Designing Urban Farms in Densely Populated Cities

LWS 548 Major Project

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Executive Summary

The global population is increasing so is the demand for the food supply. The settlement of more than half of the population in urban cities and the modern lifestyle has indirectly contributed to disturbing climate norms. Looking at the situation, urban farms can be a possible solution for improving the landscape of cities. Allocation of productive infrastructure can likely be an effective solution to achieve the long-term goal of sustainability.

This paper focused on analyzing the potential of designing urban farms in a network of densely populated cities. The study examined integral benefits and challenges associated with the establishment of urban farms in densely populated cities developed and developing cities. Additionally, it focused on explaining the importance of designing and planning tools by reviewing all the factors of consideration at a spatial scale with a complete description of possible designs. Lastly, based on the synthesis of the dataset collected, research, and case studies, it suggests that the contribution of urban farms has a positive impact on eliminating food hunger in the future.

INTRODUCTION

The world is expected to face **a global food production crisis** due to the rapidly increasing population and climate change (Tomazin, 2019). To meet the growing demand for sustainable resource management, agriculture production needs to be significantly increased. Therefore, to counter the global food crisis, urban farming has been suggested as a possible solution (Miccolia et al. 2016). Urban farming is defined as the growing of plants including trees within or at the fringes of cities with planned input provisions, processing, and marketing services (Smit et al. 1996). This allows the placement of green space in the urban environment and integrates natural cycles with existing infrastructures (Viljoen et al. 2005). This infrastructure also provides potential opportunities for business, architecture, and economic development and acts as social, environmental, and economic pillars for developing sustainable cities (Pfeifer et al. 2015)**.**

Urban Farming can help combat major developmental challenges such as rapid climate change, and lifestyle changes. Furthermore, it helps in increasing the biodiversity in the cities (Steel 2008). The designing of urban farms in developed cities is usually associated with lifestyle, health, community development, and innovation. However, in developing countries, they must be designed also to meet the energy demand of the rapidly growing population (Tornaghi, 2014). Overall, the motivation globally for developing urban farms is to overcome the predicted crisis caused due to climate change, urbanization, and increasing population. Moreover, increased dependency on industrial-based food or processed food is also igniting a movement of discovering an "Alternate Food Production System" mainly urban farms in city fringes (Agymann, 2014). Globally, numerous developing and developed cities are now investing in urban farming initiatives to develop sustainable and self-sufficient cities, for instance, Gotham Green Rooftops have been established in Central New York and Indoor Office farms in Tokyo (Cockrell et al. 2012).

However, the introduction of these farms requires strategic planning and designing. Development of these farms can be done at varied spatial levels, starting from small yards in the local neighborhood to the large commercial urban farm that can feed larger communities (McClintock 2014). The Research and development strategies, design, and innovation have made it possible to grow food in, on, and around the building in compacted areas using soil or soil-less nutrient cultures (Thomaier et al. 2015). They can be established indoors and outdoors to achieve ecological, social, and economic benefits (Lin et al. 2017). Certainly, using current technology and

designing tools, prototypes can be created, and old buildings can be transformed into local urban farms (Nasr et al. 2014). This sustainable adaptation improves environmental quality, strengthens the urban community, and constructs a green economy.

They encourage a circular economy i.e. reuse & recycling of waste. The urban waste is composted and efficiently reused as a substrate for crop production (Ackerman, 2012). Moreover, various urban farm designs such as green roofs and community gardens help in stormwater management, reducing the heat island effect and increasing the infiltration of excess runoff (Zeeuw et al. 2011).

It is also recognized as an alternative to the current agriculture system that depletes soils, overutilizes freshwater resources, and synthetic fertilizers, and causes groundwater and aquatic habitat degradation. (Pual et al. 2012). Subsequently, Urban farms generate green jobs and support opportunities for work and education along with improving the livability of the community. For instance, urban farms help in accessing fresh food locally and reduce supply chain losses (Proksch et al. 2017). Thus, these green pockets in urban landscapes are the base for enhancing the quality of life, and use of the environment for mental as well as physical well-being (Bu et al. 2021).

PROJECT OBJECTIVES

The main objective of this report was to identify "the potential of developing urban farms in densely populated cities" and provide recommendations on designs that promote urban food security, efficient resource utilization, and a circular economy.

Addressing this goal, the following questions are addressed:

• What are the potential benefits and challenges of establishing urban farms for developing sustainable cities?

- How can urban planning and designing tools help in constructing urban farms in old buildings and densely populated city structures?
- What type of design promotes food security and a circular economy?
- Can urban farms help in eliminating the urban hunger of the urban community?

METHODS

A systematic review of the published and unpublished literature research papers, articles from credible journals, books, newspapers, and case studies of urban farms established in densely populated cities was evaluated. In addition, datasets were gathered from government websites, and reputed agencies to seek help from experts and professionals in the urban designing sector and land use planning sector.

The research focused on identifying the following areas:

- The potential economic, social, and environmental benefits of designing urban farms and the associated challenges of establishing these farms.
- Elaborated the analysis of the use of designing and planning tools for integrating agriculture with urban spaces with case studies.
- Detail descriptions of suitable urban farm designs that promote food security and a circular economy.
- Summarized dataset to explain the contribution of urban farms in eliminating hunger.

LITERATURE REVIEW

A. Potential Benefits of Designing Urban Farms

There are multifarious social, economic, and ecological benefits to designing urban farms in developing cities.

