URBAN HORTICULTURE AS A FOOD SECURITY STRATEGY: A REVIEW.

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ABSTRACT
United Nation population projection estimated that the world population could reach 9.15 billion by 2050, this requires 70% increase in global food production especially in developing countries where it has to double. Presently, sustainable food supply is threatened due to exponential population growth, climate change and limited natural resources. The recent COVID-19 pandemic crisis has impacted sustainable fresh food supply and has affected the food supply chain and prices significantly. It becomes imperative and of utmost importance to secure safe and sufficient supply of affordable but nutritious food rich in vitamins and minerals to feed the populace. 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 innovations are ecofriendly, energy-saving and ensures food security through steady supplies of fresh fruits and vegetables to urban and peri-urban neighbourhoods. There is a need to integrate information technology tools in urban horticulture, which could help in maintaining consistent food supply to ensure food security, alleviate poverty, generate revenue, mitigate against climate change and improve the wellbeing of the populace in order to make agriculture more sustainable.
Keywords: Urban horticulture, food security, urban dwellers; sustainability, fruits and vegetables

INTRODUCTION
The world population is expected to reach 9.6 billion by 2050, approximately 70% of the people are predicted to live in urban areas (United Nations (UN), 2018). Increased populations in urban cities as a result of rural–urban migration will place more pressure on arable land, food, fruits and vegetables. In addition, it increases the distance to traditional sites for food (Prain *et al.*, 2010; Suman, 2019). Further to these urban problems, food insecurity, unemployment and climate change has been a global challenge (WHO, 2008). Recently, the outbreak of COVID-19 limited peoples' ability to access food by reducing income and increasing unemployment (Khan *et al.*, 2020).
Food security exists when people have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs thereby ensuring healthy life (FAO, 2008). The diets of many urban dwellers are deficient in micronutrients such as vitamin A, iron, iodine, zinc (Tenkouano, 2011). Providing adequate food, reducing environmental pollution, employment and income generation are important aspects of urban and peri-urban horticulture. Presently, there is increased demand for horticultural produce with population growth (Singh *et al.,* 2013). Fruits and vegetables are essential part of horticultural crops rich in fiber, minerals and bioactive compounds that enhance balanced nutrition.
Urban horticulture is a veritable solution to achieve a sustainable food supply and food security in cities (Amao, 2020). It involves the cultivation of fruits, vegetables, mushrooms, herbs, and aromatic and ornamental plants that can grow easily in a city and its surroundings (Jawaharlal and Kumar, 2013). Urban horticulture includes activities such as the production and delivery of inputs, processing and marketing of products (FAO, 2007). It majorly uses human, material resources, products and services found in and around urban areas and recycles the materials (Basera *et al.*, 2020). Urban horticulture compliments rural agriculture in terms of provision and marketing (Mougeot, 2000). Hence, urban horticulture provides produce that cannot be easily transported from rural to urban areas (Van Veenhuizen and Dason, 2007). The scope of urban agriculture encompasses economic activities, location, areas, scale of production and products destination (Mougeot, 2000). Cultivating horticultural food crops in urban landscapes and open spaces will improve food and environmental sustainability (Khan *et al.*, 2020). Not much has been done on the concept of urban horticulture as a strategy in hunger mitigation in Nigeria, taking into cognizance the significance and technologies to combat the challenges facing urban residents. This research therefore seeks to close this gap by reviewing the hidden potential of urban horticulture as a strategy in hunger mitigation.

NEED FOR URBAN HORTICULTURE
1. Poverty alleviation: Poverty is rampant in Africa and job opportunities are specialized outside the agriculture sector (Eigenbrod and Gruda, 2015). Urban horticulture

offers local food production and employment opportunities for the future, particularly in developing countries (De Bon *et al.,* 2010). Communities occupied with large buildings with scarcity of lands could integrate urban horticulture activities to improve their livelihoods and ensure food security (Galhena *et al.*, 2013).

2. Fighting environmental challenges and waste management: Cities are becoming more polluted due to rapid urbanization, increase in structures and industry (Khan *et al.,* 2020). Urban horticulture can help curb rising environmental pollution since plants absorb air and soil pollutants. Another advantage is reduced transportation costs because of proximity to the market where fresh food is purchased (Artmann and Sartison, 2018). Moreover, high-tech urban horticulture enhances all year-round production of food as compared to traditional methods, thereby reducing CO_2 emissions generated through transportation (Fanelli and Di Nocera, 2017). Currently, at international levels, several strategies are being adopted to reduce food loss and waste (Fanelli and Di Nocera, 2017). Waste management is another hazard that can be minimized, to some extent, by integrating horticultural plants into the urban landscape. Inorganic waste like used plastic water tanks, plastic bottles, baskets, rubber tires and polythene bags can be utilized as pots and hanging baskets filled with substrate and plants. These materials have been successfully used as growth media (Orsini *et al.,* 2009). Inorganic materials enriched with heavy metals should not be used (Smit and Bailkey, 2006).

