

The Significance of Vertical Farming Concept in ensuring Food Security for High-Density Urban Areas

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ABSTRACT

Cities are increasingly turning into megacities due to their enlarged and intense population. There has been a global attempt by designers to spread the view that cities can be potential areas for producing loads of food required by communities and fitted for specific ecologies. A similar trend has been spread to developing countries where it is essential to provide food for local consumption, and serious attempts are made to distribute food materials to protect particular urban communities. Therefore, recent attempts of food security have aimed not only to guarantee availability but also the provision of sustainable, locally-fitted and food production that is not industrialized to sustain the potential for production. The solution seems to be Vertical Farming (VF). Producing food can be brought into cities through VF and this significant step, if taken, can make life in cities more viable. The present research aims to review the VF plays in the future of food production in high-density cities. The present research reviews the body of related literature, both online and printed publications on the issue. VF is a turning point of the millennium in urban designing but not limited to that. It further presents a new type of architecture as both a local and global remedy for the 21st crisis.

Keywords: Vertical Farming (VF); Food Security; Urban Farming; Urban High-density; Urban Planning

INTRODUCTION

City migration and growing population will produce ever-growing needs for accommodation, health and hygiene services, occupation, as well as transportation. Besides these stresses, a growing population of cities also add to the demand for unchanging, available, and nutritious food supplies. Prospective mega-cities are expected to be more locally or culturally various, especially bigger, poorer, and less well-developed than present city populations (Besthorn 2013). Nevertheless, within recent decades, cities are viewed as the cause of environmental degradation as well as resource depletion (Touliatos, Dodd & McAinsh 2016). Consequently, city policies need to include food safety issues. Guaranteeing food safety need to surpass short lived reactions like emergency food help and consider the democratic aspect, offer a long-term solution to ensure the right to food (Ahlström and Zahra 2011).

According to the American Planning Association (2007), the fact that cities are separate from where their food supplies are produced is directly associating to with many key problems the U.S. is facing today (e.g., weather change, pollution). Accordingly, they introduced the Regional Food Planning in 2007, which emphasizes 'food system planning'. Which is a rather new idea that originated from American society's growing attention to what it eats, where and how its food is made, and the existing inequities in the spread of resources of food (American Planning

Association 2007; Specht et al. 2014). Emergent themes as explained by Food secure Canada are mainly related to food catered for people; valuing food providers; localizing food systems; localized control, constructing knowledge and skill; nature friendliness (Miller 2011). As a result, food safety needs improving three correlated issues of food availability, access, and utilization (Anderson and Strutt, 2014; Eigenbrod & Gruda, 2015). As defined by the World Trade Organisation (WTO) (2000), food security refers to physical access to food, the stability of food provision as well as the economic access to the target product (Ahlström & Zahra 2011). UN Food and Agriculture Organization defines food security as an ideal in which all people can always physically, socially and economically access adequate, healthy and nourishing food to satisfy the food requirements and interests in order to live an active and healthy life (Hosseini et al. 2017).

Food security is of a high significance even in parts of the developed countries where fresh food materials are lacking -metaphorically known as 'food deserts'-. Instead, the problem deals more with the quality of food production systems. They need to produce more food materials locally, and urban farming is supported more than ever before to relate food producers to buyers (Specht et al. 2016). The aim of developing domestic food production, processing, and spread is to make sure that healthy food is provided to all, and the sustainability of the food production system is also ensured. There have been such movements as Community

Food Security (CFS) that highlighted the significance of local food production and sustainable farming attempts. These movements have emphasized that local food should be produced and distributed in a way that is availed to everyone and its contextual and economic effects remain in the long run (Menezes et al. 2017).