Ecological benefits

Urban farms on the one hand are helping to fight climate change and promote food security they also serve additional benefits like increasing biodiversity, reducing pollution, and sequestering carbon (Masi, 2014). These green areas act as cushions that reduce the impact caused by s heavy precipitation in the cities and the load on the waste treatment plants (Freshwater Society, 2013). Edible plantings help reduce the average high temperature in the cities to 36% by maintaining a cool microclimate through evapotranspiration (Zeeuw et al. 2011).

Presently, the major ecological benefit of well-designed, high-technology, and closed-loop urban farms is that it indirectly links the agriculture and allied manufacturing industries together (Smeets, 2009). Such as the "heat-roundabout" project launched in Rotterdam that interlinked industries to create a closed-loop system. The planners here connected the greenhouse gas-producing industrial firms in the ports to urban farms in the Westland area. The innovative approach reutilized the gases from the industries for food production. Similarly, the organic waste produced in cities can be recirculated to produce the soil for growing food in urban farms which prevents the biodegradable waste to move to landfills and the potential release of methane and greenhouse gases (Viljoen et al. 2015). Other aligned benefits are that urban farms attract pollinators, and beneficial insects and protect cultural and heritage crops (Lovell, 2014 P3).

Social benefits

Urban farming is an important pillar of urban food security strategies in developing countries. They aid in fighting chronic hunger and support the low-income local community. For instance, A study by Morgan in 2009 found that the integration of urban farming in planning strategies to combat food insecurity helped nations like Uganda (Kampala) and Tanzania (Dar es Salaam) to fight the prolonged stress of chronic hunger and helped the low-income neighborhoods to access food as the grocery outlets were too expensive and the markets were limited (Morgan, 2009). Furthermore, when focusing on Fortuner cities like New York, Chicago, Toronto, Netherlands, and London urban farms can act as readily available sources of healthy and fresh food within a few miles of the city (Cockrell & King, 2012).

A review by Masi et al. 2014 analyzed that urban farming helps in promoting social cohesion. Urban farming act as an epicenter that provides skilled training to unemployed workers and indirectly also reduces social crimes (Dimitri *et al*. 2015). Many intercultural urban farms in Berlin such as Growing Power Inc., a youth training center, and in Clevland: The Refugee Empowerment urban farms are successfully helping the urban youth to engage in training, become skilled, and return to society (Miller, 2014). Also, urban farms like "Uit Je Eigen Stad" (From your City) present in Rotterdam are used for educational purposes. They offer internships, courses, and workshops that encourage young minds to work (Van den Broek, 2013).

Economic benefits

Urban farms have huge economical potential. When constructed at the site and neighborhood scale, it provides economic support to the producers and local enterprises. But when expanded to commercial-level urban farms additional income investors through recreational and tourism (Tuijl E.V., 2018). To exemplify, rooftop farms like the one in Brooklyn are open to the public, where tours are organized, agriculture lessons are provided for the locals paying a fee organizers gain profits through selling produce as well as through recreation (Van der Valk, 2012).

Also, high-tech commercial farms, are essential for innovation and research. On-site research and Development Labs, on the farms release new products that are sold at premium prices to consumers (Terneuzen, 2016). One likely example is Urban Farmers AG, which expanded its Research and Development labs and rooftop farms to commercial office buildings in the Netherlands in 2016 Urban Farmers AG's investment in growing technology is profitable because of its premium products (Van der Heijden, 2015).

B. Challenges of Designing Urban Farms

There are several challenges in developing urban farms. Importantly, urban agriculture has a huge initial investment and operational cost. It involves the lifetime cost of maintaining infrastructure and timely marketing (Van der Valk, 2012). With increasing urbanization, there is potentially a lack of availability of land. For instance, developing nations like Lagos (Nigeria), Ouagadougou (Burkina Faso), and Mumbai (India) find it difficult to allocate farming resources between densely populated buildings (UN 2012).

According to research by Dimitri et al. (2016), urban farmers initially might fail to gain enough income. Therefore, losses may disturb the financial grid. Furthermore, urban farming is not a new concept. Many investors in developed and developing countries have adopted this concept but due to knowledge gaps and financial losses, many farms had to shut down (Steel, 2008). For example, the first commercial farm constructed in the USA in the early 1970s, due to a lack of market demand for the product had to shut down by the mid-1980s (Kozai, 2013).

The study by Vaneker (2014) suggests that consumers avoid buying produce from urban farms, thinking it might be contaminated and toxic due to high levels of air pollution which is also a major barrier. In addition, research by AD (2015) described that urban farming in combination with livestock rearing (pigs) in Rotterdam led to a huge protest in 2014 in the city when the odor from the livestock disturbed the surrounding living and working community a serving challenge of urban farming.

C. Utilization of Designing Tools in integrating agriculture with urban spaces

Urban farms in cities may be developed for commercial as well as non-commercial activities and can be designed in indoor and outdoor spaces. The adoption of urban designs such as hydroponics, Zero Acreage farms, green roofs, greenhouses, living walls, and Agro parks can be done in indoor and outdoor spaces in densely populated cities and a combination of different designs is possible depending upon the scale of expansion, finance, and space (McClintock, 2014). For instance, zero-acreage farms can be integrated with community gardens on the roofs.