3. Ensures food supply and sustainability: Consistent food supply is threatened due to climate change, farmers and herders conflict, natural disasters, conflicts between countries, the refugee crisis and worsening inequality (Khan *et al.,* 2020). According to the Food and Agriculture Organization (FAO), 820 million people are suffering from hunger, out of which, 113 million are at risk. In addition, the outbreak of the COVID-19 virus has further threatened the lives of millions. Due to the COVID-19 virus, urban food systems are highly disrupted. Growing vegetables in urban horticulture enables continuous supply of food with high quality (Khan *et al.,* 2020).

4. Food security and nutrition: Globally, food security is at high risk following urbanization and industrialization of productive lands (Dutt, 2020). It is expected that by 2030, world food demand will increase to 43% (FAO, 2011). As a result of this, it is suggested that urban horticulture has the potential to provide safe and abundant fruits and vegetables to meet this challenge (Saha and Eckelman, 2017). Urban horticulture could also resolve the clashes between farmers and herders in Nigeria.

5. Improvement of climate and microclimate: In recent years, many people developed interest in urban horticulture due to climate change issues and sustainable food supply in urban areas (Hardman and Larkham, 2014). Cities are being polluted with transportation, industries, and domestic activities (Hamilton *et al.*, 2014). Well planned, organized vegetation can improve the urban microclimate and significantly reduce temperature and greenhouses gases (Smith and Gregory, 2014).

6. Conservation of biodiversity: Urban horticulture makes a major contribution by balancing the ecosystem, hence maintaining biodiversity. Flora and fauna diversity are drastically reduced in cities in comparison to rural areas (Aronson *et al.,* 2014). This resulted to decrease in natural resources and affected nutrients and water cycling (Cardinale *et al.,* 2012). Green spaces in urban areas offer important refuge sites and natural habitats (Goddard *et al.*, 2010).

7. Source of recreation and reduction of gender inequality: The trend for more urban horticulture in developed countries is gaining popularity. People frequently practice horticulture on small areas of private land, home gardens, school gardens and even on leased lands (Van Leeuwen *et al.,* 2010). Gardening promotes social association and cultural activity among people. In urban horticulture, older people can engage themselves in gardening. It has been proven to reduce physical and mental stress (Lu *et al.*, 2020). Men and women working together in a good environment reduces gender inequalities. More than 65% of participants in urban horticulture are women (Orsini *et al.*, 2013). Involving women in urban horticulture empowers them to be independent (Galhena *et al.,* 2013).

8. Self-reliance and land management of cities: Urban horticulture plays significant role in self-sufficiency and making cities to be independent. They can strive to grow enough fruits and vegetables for the inhabitants. The argument is that, if cities are sustainable it means that the world would be sustainable (Ni *et al.*, 2016). Many cities are self-sufficient and independent in horticulture, while some are self-sufficient up to a certain level (Mok *et al*., 2014). In Berlin, urban horticulture was of utmost importance as it provided fruits and vegetables during a crisis of limited food (Specht *et al.,* 2015).

9. Public health: Intensified use of fertilizers has significantly increased the nitrate concentration in the soil (Gallardo *et al.,* 2005). Moreover, indiscriminate use of pesticides and its surface runoff has lessened water quality and made it more toxic to non-target organisms (Iwafune *et al.*, 2011). In this regard, urban horticulture has reduced the load of inorganic fertilizers and pesticides that can cause cancer and hazardous to human health. Hence, the use of organic foods that are natural, healthier (high in vitamins, minerals, and proteins) have been promoted. Additionally, there is more interest in indoor planting, thus providing relief, reducing stress and enhancing physical and mental

health. Indoor planting improves air quality, visual stimulation and has psychological benefits (Park *et al.*, 2016).

