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Urban Horticulture for Sustainable Food Production and Food Security

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ABSTRACT

Sufficient food production, stable food supply, and environmental protection in urban surroundings are major global concerns for future sustainable cities. This is due to exponential population growth, increasing urban dwellings, climate change, and limited natural resources. The solution to these problems lies through the plantation of fruit and vegetable home gardens, utilization of rooftops and small plots for small-scale vegetable production, which can provide families with sufficient production and for income generation. But there is a need, to integrate information technology tools, breeding crops suited for urban farming, and closing the on water, waste, and energy, to help maintain consistent food supply as well as make agriculture more sustainable.This review discusses the significant features of contemporary urban horticulture, in addition to illustrating traditional, technology and innovations essential for urban horticulture to meet all food and nutritional requirements of growing urban populations.

Keywords- *Contemporary, Food security, Nature- therapy, Plant factories, Sustainability, Urban farming*

Introduction

Phenomenal changes in human civilization have been observed since the beginning of the 21st century. People prefer to live in big cities because of their conveniences and diverse amenities. The land around cities was utilized for commercial purposes and transformed into malls, housing expansion, roads construction, and small and large industrial settings. The drifting of the population from rural to urban areas and population concentration in urban areas in a short period has created problems, like reduction of farmable land, increased malnutrition, urban poverty, and increased distances to traditional sites for food production (Suman *et al.,* 2019). The general increase in population, food scarcity, and climate change is one of the main concerns of this century, globally. As a consequence of environmental damage, in terms of global climate change, there has been a decrease in space suitable for crop production, which feeds increasing urban and peri-urban populations.

According to the latest estimate of the United Nations, the World's urban population is expected to be 9 billion in the year 2050 which means production should be increased by 60% more, and agricul-

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tural land will continue to be strained further to meet the nutritional needs of these densely populated areas (Eigenbrod and Gruda 2015; FAO 2015). With urbanization, globalization, and a growing world population, it becomes imperative and of utmost importance to secure sufficient food supply for the world's population. Many cities are expected to boom shortly. The solution to the present situation lies in increased food security among the world's poor through the introduction of Urban Horticulture which can provide households with sufficient production as well as serve as a source of livelihood (FAO 2011; Martellozzo *et al.,* 2014).

Urban horticulture means the relationship between plants and urban areas, which deals with at most and functional use of horticulture methods to preserve and improve the surrounding area and also helps to obtain economic returns from it. Urban horticulture provides more efficient land use in urban areas with a low level of input usage, fertilizers, and water when needed. Besides, it resulted in a high yield with good quality in every season. However, this field of study is large and complex and has only recently gained momentum. In Urban Horticulture fruits, vegetables, flowers, and other indoor and outdoor plants are grown for harvest, aesthetic, architectural, recreational, and psychological purposes, but they stretch out far beyond these benefits

Traditional urban horticulture

The major reason to engross in urban horticulture is due to the availability of fresh, healthy, and cheap food, which are nutritious and increases the overall food intake. So due to this reason ever since humans began to shift from living in villages to urban environments traditional urban horticulture was practiced. Urban dwellers started to grow food crops to fulfill their daily need as cost of living in cities were extremely high. Crops were grown on rooftops, balconies, garden plots, smaller areas around homes, along roadsides, and in any vacant space to fulfill the needs of urban residents.

Home gardening, also known as backyard or kitchen gardening

To combat malnutrition and meet home food requirements Home gardening is perceived by all levels of society. Home gardening is a leisure activity of people worldwide, providing them with an opportunity to spend their free time in healthy outdoor activities (Galhena *et al.,* 2013). Here crops are planted in the ground, or various types and sizes of containers in backyards, balconies, vacant spaces, or any kind of small garden. Moreover, home gardening provides fresh vegetables and helps to save the home income spent on food commodities to some extent. In developing countries, Home gardening is particularly valuable, where 60 to 80% of a family's income is spent on food items (Nugent, 2000).