However, there are different factors to be considered factors such as scale, location, management and organization, strategic focus, and market dimensions (commercial vs non-commercial) when deciding the design of urban farms (Lupia, 2016). Tuijl E.V. (2018) states that locational dimension and strategic focus are the two major factors of consideration. The locational dimension focuses on the location of the Urban farm in the cities and the strategic factor concentrates on the purpose of constructing a urban farm along with the market orientation, and the products it is generating. For instance, the purpose of designing urban farms in developed cities is for leisure, recreation, and instant access to fresh produce whereas in developing and underdeveloped cities, the motivation is to use food to eliminate hunger and process it for value addition.

Designing based on the locational factor

- Urban regions and Peri-Urban regions

  Urban farms located in metropolitan urban regions of developed cities such as New York, Singapore, Paris, and Germany can be considered centric examples that have the potential to supply fresh produce to urban dwellers. For instance, the Gotham Green Farm in New York. Wherein, the urban farms are found in peri-urban regions designed as Agro Parks. Logistically, they are constructed near highways and airports. The major focus of these

designed Agro Parks is to grow fresh produce that can be easily transported to urban centers (Van Den Broek, 2013). One of the famous examples of these located peri-urban Parks is Bio Park Terneuzen in the Netherlands. The company uses the heat and CO_2 produced by the industries in urban centers to produce fresh vegetables to feed the community.

- Wasteland and old build structures

There have been many small-scale initiatives done in the abandoned lands of urban centers to design urban farms. One such example is the "Guerrilla Gardens" designed at the former industrial lands of Detroit (Tracey, 2013). This Urban Farm initiative fulfills the social and commercial needs of the community as it generates work for the large unemployed sector of the associated community and aids in generating income through the sale of the produce (Cockrall- King, 2012). Another example is the use of a large vacant community swimming pool in Rotterdam as a mushroom farm (Cox and Slegers, 2014).

- Indoor and Outdoor Layout

Designing the layout as indoor or outdoor is another important aspect of designing urban farms (Tuijl E.V. et al. 2018). Modern technology and high-tech systems have enabled the establishment of agriculture plantations inside buildings through the use of modern installations and equipment such as LED lights (Kozai, 2013). For instance, modern indoor farms such as Vertical Farms and the Plant Factory with artificial lights (PFAL) use an artificial lighting setup for the cultivation of the crops. Other examples are the Sky Green Farm Vertical Farm in Singapore and The Plant in Chicago.

Designing Based on Strategic Purpose

Some urban farms are used solely for commercial agriculture activity while other urban farms are constructed for education, research, development, and leisure purposes (Thomaier et al. 2015). According to a study by Cockrall- King, 2012 Urban farms in suburbs are usually constructed for meeting social and environmental goals such as increasing social cohesion, education and learning, health care, climate protection, and greening cities. Whereas, the new high-tech models of urban farms in developing cities focus on combining food production with economic activities, such as a combination of restaurants and processing centers with rooftop gardens and vertical farms (Torreggaiani, 2012). As an example, Agro Farms in parts of China grow multiple valued crops

and those farms are used also for leisure purposes (Yang et al. 2010). On the other hand, The Plant in Chicago, an aquaponic farming center has a vision and purpose to promote zero wastage and education (Vijoey, 2017).

Case Studies

Gotham Greens Rooftop Farms

Gotham Green established its first hydroponic rooftop house in 2009 in partnership with Whole Foods Market and has currently expanded to three greenhouses in New York and one in Chicago. It was one of its first commercial-scale hydroponic rooftop farms established in New York.

Source: Gotham Green Urban Farms (Proksch, G. 2017). Creating Urban Agricultural Systems: An Integrated Approach to Design. United Kingdom: Routledge.

This established greenhouse at the top of the supermarket of 15,000 ft produces annually 30 tons of fresh vegetables including lettuce, basil, and other leafy green veggies. This well-designed high-tech farm saves around 4 million liters of water per year and uses 20 times less water than conventional farms (Proksch, G. 2017).