Challenges faced by urban farmers

Urban horticulture faces a number of challenges that are interwoven on urban development planning. Water has to be provided and waste managed in line with the economy, environmentally friendly practices and equitable sustainable management (Poverty Reduction Trust, 2019). High price of land and urban pollution restricts urban horticulture (Eigenbrod and Gruda, 2015). Lack of laws supporting integration of urban agriculture into land use planning, urban greening, urban habitat diversity, reduction in noise and pollution is an impediment to urban agriculture (Ziwenga, 2014). Urban farmers face threats from thieves, animals destroying their crops and lack funds to improve their farming (Chaminuka and Dube, 2017). FAO in 2007 summarized urban horticulture challenges into five broad challenges: lack of political and institutional recognition of urban agriculture, shortage of land and water for horticulture, lack of product quality due to poor production and crop protection management, low output due to low income and small-scale farming which lacks adequate inputs and shortage of market and poor vegetable preservation (Basera *et al.*, 2020).

Factors Involved in Urban and Peri-Urban Horticulture

1. People: Most of the people involved in urban and peri-urban horticulture are poor. In many cities, one will see lower and mid-level government officials and school teachers in agriculture, as well as richer people who want to invest. Women are an essential part of urban farmers, since cultivation, processing, selling activities, among others, can be done along with their domestic tasks (Suman and Bhatnagar, 2019). High work efficiency is attributed to women with regards to output in agricultural practices.

2. Location: Urban and peri-urban horticulture can be carried out inside the cities (intra-urban) or in the peri-urban areas. The activities may take place on the homestead (on-plot) or on land away from the residence (off-plot), on private land (owned, leased) or on public land (parks, conservation areas, along roads, streams and railways), or semi-public land (school and hospital yards). Connection with the main stream is necessary for transportation and proper handling of produce (Suman and Bhatnagar, 2019).

3. Food products: Urban and peri-urban agriculture provides food products from different types of crops (root crops, grains, vegetables, fruits, mushrooms) and nonfood products (like aromatic and medicinal herbs, ornamental plants, tree products, etc.) or combinations of these (Suman and Bhatnagar, 2019). Mostly, perishable and relatively high-valued vegetables and byproducts are favored. Production units in urban agriculture are more specialized than rural enterprises, and exchanges are needed across production units. Consumer's acceptance is key in order for any food product to become popular within the city.

4. Product market: In most cities, fruits and vegetables are produced for self-consumption, with surpluses being sold. However, provision of market should not be underestimated. Products are sold at the farm gate, by cart, in local shops, on local (farmers) markets or to intermediaries and supermarkets (Suman and Bhatnagar, 2019).

TRADITIONAL AND INNOVATIVE CROPPING SYSTEMS USED IN URBAN HORTICULTURE

Traditional urban horticulture started when people moved from villages to urban environments. Urban horticulture provides frequent supply of fresh fruits and vegetables that are inexpensive to residents. Traditional systems practiced are home gardening, community gardening, and edible urban horticulture landscapes. These systems facilitate the production of food crops on rooftops, balconies, garden plots, smaller areas around homes, along roadsides and in any vacant space in cities.

Home Gardening

Home gardening is being practiced by rural and urban dwellers, it is a common form of urban agriculture aimed at abating malnutrition and meet home food demands. This system includes mixed cropping of fruits, vegetables, trees and condiments that serve as supplementary sources of food and revenue (Suman and Bhatnagar, 2019). The advantages of home gardening are that it is near to the home of the growers, provides fresh vegetables, saves the home income spent on food (Oluoch *et al.*, 2009). It can also enhance the quality and quantity of fruit and vegetables to communities (Bohn and Viljoen, 2011). There are some risks of home gardening in urban areas with a history of use of lead-based paints, prior industrial use, or buried trash (Kumar and Hundal, 2016). However, the use of compost and mulch to improve the soil for gardening also makes them safer for food crops (Brown *et al.*, 2016).

Community gardens

Community gardening is known as the collective cultivation of plants on a shared area by a group of community members. These gardens are located in urban environments and are usually managed by the municipality. In community gardens, people collaborate with each other and share the facilities. These community gardens can be supported by private organizations or governmental programs, by providing access to seeds, water, fencing, mulch or other required materials. In community gardens, vegetables, fruits, flowers and herbs are grown in either individual or shared plots. If there is risk of soil contamination, plants can also be grown in wooden boxes, raised beds, or containers; they may also use vacant spaces (Eigenbrod and Gruda, 2015). Community gardens help to provide food to struggling neighborhoods, strengthen communities, educate people, make the city greener, promote intercultural communication, along with providing a more continuous food supply (Metcalf and Widener, 2011). In cantonments in India, soldiers produce fruits and vegetables on vacant lands transformed into farms. It has expanded the supply chain of agricultural goods and has made the city eco-friendlier (Suman, 2019).