Community gardening

Community gardening is the collective cultivation of plants on a communal area by a group of community members where vegetables, fruits, flowers, ornamental plants, and herbs are planted in either individual or communal plots. These gardens are set in urban environments, which are sited in various areas of a city, and are generally owned or managed by the municipality. These community gardens are sometimes supported by private organizations or government programs and provide access to water, mulch, fencing, seeds, or other required resources. In developing countries, community gardens are encouraged for the food security of the poor, as they offer residents to share subsidized land to grow their food. While in developed countries, it aids to provide food to struggling neighborhoods, strengthen communities, educate people, and make the city greener. It also promotes intercultural communication, along with providing a continuous food supply (Metcalf *et al.,* 2011). According to an estimate from the American Community Gardening Association (ACCA), there are more than 18,000 community gardens present in the United States and Canada (Kortright *et al.,* 2011).

Edible urban landscapes

To enhance the self-sufficiency of citizens with lower incomes, such as older citizens, workers, and families with multiple children, in the 19th century Berlin Germany started Edible Urban Landscape. Here, outdoor areas are planted with fruit trees and vegetables, from small scale to large scale (Thomaier *et al.,* 2014). The main aim of urban edible urban horticultural landscapes is to improve cities' food security. So they are described as the Future of Public Parks. For example The George Washington Carver Edible Park, in Asheville, North Carolina has a multi-layered canopy of fruit and nut trees planted beside edible groundlike strawberry plants and these are all free for the picking.

Modern Cropping Systems

It is a new innovative technique developed to maximize yield, use less space while reducing environmental pollution and which can be adopted efficiently in urban areas. These techniques are beneficial, efficient and have the possibility of making horticulture more sustainable (Nandwani, 2018).

Indoor Growing Systems

Some sites in urban areas or even entire cities due to contamination are rather unsuitable for large-scale urban horticulture production outdoors. To overcome this indoor farming systems are adopted. In an indoor farming system, combined efforts of agricultural production and buildings are used to create an integrated whole within the protected surrounding of a building. And these indoor growing methods are sometimes called "Z-farming", which designates them as using zero acreage (Ali, 2017). The roofs of schools, shopping malls, hotels, apartment buildings, and supermarkets are considered the ideal places for indoor farming. It provides a new pattern of food supply, farming technologies, specific networks, and improves opportunities for resource use efficiency in urban spaces. Vegetable production is combined with existing buildings as an integrated method is to save resources and improve resource efficiency

Living Edible Wall or Vertical Gardening

In Living wall landscapes or vertical gardens an alternative green system is provided in which plants are supported along a wall vertically. No external support is required from the base for rooting in vertical farming, as nutrients and water are provided within the vertical structure. Vertical farming is equipped with automatic temperature, humidity controls, and solar panels to heat and light the building. So, the environmental conditions are constantly controlled, enabling year-round harvests. A typical vertical farm model to provide enough food for 15,000 peopleis around 167.5 meters high and 44 meters long,with a total space of only 28 m^2. Meanwhile,Singapore's government has participated in vertical farming since 2014 and used the country's 250 acres to expand vertically. Before then, nearly 90 percent of food in Singapore's groceries were imported but since the adoption of vertical farming, the percentage of imported food decrease by 10 percent in the first year and continues to follow this trend, helping the country become independent from foreign traders.

Rooftop Gardens and Greenhouses

Jafari *et al.,* (2015) the first rooftop garden was developed in Germany to improve aesthetics. Situated on the top of houses or industrial buildings they represent an innovative alternative for promoting self-sufficient by making use of underused roof structures. For growing shrubs, trees, vegetables, fruits, and other plants, the roof of the building is covered with a substrate. Rooftops are being used globally for several purposes other than planting crops. Rooftops gardens prevent heat loss in winter as compared to conventional roofs and these rooftops increased cooling by providing shade, evapotranspiration, thus provide savings on energy consumption. At present, in Singapore, rooftops are used for cooling and to reduce energy consumption (Chen, 2013). In Berlin, urban rooftop greenhouses are built for their social, educational aspects, and for energy efficiency (Specht *et al.,* 2015). It was reported that that green rooftops increased the lifespan of roofing membrane up to 40–50 years as compared to conventional roofs, which normally have life spans of 10–30 years, by protecting them from UV radiation and thermal stress (Oberndorfer *et al.,* 2017). Moreover, these rooftops have aesthetic value and increase the value of the property.

