. If less productive, conventional production methods are used, then 14 times more land will be required to fulfil the needs of the residents. That all urban cities could be self-reliant and self-dependent is a future challenge; it is only possible through adopting urban horticulture initiatives. This is challenging, but targets can be achieved with the financial and technological support to communities.

Water use can be a concern in urban horticulture in arid regions of the world. A study of household water recycling, showed that “greywater” from sinks and showers in the household could be used for home gardening, but should be filtered. Public acceptance was high; 76% of respondents would reuse greywater for gardening, but infrastructure/plumbing changes would be necessary to promote widespread implementation of these systems [69].

2.9. Public Health

To fulfil food demands, the intense use of fertilizers has significantly increased the nitrate concentration of crop fields, vegetable fields, orchards, and groundwater [70]. Moreover, the excessive use of pesticides and its surface runoff has degraded water quality and increased its toxicity to non-target organisms [71]. In this regard, urban horticulture has lessened the load of synthetic fertilizers and pesticides that are carcinogenic and hazardous to human health, and it has promoted the use of organic foods that are natural and healthier. The other advantage of urban horticulture is that the food produced locally is fresh and high in vitamins, minerals, and proteins when consumed [48].

Urban environment refers to areas that are dominated by made structures, such as large residential and commercial buildings made-up of concrete and glass. Urban environments are more polluted due to anthropogenic activities, such as smoke and toxic gases exhausted by vehicles and factories [72]. This urban environmental pollution causes several health related issues, such as respiratory and heart problems [73]. Moreover, congested spaces and less physical activity has led to increased sedentary behavior, depression, and techno-stress in adults, and an increased number of mental disorders in children [74][75][76]. Urban horticulture can complement parks with forest environments, and both will promote human health and quality of life [77]. Nowadays, in urban areas, green spaces are used by healthcare centers as a form of natural therapy in controlling diseases, as there is a positive relation between health and nature. Several studies revealed that time spent in natural green environments reduces nervous activity, improves immunity, cell activities, and stabilizes pulse rate [78][79], while it decreases cholesterol, salivary cortisol (stress hormone), and systolic and diastolic blood pressures [80][81].

In addition, there is an increased interest seen in indoor planting, as urban horticulture provides relief, reduces stress, and improves physical and mental health. Indoor planting improves the quality of air, visual stimulation, and has psychological benefits [82][83]. Green spaces and natural food in urban horticulture has increased the longevity (and socioeconomic statuses) of senior citizens [84]. Keeping in mind the positive physiological and psychological effects of urban horticulture on human health, it should be considered an essential part of urban civilization to promote health in the future.

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