Urban edible horticulture landscape

Edible landscaping is a holistic approach towards making urban infrastructure more sustainable. In urban edible horticulture, outdoor areas are planted with fruit trees and vegetables; this practice varies from small scale to large scale (Bohn and Viljoen, 2011). The intention of urban edible horticultural landscapes is to improve cities' food security and to connect to rural areas for food supply (Lovell, 2010). In developing and developed countries, edible landscapes can be practiced on vacant lands, green belts and roadsides.

MODERN CROPPING SYSTEMS

Poor soil and water quality are the major challenges facing urban crop production in cities. New techniques have been developed to increase yield, while minimizing environmental pollution. The innovative techniques require less space and can be adopted efficiently in urban centers. These techniques are proven to have numerous benefits and more efficient with the potential of making horticulture sustainable (Nandwani *et al.,* 2018).

Indoor growing systems

Presently, indoor crops are being grown in agricultural buildings to avoid external contamination by creating a confined environment (Specht *et al.,* 2014). Sometimes these indoor growing methods are called "Z-farming", because zero acreage is used (Ali *et al.,* 2017). Z-farming includes indoor farms, vertical green houses and edible green walls (Specht *et al.,* 2014). Nowadays, projects on Z-farming have been supported at commercial level by private and nonprofit organizations in many cities of the world (Thomaier *et al.,* 2014). The main purpose of incorporating vegetable production with existing buildings is to save resources and improve resource efficiency (Specht *et al.,* 2015). Currently, Z-farming is a major practice in Europe, Canada and the United States (Komisar *et al.,* 2009). It is a technique aimed at sustainable urban agriculture (Thomaier *et al.,* 2014), thereby providing a new path of food supply, farming technologies and improves opportunities for efficient resource use in urban spaces.

Vertical farming: an urban farming technology

This technology involves growing plants arranged in layers that may reach several stories high in controlled indoor environments, with precise light, nutrients and temperatures. This new farming technology is growing rapidly and entrepreneurs in many cities are taking an interest in this innovative farming system (Benke and Tomkins, 2017). Vertical farming can reduce the transportation costs due to its proximity to the buyer. This system needs less amount of water than outdoor farming because it involves waste water recycling (Chatterjee *et al.,* 2020). Because of these characteristics, vertical farming is widely implemented in desert and drought stricken regions, such as some Middle Eastern countries, Africa, Israel, Japan and the Netherlands (Birkby, 2016).

Living edible wall

Living wall landscapes or gardens provide an alternative green system in which plants are supported along a wall vertically. Here, there is no support required from the ground for rooting, as nutrients and water are provided within the wall. The installation of living wall systems creates healthy, vigorous and long-lasting green systems, which are resource efficient and provide sufficient space to plants and their roots to anchor (Banerjee and Adenaeuer, 2014). Vertical plantings along a wall have numerous benefits, such as noise reduction and air purification. Moreover, it plays a vital role in maintaining the ecological environment of the urban area (Van Renterghem *et al.,* 2014). Besides edible plants, evergreen plants such as Myrtle *(Myrtus communis)*, Orchid Rockrose *(Cistus x purpureus)* and Germanders *(Teucrium x lucidrys)* thrive in living wall systems (Perini *et al.,* 2011).

Rooftop gardens and greenhouses

Rooftop gardens and greenhouses are sited on the top of houses or industrial buildings by utilizing underused roof structures (Harada *et al.,* 2018). Generally, in a rooftop garden, the roof of the building is covered with substrate into which shrubs and other plants are grown (Bates *et al.,* 2013). The first rooftop garden was developed in Germany to improve aesthetics (Jafari *et al.,* 2015). In Berlin, urban rooftop greenhouses are used as they are energy-efficient, depend on local resources, and have social and educational aspects (Specht *et al.,* 2015). Moreover, these rooftops provide shade to increase cooling, evapotranspiration and provide savings on energy consumption (Liu, 2002). Oberndorfer *et al.* (2017) reported that green rooftops increased the lifespan of roofing membrane up to 40–50 years as compared to conventional roofs, which have life spans of 10–30 years, by protecting them from UV radiation and thermal stress. In addition, these rooftops have aesthetic value and increase the value of the property (Bianchini and Hewage, 2012).

Use of soilless culture

Soilless culture is the cultivation of plants in systems without soil-in situ. Instead of using soil, plants are grown on organic or inorganic substrates (Gruda and Tanny, 2014). Due to increase in soil erosion and the loss of arable land, soilless cultures will rise in the near future. These modern techniques require less water

(Chalmers, 2004) and space relative to traditional agricultural systems. Owing to their light weight and their sustainability with respect to resource use efficiency, soilless systems are suitable for urban areas. More so, there is minimal use of pesticides and in controlled environment settings, the produce are of high quality and hygienic. There is constant production during the whole year providing a consistent food supply to ensure food security (AlShrouf, 2017).