New technologies for indoor farming

Plants Factory is another type zero acreage, which is advanced Urban Horticulture Technique. Plant factories are enclosed or semi-closed horticultural systems that produced high-quality, edible, ornamental, medicinal, or industrial plants year-round with extremely high productivity and efficiency. In a small land area, a multitier system (up to 16 vertical layers) can be built to support the mass production of plants. Plant factories with artificial lighting (PFALs) fulfill specific needs on growth and bioactive compound accumulation in plants. By regulating light-emitting diode (LED), all environmental factors inside a plant factory are controlled without limitations of climate or location light and root-zone environments (Chandra, 2020).

Light-emitting diode (LED) lamps optimized the plant management processes as it offers the use of plant-related radiant energy which is very important for plant growth, plant development, and product quality (Gruda and Tanny, 2014). Compare to

existing horticultural lighting, LEDs are small in size, have better longevity, and have low heat emission even at very high light intensity levels. Moreover LED lamps can control spectral composition, which allows selecting of the most favorable light spectrum for photosynthesis (Gruda and Tanny, 2014). For the same wattage of input power LED array provides three times more light output on an equivalent area basis and can be easily integrated into digital control systems. Hogewoning *et al.,* (2010) reported that increasing blue light increases cucumbers biomass in a greenhouse. Lettuce seedlings that are raised in blue light after transplanting promote good growth in plants including high shoot and root biomasses, high content of photosynthetic pigments, and high antioxidant (Johkan *et al.,* 2010). Plant-specific choice of light intensity and spectrum (far-red and blue light) using LED can significantly reduce fertilizer and chemical use, due to shortening of the vegetation period and improvement in plant morphology. (Gruda and Tanny, 2014). Even though LED has little energy consumption and produces very little heat, the energy costs are still high.

Use of Soilless Culture

An innovation technique developed recently in Crop production is the use of soilless media to culture plants. Instead of soil, organic or inorganic substrates are used for plant growth. The term soilless culture is defined as the cultivation of plants in systems without soil in situ which includes modern cultivation systems like aeroponics, hydroponics, and aquaponics. Compared to traditional agricultural systems, modern cultivation techniques require less water and space. With the surge of soil erosion and the loss of arable land due to the present farming conditions, the importance of soilless cultures is likely to increase soon. As soilless farming is sustainable in terms of resource efficiency, lightweight, less utilization of chemicals and water in controlled environment settings, they are especially suitable for urban areas. Moreover, there is constant production during the whole year. However, in some cases, these techniques are expensive and require a constant source of electricity for pumps for water flow, light, and aeration. But they offer value in providing a consistent food supply to ensure food security and the vegetables and fruits produce under the modern techniques are of high quality and hygenic.

Hydroponic

Cultivation using the Hydroponics system does not require soil but relies on nutrient-enriched water. Here, roots are either suspended in water or use growth media such as rocks, clay, or pebbles for support (Von-Seggern, 2015). Sunlight can be supplemented or replaced with emitting diode (LED) lights, utilize controlled temperature environment, due to this reason there is a reduction in the use of chemicals, thus chemical-free fresh products are produced which are available to urban areas year-round. Therefore for urban areas where fertile land is limited Hydroponics is an important alternative planting practice.

Aeroponics

Aeroponics, which is a vertical farm cultivation method utilized 90% less water in comparison to hydroponics (Birkby, 2016). Plants grown under aeroponic systems use mist on the living roots, so plants grown under this system have higher nutritional quality, due to higher absorption of minerals (Boston, 2013). In this system, the plants are grown vertically and are arranged in a tubular frame or are suspended in a container. So this cultivation practice is beneficial for growing a large number of plants in a limited area, as it reduces the use of floor space.