On the other hand, historically speaking, agriculture has never been detached from urban life. Agriculture and city life through share specific idiosyncrasies are closely related. Urban residents inevitably admitted to the role food played in life. In the past, people were surrounded by animals and plants as the source of foods. So, they were quite aware of the source of their foods. Nevertheless, things have changed nowadays since we have everything we need wherever we need them without knowing the source. Sometimes we go to extremes and even forget the food we consume originates from nature (Benke & Tomkins 2017). Urban agriculture is the industry which makes, processes and sells food and fuel, mostly in response to daily needs for urban consumers, on land or water spread in the urban and peri-urban regions, employing many techniques of production, consuming and consuming natural supplies and city wastes to produce a variety of products and livestock (Ahlström and Zahra 2011; Benis and Ferrão 2017; Cahya 2016; Pölling et al. 2016). In summarize, urban agriculture is farming within cities as a socio-economic movement primarily located on the edge of a city area or in intra-urban open spaces and the suburban areas. It is included in the city financial and ecological system. Urban agriculture is defined as the production of harvest and livestock properties within urban areas.

Urban farming with agriculture methods elaborated on can significantly help societies and families with a guarantee for food security. It can be produced at home or in a public garden (Walters and Stoelzle Midden 2018). Farming inside cities has managed to promote nutrition in developing countries with high food security. VF can contribute to this movement (Pinstrup-Andersen 2018). VF is defined as a technique of farming that includes high loads of food production in skyscrapers which makes rapid development and planned production possible through managing nutrient solution of crops and the growth context according to hydroponics and aeroponic modes. Using cutting-edge greenhouse approaches, such constructions might be employed as a precision farming system that provides for the acquisition of healthy crop production via controlling and monitoring growth environment, elements required in growing crops with the help of different sensors (Banerjee and Adenauer 2014; Benke and Tomkins 2017; Kim et al. 2014; Pinstrup-Andersen 2018; Thomaier et al. 2015). In this study, VF is a method used in farming that involves high loads of food production in tall buildings that make rapid growth and planned production possible through controlling contextual circumstances and nutrient solutions, with the help of cutting-edge greenhouse methods. Plants, animals, fungi and other sorts of life are developed for food. Yet, fuel, fiber or similar goods or services are provided by artificially layering them vertically above one

another and leave a little urban footprint and less water and energy resources. VF is a system of producing crops inside buildings, towers or slopes and so on and make the most use of land due to its vertical structure which can accommodate plants, animals, fungi and so forth. It can also serve the purpose of keeping them in a vertical position one above another (Kalantari et al. 2018).

This study aims to review the role VF in the urban high-density area in related to food security.

LITERATURE REVIEW

ROLE OF URBAN FARMING IN HIGH-DENSITY AREAS

There is a globally increasing enthusiasm for high-density development as a subject of research. It characterizes various concepts in many countries in different cultures and different populations. Ren et al. (2013) believed that the resulting from a vast and fast city development, urban high-density area is related to an increase in population density. The expression 'high density' is more often than not related to overcrowding. Nevertheless, the concept of high density stated in terms of building density is less concerned with overcrowding. For example, a high building density estimated in terms of plot ratio represents a high ratio of floor area constructed. For bigger residence size as well as smaller accommodation size, the ratio of the plot might cause lower occupancy density. It is consequently more inhabitable for people and in its own turn improves the crowding status.

Consequently, higher building density contributed to moderate the trouble of overcrowding in living spaces (Bardhan et al. 2015). What leads to overcrowding is the shortage of space for individuals. So, it is more related to high population density. Nevertheless, as indicated in the previous example, the connection of building density and population density is not a direct one and is mostly contingent upon how population density is evaluated. Therefore, despite the fact that higher building density cuts down on occupancy density in the dwelling, it raises the total people density of the site too. Overall, high building density, as well as high people density, imply very divergent matters which makes the issue even more challenging. The rise of building density could have different effects on people density concerning how building density is evaluated. However, this crucial issue is less clearly considered in discussions of high-density development (Cheng 2010). Ellis' research (2004) indicated that residential development in the UK is taken as low density if there are fewer than 20 dwellings in each net hectare. In case this number is 30-40, it is taken as medium and when it exceeds 60 dwellings, it is reckoned as high density (TCPA 2003). Low density in the US is characterized as 25-40 dwellings per net hectare. It is considered a medium if this number ranges from 40 to 60. When this number exceeds 110, it is taken as high density.