Hydroponics

Hydroponics is a technique that relies on nutrient enriched water rather than soil. Roots are suspended in water or supported by growth media (Von-Seggern *et al.,* 2015). Sunlight can be supplemented or replaced with lighting structures that supply light, usually light emitting diode (LED) lights. It is carried out in a controlled environment, hence reduced chemical or chemical-free fresh produce will be available to urban areas year-round. It is the most adopted technology in countries that are not able to grow food during the winter. This also minimizes the threat of destructive pests and pathogens (Goddek *et al.,* 2016). Furthermore, the produce is free from dirt and animal waste. This system has several benefits over traditional soil culture as it requires less maintenance, weeding, tilling, is labor- and time-saving as nutrients and pH are easily managed under this system (Al-Kodmany, 2016; 2018). Under ideal conditions with adequate nutrient supply, the produce is uniform and yield optimally.

Aeroponics

Aeroponics is a vertical farm technique whereby 90% less water is used in comparison to hydroponics (Birkby, 2016). Under this system, vegetables, flowers and fruits can be easily grown as mist is applied within a chamber to the living roots. Plants grown under aeroponic systems have higher nutritional quality as a result of mineral absorption (Boston, 2014). This technology is also beneficial for raising a large number of plants in limited spaces. Under this system, the plants are arranged in a tubular frame or are suspended in a container, so it reduces the use of floor space.

Aquaponics

Aquaponics combine hydroponics and aquaculture practices (Perkins, 2013). In addition to producing healthy plants, the aquaponics system can also produce fish. Aquaponics only uses 2% of the water unlike traditional soil-based agriculture, since most of the water is recycled. It is a closed loop system with reuse of waste from the fish used as fertilizer for the plants (McCollow, 2014). The hydroponic beds include exchange filters, which sieves harmful acids, chemicals and gases. Gravel used in aquaponics provides habitats to nitrifying bacteria that enhances water filtration and nutrient cycling. Aquaponics has the potential to become a model of sustainable food production by achieving the 3Rs (reduce, reuse and recycle) (Diver, 2006).

Organoponics

Organoponics involves cultivating plants on organic substrates using seedbed formed by mixing soil and organic matter in the absence of artificial chemicals. This technology uses soils with low fertility, is appropriate for developing countries and for those areas that have less access to fertilizers. The system is eco-friendly and is suitable for urban horticulture as well. The demand for organic food is increasing (Yue *et al.*, 2008) and the global sales of organic foods has risen to $97 billion annually (Willer and Lernoud, 2016). As such, organoponics plays an important role in the production of horticultural crops especially in cities.

SMART CITIES AND URBAN HORTICULTURE

A smart sustainable city is an innovation that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and service. It is targeted at meeting economic, social, environmental and cultural needs of the present and future generations (UN, 2016). Cities are getting smart because of information technology solutions that enable efficient functions in real time (Batty *et al.,* 2012). Possibilities include more use of cell phone "apps" to provide real-time information required for optimal crop management and remote control and monitoring of climate controlled facilities. Food supplies could be vulnerable due to a multitude of factors, e g., climate change, impacts on rural crop production, supply chain disruption, and commodity price upsurge (Berti and Mulligan, 2016). Recently, COVID-19 pandemic has limited the food supply chain, as some shopping malls and markets were closed and there was some panic when purchasing through visiting markets. Purchasing fresh fruits and vegetables online have somewhat resolved this issue. This latest digital technological innovation can help farmers cope better with any future crises to the food system, by making agriculture more productive (Linn *et al.*, 2020).

CONCLUSION

The trend of population concentration in urban areas has created problems, such as a reduction of farmable land, malnutrition, pollution, unemployment, food scarcity and increased distances to traditional sites of food production. Adequate measures are urgently needed to combat the challenges associated with rapid increase in urban population. Urban agriculture can play a vital role in providing solution to these problems. Exploring the potential of urban horticulture through protected cultivation, hydroponics, aeroponics, aquaponics, organoponics, home gardening, roof top gardening could play a pivotal role in climate change mitigation and adaptation, create employment opportunities, improve the health and diet of the people, provide sustainable food supply to urban dwellers, as well as provide environmental protection and enhanced food security. It also offers recreational and aesthetic value to urban landscapes and individual homeowners as well as reducing mental stress. Increased awareness among urban and peri-urban people about the health benefits of fruits, vegetables and other food items and their availability with regard to their nutritional value could inspire the city dwellers towards positive approach in context of horticulture for human health wellness for nutritional security.

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