Aquaponics

Hydroponics and aquaculture practices are combined in Aquaponics. The aquaponics system produce fish in addition to producing healthy plants. Since most of the water is recycled aquaponics only uses 2% of the water in comparison with traditional soil-based agriculture. It is a closed-loop system with the reuse of waste from the fish used as fertilizer for the plants (McCollow, 2014). The hydroponic beds contain exchange filters, which remove harmful acids, chemicals, and gases, and the gravel provides habitats to nitrifying bacteria, which boost water filtration and nutrient cycling. Aquaponics can become a model of sustainable food production by achieving the 3Rs (reduce, reuse, and recycle) (Diver, 2006).

Significant features of Urban Horticulture

Food supply and Food Security

Urban Horticulture can provide a portion of fresh and healthy food for individual families, community groups, and urban markets. However, it is difficult

to quantify just how much Urban Horticulture contributes to the global food supply." Growing vegetables in the urban area will enable the continuous flow of food with high food safety standards"- A strategy which was adopted by the Wuhan municipality and they started the project "Vegetable basket". 20,000 ha of land was used for the cultivation of vegetables to provide a continuous supply of fresh vegetables since February 2020 (FAO 2020). Growing vegetables at homes in (nearby) vacant spaces will fulfill the food needs of poor people, and keep them engaged in positive, healthy activities during the lockdown. Shanghai, China is able to meet 50% of vegetable demands from production inside city borders (Lang and Miao, 2013), while Dar-es-Salaam, Tanzania produces 90% of leafy vegetables (Jacobi *et al.*, 2000). The city of Sydney, Australia produces 24% of total vegetables and 99% of Asian vegetables out of the state's total production (Mok *et al.*, 2014). And Singapore, 35.5% of vegetables are grown by people on rooftop farms and gardens. But the sustainability of urban farming highly depends on access to urban spaces(vacant lands, rooftops, lawns, and commercial places), appropriate management of spaces provided for urban farming, and individual initiatives and behavior to grow fruits and vegetables (Ward, 2014). A mapping study by (Martellozzo *et al.*, 2014) disclosed that, on average, Urban Horticulture would require 30% of the area of cities globally to provide for the total vegetable consumption of urban dwellers. For larger cities with growing populations such as New York City and Toronto, vacant lands are less and by using only vacant land it would only be able to meet less than 5% of each city's fresh fruit and vegetable needs (MacRae *et al.*, 2010). For such a city lacking in available urban space, the use of rooftop gardens, vertical farming, and indoor growing methods, could avoid the need for large amounts of land area for urban growing (Despommier, 2011).

Income generation

In developing countries, urban horticulture is a source for local food production and employment generation (De Bon, 2010). Many from the developing countries are using urban horticulture as a direct source of income generation by running their businesses (Van Leeuwen, 2010). In Africa, urban agriculture is becoming an important source of employment, where roughly 40% of urban citizens are involved in urban agricultural jobs (Zezza, 2010). In 2014, 560 km^2 of Urban and Peri-urban Horticulture in Cuba produced 50% of all fresh produce for the country and it generated 300,000 jobs, making this country a global leader in Urban Horticulture. For those who have the least employment opportunities, urban horticulture provides work opportunities. Urban horticulture is a way for the unemployed, as well as day-wage earners, to become self-reliant entrepreneurs (Kekana, 2006).