There are social and economic obligations which force modern cities to be compact. High urban density is required to house more people and cut down on the expenses associated with public services. This density makes the recognition of chances for urban farming and greenery difficult. There are problems associated with greening attempts such as disorganized urbanization and the rise in the cost of land (Bardhan et al. 2015; Lau et al. 2016). Due to the growth of population and the shortage of land, high density, as well as high rise technique, had to be taken by the state. Limited space has cut down on the functionality of green lands in different areas concerning building coverage (Mazumdar et al. 2018; Nochian et al. 2015).

In urban farming, a key factor is a location. There are areas in developed cities which have certain qualities. Therefore, they provide many chances for city-based farming and food (Irvine 2012). Downtowns are usually highly dense since the cost of land is usually high there. Therefore, designing integrated production structures can help provide local supplies for the residents (Nochian et al. 2016). The amount of lands is moderate in low-density suburbs which are designed recently. Farming around cities can produce a large amount of food. Areas waiting to be developed that are left empty for a while can be used as a temporary site for food production activities (Al-Kodmany 2018).

The promising notion is to convert highly dense cities into built methods, and customarily design future urban areas around sites for sustainable food production (de Anda and Shear, 2017). It is challenging to design city landscapes in a way to serve multiple functions. Farming can be truly beneficial if it is not only production-based and serve social and ecological purposes too. Eco-effective architecture is now being considered by designers and planners to be incorporated within a Sustainable Eco-city or what can be called an Arable city (Specht et al. 2014).

As a result, investigators look for solutions to separate fertile land from production-only and produce more food above buildings located within highly dense city areas. Figure 1 shows the conceptual design of urban farming inside the high-density areas of cities.

Cities are supposed to be the site of organic farms, hydroponics, and aeroponic farms, Control Environment Agriculture (CEA), community gardens in courtyards, as well as VF and rooftop greenhouses (Shamshiri et al. 2018). The new theory suggests that it is time the traditional forms of farming are replaced by the multi-story farms which are much more precise and can meet the needs of the future population. Concerning the two issues of equity and viability, VF gets related to the general movement regarding local food growth. The goal of designing and developing a context for VF should be the provision of healthy local food for a long time. The amount of food produced as well as its quality is of crucial importance (Despommier 2014; Nadal et al. 2017).

Moreover, the secondary processing of the crops can be integrated within VF conveniently, due to the infrastructure of the integrated ecological system inside an empty building. It can be done much more efficiently than a public garden in an empty area, as an instance. VF can be run throughout the year indoors in a well-protected area that is all advantage. These benefits put VF in a higher and stronger position than the conventional types of farming. VF manages to provide healthy food for people (Kalantari et al. 2017; Nadal et al. 2017). According to the Despommier (2010), estimations the one square block of the VF with 30 floors, can provide 2,000 calories a day for each person. It means to cater to the needs of 10,000 people in the city.

VF provides massive food for a highly populated area locally. VF has, therefore, taken a severe step to catch up with the local food wave. The ecological viability of food products is not guaranteed merely naturally by sources of food. In VF, plants can grow throughout the year all the time. Since, as compared to traditional farming, fewer crops are lost. Also, a different type of plants produces on different floors with the same square of the normal form of agriculture farm in the city. Therefore, VF has enhanced the use of space VF can be used everywhere and anywhere in the city since it does not depend on weather and soil.



FIGURE 1. Conceptual design of urban farming inside the high-density areas of cities. Source: <https://www.dezeen.com>