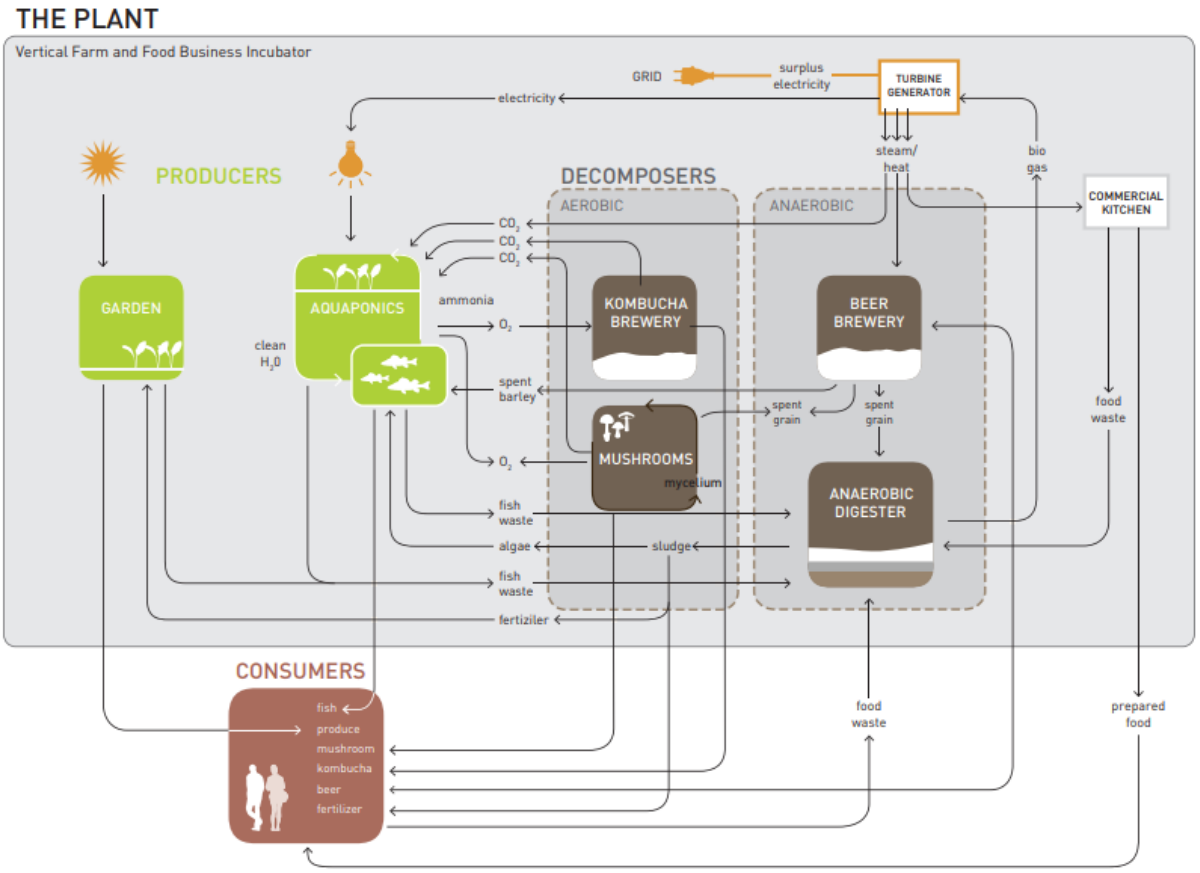
Basic Design of the high-tech Farm Gotham Farm

Support Structure	Steel frame and aluminum frame
Cover material	Glass
Growing Method	Recirculating hydroponic, high-wired aggregate, and drip irrigation
Energy Input	Solar radiation, forced ventilation, cooling, heating, energy curtains
Yield	50-70 kg/m2 lettuce
Investment cost($/m2)	300-500

The Plant, Chicago (An Integrated Vertical Farm Design)

The Plant is a nonprofit aquaponic urban farm that has been operating since 2010. This indoor urban farm is at 90,000 ft2 and indoors produces year-round leafy vegetables. This urban farm was constructed by transforming a former meatpacking facility into a vertical farm. The innovative mission of the founder, John, Edel, was to develop a closed-loop system that promotes sustainability, research, education, and development. To serve the major purpose, the founder, developed an approach where waste produced by one tenant is used as energy by another. The operators created an ecological network of producers, consumers, and decomposers who work in an integrated manner to use energy efficiently. One-third of the space in the building is under aquaponic and two third a is under the food business which includes the mushroom farm, bakery, brewery, and commercial kitchen.

The aquaponic growing beds are located in the basement of the building. The food produced through aquaponics is either used in the commercial kitchen or the neighborhood. Also, the mushroom farm is in the same building which uses in-house compost. After the harvest of the mushroom, the substrate is used as the soil in gardens.



Source: Integrated loop of The Plant (Proksch, G. (2017).

D. **Utilization of Planning tools in integrating agriculture with urban spaces**

Planning tools are equally relevant for the structural preparation of land use (Dowall and Giles, 1997). Structural planning helps in developing a broad framework that aids in the development of the infrastructure and meets the demands of the community including employment and markets. The action plan, therefore, includes the opinions of the general public, stakeholders, and decision-makers (Dubbeling, 2009).

In the last century, various planning policies and strategies have been laid out that promote creating a sustainable productive landscape (EU, 2008). The programs like “Cities Farming for Future” ensure the development of sustainable urban farm designs at the house, site, cluster, and neighborhood levels (Viljoen, 2017). For example, developing cities like Colombo (Sri Lanka) strictly followed the CFF action plan and collaborated with architects and stakeholders to include urban farms in every new building, lane, and house. Likewise, in Rosario (Argentina), the local

government has laid out policies that invite investors and experts to construct multifunctional parks that not just produce food but also may be used as playgrounds, gardens, and facilities to capture stormwater (Viljoen, 2017). Similarly, along with government policies, some research groups like the Sustainable Food Planning Group and Industrial programs like Purefood, Foodlinks, and Suschain support urban farming practitioners by providing funding, promoting cross-disciplinary dialogues, and disseminating knowledge and research findings that inform the farmers about available resources.

D. Designs that Enhance Food Security and Circular Economy

Urban farms bring significant alterations to the urban landscape. However, the benefits derived from urban farms depend upon the scale of the establishment. Depending on the space, available on urban farms can be constructed in a room or a floor, a complete corridor, or a building.

Site-specific designs

The site-specific designs can be expanded at a horizontal or vertical scale. The horizontal expansion involves the conversion of a site or building into a rooftop urban farm or greenhouse. Whereas a vertical expansion of farms involves creating screen-like permeable spaces such as hydroponics, aquaponics, and living walls (Viljoen, 2017). Both horizontal and vertical expansion are more or less confined to private areas at a site scale. Lack of space in dense cities has led to the exploration of vertical intensification of these designs (Viljoen, 2005).