Food Access

The global agri-food system is host to stark inequalities, with nearly 1 billion people suffering from undernutrition in developing countries and nearly a quarter of children and adolescents in developed countries are overweight or obese (Ng *et al.*, 2014). Within developed countries, there is much imbalance in terms of access to fresh, healthy foods. Areas that suffer from issues associated with food access have been collectively cited under the term 'food deserts.' And Urban Horticulture has emerged as one way to potentially increase access to fresh and healthy foods in food desert areas. A variety of community gardens, non-profit urban farms, and even for-profit urban farms have been dedicated to increasing food access in food deserts (Biewener 2016). People who are engaged in Urban horticulture have donated a portion of their harvests to charity organizations such as food banks to provide fresh produce to those in need (Blaine *et al.*, 2010). In Atlanta, a program called the "fresh MARTA markets", sell produce from urban farms in pop-up markets, in the underground transport stations located in food desert areas, aiming to meet transit with healthy food access (Food Well Alliance 2018). (Mack *et al.*, 2017) A mapping study performed in Phoenix, USA, shows that 68 community gardens in the city could only provide coverage to 8.4% of food desert residents but, if new 53 community gardens are introduced in vacant lots across the city would provide coverage to 96.4% of food desert residents. Thus, the spatial distribution of growing spaces, as well as the distribution networks associated with urban-produced foods, impact the ability of UH to improve food access and food security in communities.

Nutrition and Health

To meet the food demands, a high amount of chemical nutrients are used which has significantly increased the nitrate concentration in soil, crop, and groundwater (Iwafune, 2011). While the excessive

use of pesticides and their surface runoff has degraded water quality and increased its toxicity to non-target organisms (Martínez-Bravo, 2019). But Urban horticulture has lessened the use of synthetic fertilizers and pesticides and promoted the use of organic foods that are natural and healthier. Gardening improves physical and mental health through increased levels of fruit and vegetable consumption, improved dietary diversity, increased physical activity, and providing a source of stress relief and relaxation for gardeners (Armstrong 2000). A study showed that the body mass index of a community gardener got reduced and lower as compared with their non-gardening counterparts. Men who gardened had a body mass index 2.36 lower and women 1.88 lower while men were 62% less likely to be overweight and women were 46% less overweight than their neighbors. Community gardens are regarded as an important place for individuals to grow culturally relevant foods that cannot be found in local supermarkets, and the crop grown is perceived as higher quality by consumers, as food quality perception relates to aspects of the origin, trust, freshness, and flavor.

Control of Environmental Pollution and improvement in climate and microclimate

As a result of rapid urbanization, cities are becoming denser. As a result of deforestation, greenhouse gases,harmful gases emitted from industries, vehicles, and homes have raised pollution levels, the temperature of the earth and thus contribute to global warming. The reduction of crop yield and the unsuitable environmental growing condition are due to the effect of climate change (rising temperatures and irregular rainfall patterns). As the plant has the ability to absorb air and soil pollutants so, urban horticulture can lessen the ever-increasing environmental pollution. Green vegetation reduces air pollution, dust particles, and nitrogen dioxide. Moreover, vegetation contributed to reducing the intensity of solar radiation and dust particles, while rising atmospheric humidity, which will modifythe microclimate of a place. Plants have played a significant role in making cities more natural, greener, and beautiful.

Benefits of Urban Horticulture through nature-related Activity

The physiologically relaxing effects of nature-related activities, including gardening or horticultural activity, are stress reduction, improve self-esteem, social interactions, and cognitive health. Frederick Law Olmsted, the designer of New York City's Central Park observed that the trees, meadows, ponds, and wildlife calm the stresses of city life (Lee *et al.*, 2015; Park *et al.*, 2017) reported that nature-related activities decrease oxy-Hb concentrations in the prefrontal cortex and suppress sympathetic nervous activity, which is increased in the aroused or stressed state

Nature therapy, which uses natural stimuli from forests, urban green spaces, plants, and wooden materials to promote health is receiving increasing attention (Song *et al.*, 2016). Natural therapy increases parasympathetic nervous activity, suppresses sympathetic nervous activity, reduces stress hormone levels, and sedates prefrontal cortex activity, thus execute a relaxed state in people and the person feels comfortable. (Park *et al.*, 2009; Lee *et al.*, 2009). Nature therapy aims to improve immunity, prevent illnesses, and maintain and promote health via exposure to nature and, consequently, a relaxed state (Lee *et al.*, 2012). There is a significant positive relationship between exposure to natural environments and physical and mental health. Studies have reported that exposure to natural environments has been found to improved mood states and cognitive function (Groenewegen *et al.*, 2006; Park *et al.*, 2011; Shin *et al.*, 2010). Time spent in a forest can reduce systolic and diastolic blood pressures and pulse rate, suppress sympathetic nervous activity (which increases in stressful situations), increase parasympathetic nervous activity (which enhances during relaxation), decrease salivary cortisol levels (a typical stress hormone), and decrease cerebral blood flow in the prefrontal cortex (Park *et al.*, 2008).

Innovation in Urban Horticulture to increase Sustainability and Food Security

Innovations in urban farming technology

Urban farms can increase the productivity of the land by making use of space that is otherwise disused (rooftops, brownfield sites, or abandoned buildings). But urban farms need to produce more yield per unit area to make the operation profitable as the cost of urban land is high and high-tech, controlled environment facilities are capital intensive. By using designs that incorporate environmental controls, it is possible to increase the density of food production, and the use of systems that either use

towers to increase the efficiency of use of natural light, or by growing plants under artificial light can greatly increase the productivity per unit area beyond that achieved in greenhouses by stacking plants in vertical space. Use of highly automated, controlled environment growing systems to increase yields while decreasing operating costs. This system incorporates sensor networks, automation, data analytics, and artificial intelligence to optimize yields while minimizing labor costs. As energy is a key cost to controlled environment urban farms and by using energy-efficient equipment and linking operations to energy sources more yield gains and cost cuts are possible. But because of high energy inputs for lighting sources, temperature and humidity control, and high labor costs, controlled environment farms usually have very high operating costs. Due to these reasons Plenty, The plantlab, Aerofarms, Brightgrow, ifarm, Zipgrow, Spread Co., Sanan Sino-Science Photobiotech Co. which are large controlled environment farming companies, put effort and investment to develop highly automated, controlled environment growing systems to increase yields while decreasing operating costs. Electronics companies like Panasonic, Toshiba, GE, Fluence, and LumiGrow collaborate with controlled environment farms to develop and refine LED lighting systems with lower energy consumption, low waste heat generation, and optimized spectra for plant growth (Kozai *et al.*, 2016). Urban horticulture can decrease the energy associated with food production by removing the need to transport food long distances. So, by developing energy-efficient building designs, climate control systems, lighting systems, energy generation systems, a better understanding of how to manage crop physiology to maximize yield per unit and life cycle assessments to quantify the true costs of different production systems productivity can be increased (Kwon and Lim, 2011).

Breeding crops for urban farms

Plant factories are heavily dominated currently by producers of leafy greens and herbs as they can be produced in the shortest time with the least energy input and a large component of the biomass produced can be harvested and sold Cocetta *et al.*, 2017. Little effort has been made to breeding crops specifically for growing in controlled environments. Many of the phenotypic traits that are essential in breeding programs for field-grown crops, and which carry yield penalties, may not be needed in a controlled environment or urban farms, so breeding efforts for controlled environment farms should be directed to traits that are required to maximize both yield and quality under the specific conditions of controlled environment farms. The architecture of a range of crops could be changed to make them more suited to growing in vertical farming systems and by changing canopy architecture, including height, branching, or by altering the leaf structure productivity of the crop might be increase and better suited to the structure of controlled environment growing systems. Breeding and selection of shorter life cycles crop as they are highly desirable for closed farms under artificial light due to early maturation of the crop which allows more growth cycles per year thus increasing annual productivity. By optimizing root to shoot ratios as crops grown in controlled environments do not need large root systems as water and nutrients supplies are carefully controlled. One of the critical traits for plants growing using artificial light is productivity under lower light conditions. But as most fruits and vegetables required higher light intensity and a longer time to grow. Plant factories are limited to leafy crops that required low light input (Hiwasa-Tanase and Ezura, 2016). So, attempts to improve photosynthetic efficiency to increase productivity per unit of energy input will be extremely beneficial, for plants with higher energy demands and longer growing times (Kwon and Lim, 2011). But, the mechanisms and genes that control plant productivity under low light are not well understood