Horizontal Expansion

Open-air rooftop gardens

These are isolated and elevated green designs established horizontally to produce food within the city. The underused urban roofs are transformed into vegetative areas. Urban productive green roofs offer multiple benefits for instance rainwater retention improvise the microclimate of urban habitats (Proksch G. 2011). These high-tech designs are now prevalent in developed cities, especially in New York. Also, they are established at small scales with low-cost equipment in developing cities (Despommier, 2010). One famous example of a low-cost rooftop project is the micro rooftop gardens of Kathmandu (Nepal) established for research to monitor the impacts of urban agriculture on climate change adaptation and mitigation. The researcher concluded that these

small farms can cumulatively have the potential to balance urban heat and protect cultural crops that ensure local food security in the cities (Dubbeling and Massonneau, 2014).

Source: ENPHO (Rooftop Gardens in Kathmandu (Nepal)

Greenhouses

A wide range of greenhouse designs can be constructed ranging from high tech to low tech at a site scale. The low-tech greenhouse structure usually uses solar radiation as a resource for the growing of the crop but a high-tech greenhouse needs investment to maintain certain growth conditions (Mandel L. 2013) and usually operates with a computerized system. The main benefit of growing food in the greenhouse is that with passive zero-cost solar energy and high-tech technology design the overall output increases concerning space (Proksch G. 2011). Undeniably, greenhouse fosters more energy utilization in a small available space and is a viable option to grow food in densely populated cities with limited space.

High-tech Venlo-style greenhouse

SOURCE: The High-Tech Venlo Style Greenhouse (Proksch G. 2017)

Growing Balconies

A high-tech prototype design called Growing Balconies was first proposed in the dense city of London to create a productive green infrastructure. These balconies can be designed to give people easy access to nature. Therefore, they are an integral part of urban green infrastructure in densely populated cities now in many developing and developed cities. According to Brodka et al. (2020), many small towns in Poland are using the balconies of detached houses and blocks for growing food. The planned distribution of plants is done in the space where 33% of the plants are grown in balconies and 51% are placed at the block of the flat.

Source: Bohn & Viljoen (2009)

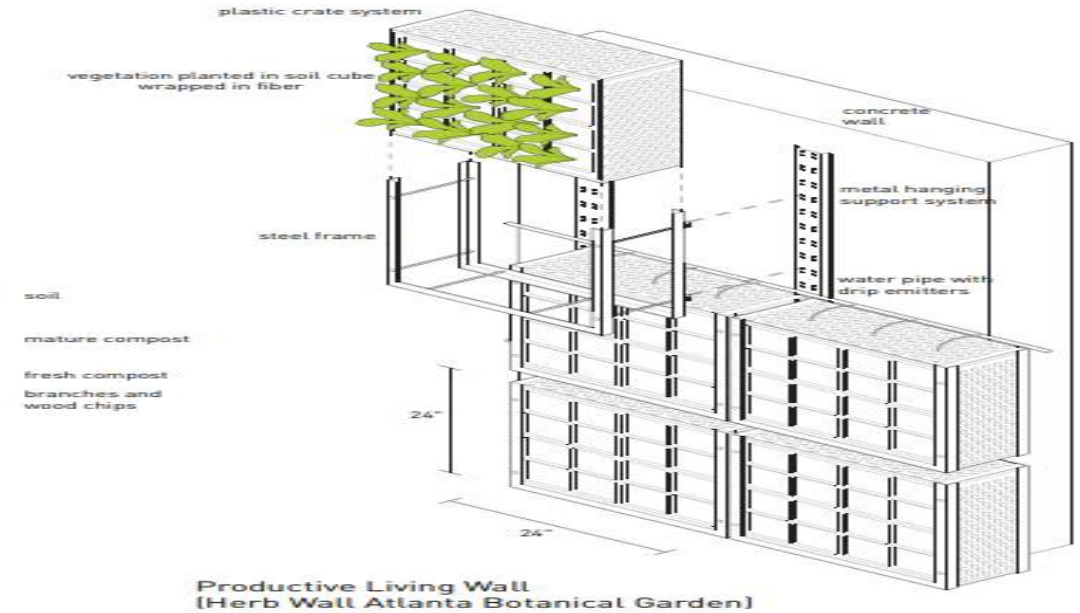
Vertical Expansion

Green Facades

A green façade is a design that makes maximum use of space vertically. It involves the cultivation of vines, climbers, or fruit trees that spread along the wall. Soil is used as a nutrient medium for growth and the roots and stems are supported at the base by trellis structures. Perennial plants such as grapevines and climbing beans, which take at least five to six years to fully spread vertically over the wall are used under this design (Graaf P. A., 2012).

Living Walls

In this unique design, the pre-vegetative wall panels are employed vertically like a blanket with additional support on the walls. Plants in these living walls are supplied water and nutrition through the drip irrigation system. However, research by Proksch G. (2017) suggests that the major challenge is the equal distribution of water in vertical cultivation systems**.** This method of designing was adopted in Atlanta's Botanical Garden where 16 different forms of culturally important herb species are cultivated on 24 inches of square metal frame it makes the best use of space and resources but quantified production using this design is still questionable (Smil 2000).