Closing the loop on water, waste, and energy

Modern, high-tech greenhouses and plant factories can have a very positive impact on the water use efficiency of crop production (greater than 90%) Despommier, 2011. These efficiencies are driven by controlling humidity and temperature to optimize transpiration, on-site recycling of water including condensation of transpired and evaporated water vapor from humid air, and on-site collection of rainwater. By using fertilizer and soil amendment products from by-products of wastewater treatment processes (e.g. composted, bio-solids from conventional wastewater treatment plants, precipitated struvite) could provide a safe source of plant nutrition while also decreasing nutrient disposal into surface waters and ocean. Developing infrastructure for collecting and processing waste to ensure high standards of

Table: Technology use and food production of the recent innovative urban Horticulture practitioners worldwide.

Farm	Product grown	Production capacity	Applied technology	Other technology
Aerofarms The US	Leafy greens (has grown over 700 different crops to date.)	907,184 kg/year, 390 times higher/m^2 than conventional farming.	Indoor farming Vertical farming. Aeroponic farming	Organic seeds, LED growlight, patented reusable cloth medium from recycled plastics, smart farming technology.
Growing Underground London, The UK	Microgreens, salad leaves, herbs	700 boxes of microgreens/day	Hydroponic, Indoor, Vertical farming. Precision automation	LED growlight
La Caverne Paris, France	Organic certified product, mushrooms, microgreens, chicory	300 kg chicory/month	Hydroponic, Indoor farming, Vertical farming.	Cycloponics
Urban Farmers AG De Schilde, Den Haag, The Netherlands	Tomatoes, vegetables, microgreens, fish (tilapia)	50,000 kg of vegetables, 20,000 kg of fish/year	Aquaponic, Indoor farming, Vertical Farming, Rooftop Farming, Precision, Automation.	LED and hydroponics allows crops to grow 30–50% faster than conventional farming
Plant Lab Den Bosch, The Netherlands	Vegetables, tomatoes, herbs	Produce three times of the best greenhouse production, or up to 40 times of the open field production	Indoor farming Verticalfarming Precision automation	LED growlight, Plant Production Unit (PPU)
Badia Farms Dubai, UAE	18 varieties of microgreens	-	Hydroponic Indoor farming Vertical farming Precision automation	LED
Nuvege Kyoto Japan	Lettuce	6 million lettuces/year	Hydroponic Indoor farming Vertical farming	LED growlight
Sky Green, Singapore	Tropical vegetables: Chinese cabbage, Spinach, Lettuce	1000 kg/day produce ten times of the conventional farming production	Soil based, Hydroponic, Indoor farming, Vertical farming	Hydraulic technology for the rotation of planting systems, rotating tiers.
Pasona O2 Japan	200 species: fruits (oranges, tomatoes), vegetables (leafy greens, broccoli)	-	Indoor farming Verticalfarming Roof top farming	Building Integrated Agriculture (BIA), HEFL, fluorescent, LED growlight
iFarm Taiwan	30 varieties of vegetables, including arugula, ice plant, and mustard leaf	Produces over 100 times what a traditional farm could with only a tenth of the water	Indoor farming, Vertical farming, Hydroponic LED growlight, fertilizers from organic soybeans	

Main source Dian.T. Armanda, *et al.* 2019

food safety and reliability of quality supply, free from contamination with inorganic wastes such as glass, plastic, and metal. And by working on design systems to capture waste heat for use in building-integrated conditioned farms to help decrease the energy demand for temperature control in both the plant growth facilities and the attached buildings. There is a need for more data and careful analysis to understand the implications of different strategies to close the loop on water, waste, and energy in all farming systems, including UH. These will inform efforts to develop and implement the infrastructure and systems required to enable the reuse and recycling of resources across the food-water-energy.

Controlled environment farms are less prone to weather variability, climate change, and natural disasters

Climate change increases variability in temperatures and rainfall which trigger diseases and pest infestation and this causes difficulty for the outdoor grower. Crop failures will raise the price of fruits and vegetables. But in environmental controls conditions, it allows growers to increase yields in a given area irrespective of variability in weather. Controlled environment farms act as an alternative food supply by providing a cushion to external commodity price shocks, source of safe and unpolluted food following environmental crises (Ismail, 2015). Growing crops in controlled environment conditions increase food production by controlling temperature, humidity, and light (day length) which enabling all year round and can ensure the product is free from pollutants.

Opportunities

Urban horticulture is an important element of food security strategies. In developing countries, it contributes to livelihood (feed citizens, fight chronic hunger and employment generation) and act as an attractive approach to sustainable city environments. In developed countries, it gives citizens access to healthy and fresh foods besides countering "food deserts". Urban horticulture also contributes to ecosystem services, offers potential for recreational, tourist, and marketing purposes other than food provisioning. It affects ecological processes, dimensions in cities, increasing biodiversity, and the reduction of pollution, etc. Many urban farms are open for the public and it helps to escape stressful daily life. As a result of the high cost of urban land, vegetables with high water and fertilizer efficiency are more profitable than growing other crops, which makes urban horticulture the most competitive branch of urban farming. Crop grown in UH have special nutritional value as well as a short life span and that no further processing after harvest is needed. As production of fruit and vegetables in urban areas increases access to fresh produce of high nutritional value which impacts the quality of diets and, consequently, supports the struggle against undernourishment. Moreover, it is important for innovation, research, and knowledge development. Many high-tech urban farms use new (indoor) vertical growing technologies and closed-loop systems. Horticultural cropping systems in urban areas may be linked to the production of animal proteins in aquaculture through the use of aquaponics, where fish production is linked to horticultural crop production. Examples with such closed-loop systems are The Plant in Detroit and Growing Power Inc.

Challenges

Despite its potential for sustainability, there are several weak points regarding Urban Horticulture. Food production through urban horticulture shows obstacles at different societal levels and is strongly interrelated. Commercial urban horticulture faces a variety of challenges, which include lack of access to viable land, resources, and training. Urban farms and community gardens compete with residential and commercial developments for space, and this often proves difficult without public or governmental support. And renting land within the city constitutes a major expense for commercial urban farmers, thus making it difficult to stay profitable whilst keeping produce prices affordable. While finding equipment and tools for smalls scale production can also be a challenge and buying high-quality organic amendments at affordable prices is difficult as these products are often sold in bulk. Urban farming requires large investments for operational costs (infrastructure, energy, and management) so, it is hard for beginner urban farmers to generate sufficient income. While Vertical farming leads to high energy costs. Therefore it is nearly impossible for commercial urban farms to meet all of the goals and expectations at once, and usually, one trait is suffer. Finally, the multi-complex nature of interaction achieved through urban horticulture does not always go hand in hand with high food quality and efficient use of resources. Urban Horticulture is not

as healthy and fresh as expected. Due to air and soil pollution in cities, urban vegetable might contain high concentrations of heavy metals and new soilless growing technologies lacks sufficient natural nutrients.

Conclusion

All over the world urban horticulture has contributed to social, economic, food, and ecological sustainability. It increases community livelihood, saves energy, sustains the environment, improves health through fresh food supplies in urban environments, offers recreational and aesthetic value to urban landscapes and individual homeowners. Even thoughurban horticulture has some constraints, positive impacts predominate and most of the risks and constraints canbe eliminatedby executing urban horticulture correctly with caution. But the full potential of urban horticulture as a food and livelihood provider will only be achieved when it is integrated into consonance with urban land use planning and policy. Moreover, the expansion requires educating farmers, urban dwellers, and students and this can be achieved bylearning from the past and researching. And when these ideas are put into action, urban horticulture will contribute to food security while offering considerableinnovation potential.During the COVID-19 pandemic, people started to realize the fragility of the global food system and started to grow their produce which prevent markets disruptionsand helps with stabilizing food prices.

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