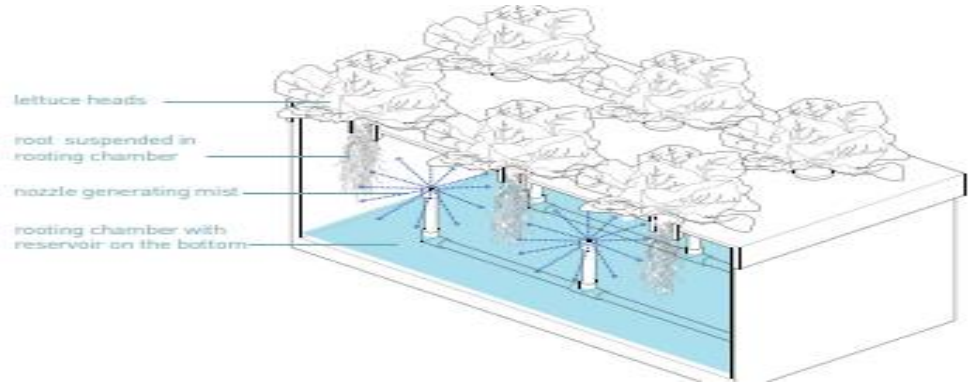
Source: Structure of Productive Living Walls (Proksch G. 2017)

Hydroponics

These are the soil-less planting design that uses nutrient-dissolved water culture for the growth of the greens. In many urban agriculture projects, a recirculating hydroponic system is employed that potentially moves the nutrient solution within integrated building systems (Resh et al. 2017). Analysis by Bernstein (2011) stated that crops grown in hydroponics produce higher yields than one grown in soil that uses more space and time. The researcher clarified that the major reason that accelerates the growth rate was the controlled growing environment with regulated nutrient injection.

Aeroponics

The aeroponic design is one of a kind of hydroponic design that sprays the plant roots with a mist of the nutrient solution. In this indoor crop cultivation system the plant roots are enclosed in a rooting chamber or a A-frame box. This vertical growing design at a commercial scale, is usually used for the cultivation of lettuce and herbs. Tower gardens like aeroponic designs are laid out where 5-7 feet of tubes suspend vertically in a small growing space to produce yield (Jeavons J., 2002).



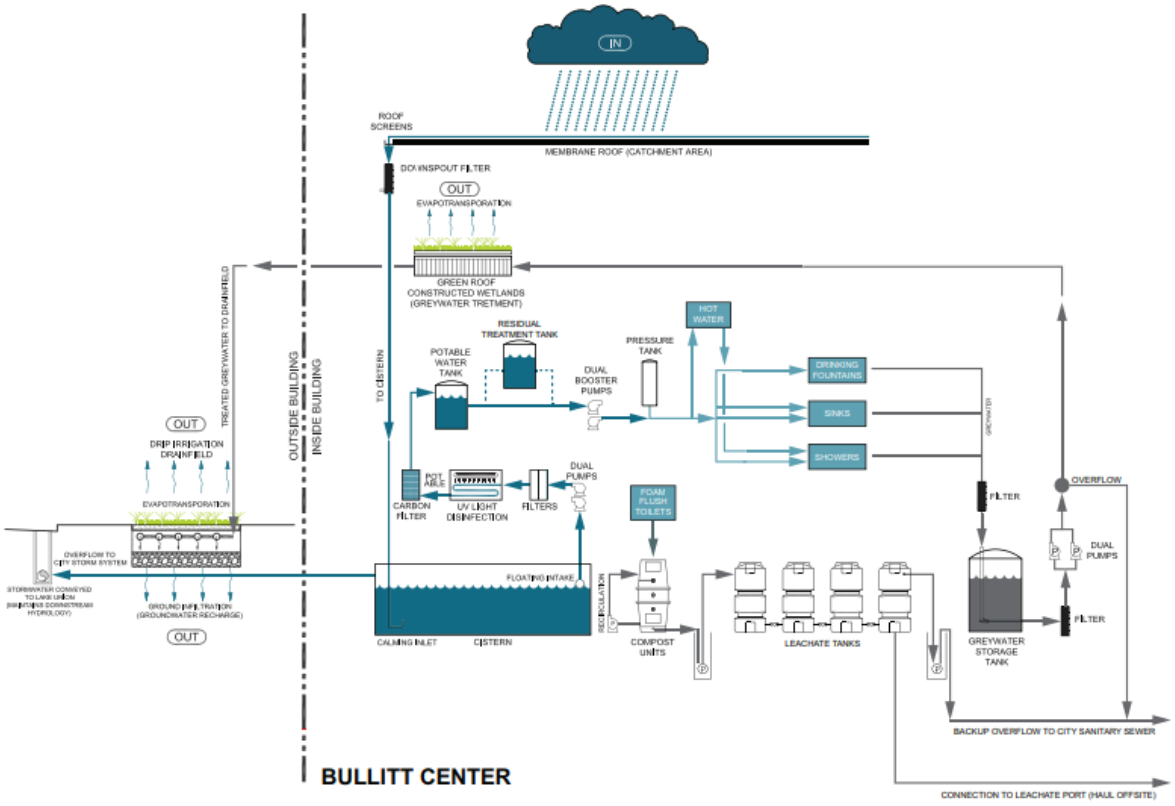
Source: Aeroponic Chamber (Proksch G. 2017)

Neighborhood-scale sustainable designs

Building Integrated Agriculture (BIA) design

Weber Thompson proposed an award-winning design to improve resource efficiency and reduce the wastage of water. The motivation for constructing this neighborhood-scale design was to produce maximum food from a small space by recirculating and reusing the treated rainwater,

greywater, and wastewater for household purposes (Eco Laboratory, 2016). In this integrated design, rainwater is collected and purified using UV filters and later used as potable water. On the other side, the collected grey and the blackwater are treated through the wastewater treatment system and used for agricultural purposes. Additionally, the methane produced through wastewater treatment plants is used for heating and electricity purposes. This closed-loop sustainable design integrates agriculture production with water recycling (Gould D, 2012).



Source: The Layout of Building Integrated Agriculture Design (Proksch G. 2017)

Permaculture

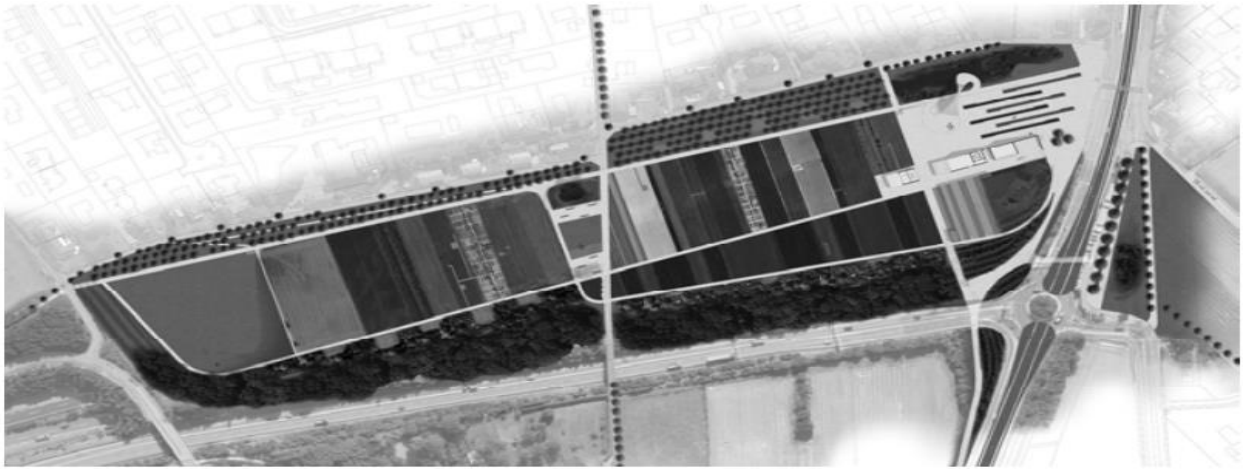
The permaculture design was developed by Bill and David Holmgren in the 1970s in Australia where they integrated high-yielding crops with trees and shrubs. (Hemenway T., 2009). The farm in the urban centers was arranged horizontally in four to seven layers composing shrubs, crops, rhizomes, and diverse tree species. (Mars, 2005) This polyculture design stimulated a beneficial

relationship that minimized input cost, promote food security, handle waste, and improves the aesthetic and ecological condition of an underused and degraded urban space.

Permaculture designing in urban corridors in South Devon, UK (Hemenway T. 2009)

Agro Parks

Agro parks are well-designed spaces in the cities that are completely devoted to the cultivation of crops. One such famous nine-hectare park exists on the outskirts of Geneva. This agro park named Pac Agro Urbain de Bernex et Confignon has been strategically designed by Verzone Wood Architects at the municipality boundaries. It is Europe's first Productive Park known to connect the city with Farms. It connects the crop fields with market spaces and leisure spaces. The linear Urban farm design maintains biodiversity, efficiently utilization of space and significantly supports the poor for food in the community (Viljoen, 2017).



Source: The Parc Agro Urbain de Bernex et Confignon, Geneva (Switzerland), Verzone Woods Architects (Viljoen et al. 2017)

Community Garden

Community Gardens have been a traditional and nonmechanized design that makes use of underutilized spaces to bring together the community, enhance biodiversity and improve local food security. Prinzessinnengarten a community garden located in Berlin; Germany is one great example that grows around 500 varieties of crops. Society's participation in the community has helped transformed the underutilized space in the city into a food and knowledge-sharing hub. The research by Proksch G. (2017) reported that community gardens like Prinzessinnengarten foster a culture of food safety, preparation, and communal consumption.

Source: Container based Prinzessinnengarten at Berlin, Germany (Proksch G. 2017)

City scale designs

Organoponics

Construction of this design involves establishing raised beds on paved and concrete areas. To speculate the potential of this design the Cuba Laboratory of Urban Agriculture, constructed organoponics at paths, edges, and various topographies of the city. To test the design for resource efficiency they used urban waste as substrate and examined that organogenic were able to produce 80,000 tonnes of food per year using 1000 tons of urban waste (Viljoen and Howe, 2005).

Continuous Productive Urban Designing (CPUL)

Continuous Productive Urban Landscape designing (CPULS) converts unused spaces into productive Landscapes with a focus to develop and build a climate-resilient and self-sufficient city (Bohn et al. 2014). The CPUL design enhances the green infrastructure in the cities by planting productive crops around the densely populated buildings. This design strategy was first adopted at the city scale in Bobo Dioulasso in Burkina Faso. They constructed 1.65 km of long green corridor in the previously existing vacant spaces in the city. They divided the land into four zones. Part of the zones was used for growing food and the rest was used for forestry, recreation, and education. The design used minimal resources for instance only planting beds and fields were created on the vacant pathway which in the long term was proven to be beneficial for the community (Sy et al. 2014).

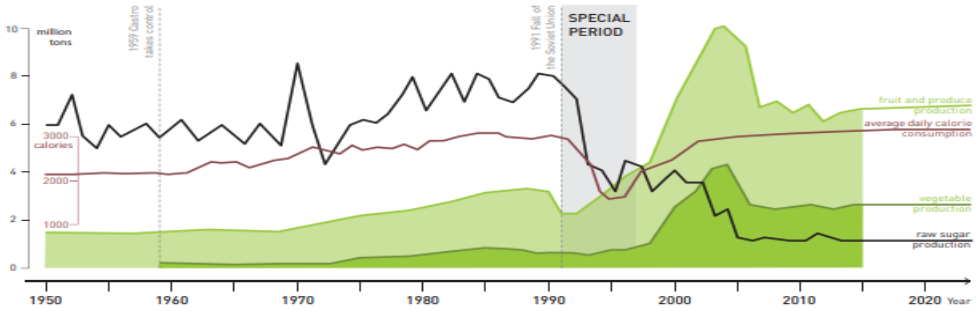
F. Can urban farms help eliminate food insecurity?

The complete elimination of hunger is a huge question, but the efficient use of underutilized spaces can help reduce food hunger to some extent. Quantitative research by Clinton et al. (2018) analyzed factors such as global population, urban, meteorological, terrain, and Food and Agriculture (FAO) datasets and estimated that the existing vegetation in urban areas is currently producing around $33 billion of food annually but if the total underutilized area is converted to a productive landscape, it can potentially increase the global food production to $100- 180 million tonnes annually with saving energy of up to 14 to 15 billion kilowatt hours, nitrogen sequestration

between 100,000 and 170,000 tonnes and avoid a stormwater runoff between 45 and 57 billion cubic meters annually. The study concluded that instead of stating 100% elimination of food hunger the potential exploitation of unutilized land in urban areas can reduce food hunger. Similarly, a Research Professor from Australian National University in his study concluded that "Urban farming might not feed the world but it can reduce hunger and increase the natural capital of the cities to a great extent"(Crawford, 2018). Likewise, the owner of the famous Gotham Green Farms stated that " Urban farms can't replace traditional farms but contribute to the food supply chain" (Crawford, 2018). Currently, many countries worldwide are generating policies such as one passed in the USA the Urban Agriculture Incentive Zone Act. This policy promotes the development of urban farms in urban plots and in return offers tax rebates. Similarly, in Cuba, major alterations made in the national policies helped in fighting urban hunger and helped to make the cities more food secure:

G. Case study

Cuba was always dependent on imported food but with the fall of the Soviet Union in 1991 it lost its primary importers of food. Before 1991, Cuba used to import 63% of its food and 90% of its oil from the Soviet Union. After 1991, the Economy collapsed, and urban dwellers faced a huge shortage of oil as well as food. Looking at the growing food hunger, Cuba's government prioritized food insecurity as a major issue and amended its food growing and land use policies. The major change that the government made in the land use and food distribution policy was that the government vanished the role of an Intimidator. Earlier the farmer had to have approval from a government body and officials before they brought their produce to the market but this policy encouraged them to grow food in underutilized spaces of the city and sell the produce directly to the consumer by setting up farmers markets. Additionally, the government made policies to incentivize the farmers that produced food organically. Especially, the capital of Cuba, Havana worked on the issue by adopting Organoponics- a specific design of the farm's farm. Different forms of Organoponic designs were established on site, neighborhood, and city scale and those farms were operated by locals, business personnel, and government. Within 10 years, the cities became self-sufficient and started producing 58% of countries vegetables. According to one of the reports, the city now grows 90% of its food by using organogenic.



Source: Dataset of food production in Cuba (Proksch, 2017)

H. CONCLUSION

The unprecedented shift of people to urban areas in developing countries has resulted in a great challenge of food insecurity in urban centers. Designing urban farms help connect the urbanities to nature, minimize food crisis, and maintain the environmental infrastructure coupled with other important social and economic benefits. Despite several benefits, there are major challenges such as investment and operational costs, knowledge gap on the allocation of resources, poor design, and physiological barriers that limit success.

However, the use of designing and planning policies can make a profound effect and contribute to the establishment of a productive landscape in cities. Bridging designing strategies, planning, beneficial dialogue with stakeholders, and knowledge sharing can create for best utilization of unutilized space. Intra- urban spaces whether horizontal or vertical can be used at varied spatial levels (i.e. site, neighborhood, and city scale) to create sustainable structures. At a site scale, rooftop gardens, greenhouses, living walls, hydroponics, and aeroponics can be designed indoors or outdoors for commercial or noncommercial purposes to grow culturally and economically important crops. Whereas, sustainable designs at the neighborhood scale like Building Integrated Agriculture (BIA), permaculture and Agro Parks, community gardens, etc can potentially support the green economy and local community in the long term. Furthermore, implementation of city-scale urban farm designs such as Continuous Productive Urban Designing (CPUL) and Organoponics with appropriate use of technology, design, and science can overall elevates and improve biodiversity, support food security for a family, and empower a community through recreation and education.

Even though Urban Farms can act as strong pillars to alleviate food security and resource use efficiency by best utilization of vacant spaces through appropriate designing and planning but they can not be relied on for feeding the increasing global population. Eventually, the integration of agriculture with urban space can potentially pave a path for a sustainable, food-secure, and climate-resilient future for cities.

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