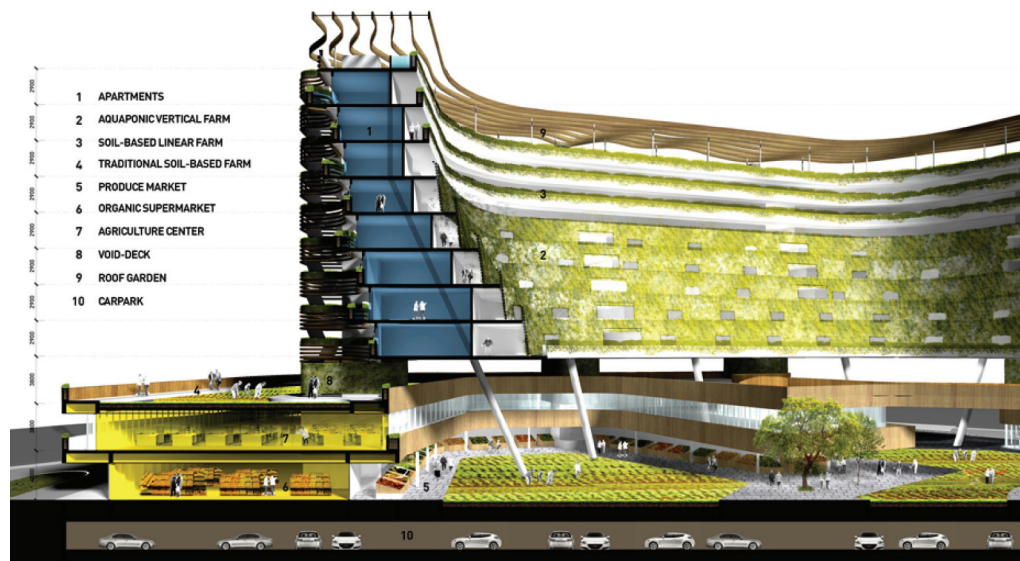


FIGURE 2. Conceptual design of vertical farming integrated with residential apartments. Source: <https://www.dezeen.com>

Consequently, VF produces more food and reduce wasted food (Kalantari et al., 2017). Furthermore, this method raises the amount and quality of crops. It can hopefully be produced inside city boundaries and cuts down on far distances (Suparwoko and Taufani, 2017). In some cases, VF can be a remedy while in others it can be an obstacle. Because the developed countries mostly import the food products exported from developing countries, if the former employ VF this resource movement can be well adjusted. The major drawback of food security is the insufficiency of land, costs of providing it and adequate food. If VF is promoted in developed countries, they can grow at least part of what they need but import from other countries usually. The result would be that many pieces of land get free in developing countries and can be used instead of providing their local food (Hosseini et al. 2017).

A vertical farm as big as a house in the U.S. is capable of feeding a small city. The body of previous research has shown that VF can be a means to provide urban food in a viable manner. However, it all depends on where the city is placed and how it is designed (Al-Chalabi 2015). The idea of the edible city was introduced by Bohn & Viljoen (2011) who also coined the concept of Continuous Productive Urban Landscape (CPUL). They supported the idea of interrelated productive landscapes as an essentiality in realizing a sustainable urban system. Figure 2 shows the conceptual design of vertical farming integrated with residential apartments.

METHODOLOGY

The study comprehensively reviewed related lectures which had been peer-reviewed and sought the answer to how VF can solve the food security problem in the urban high-density area? The corpus was obtained from Science Direct, Web of Science, Scopus, ProQuest, and Google Scholar.

These databases provided access to all publications that were required. The following key terms were searched for VF, Urban Farming, farming in urban areas, high-density areas and food security. The titles, abstracts, and keywords were searched for the key terms just mentioned. The year was set from 2007 to 2017 from different source types such as journals, thesis, reports, books and conference papers. Afterward, the papers found were reviewed to check for the relevance and determine the eventual outcomes. More resources were introduced in the reference list of every paper. Therefore, the snowball sample selection was followed in this phase. The papers found were reviewed, compared and contrasted to see how VF affected highly populated areas about food security. The process of research is shown in Figure 3.

DISCUSSION AND CONCLUSION

Considering the ever-increasing urbanization and growth of population, planners and designers worldwide have begun to view cities as sites for food production to satisfy certain social and ecological needs. City area needs the most severe attempts but at the same time have the benefit of integrating local food production services in planning. It is mainly because of the high concentration of consumers and large numbers of the sparse population with restricted access to fresh food and farm fields. Our restricted resources globally have gradually led to the performance of precision farming. In this method, only the requirements of the plant are provided. So, it can cut down on water waste, energy, natural light, nutrients and the loss of products is kept to a minimum too. There are more important aspects of urban farming than just local food. How it finds its way in the social, economic (and ecological life does matter too). In urban farming, city resources are used including the land, workforces, organic waste material as well as water.

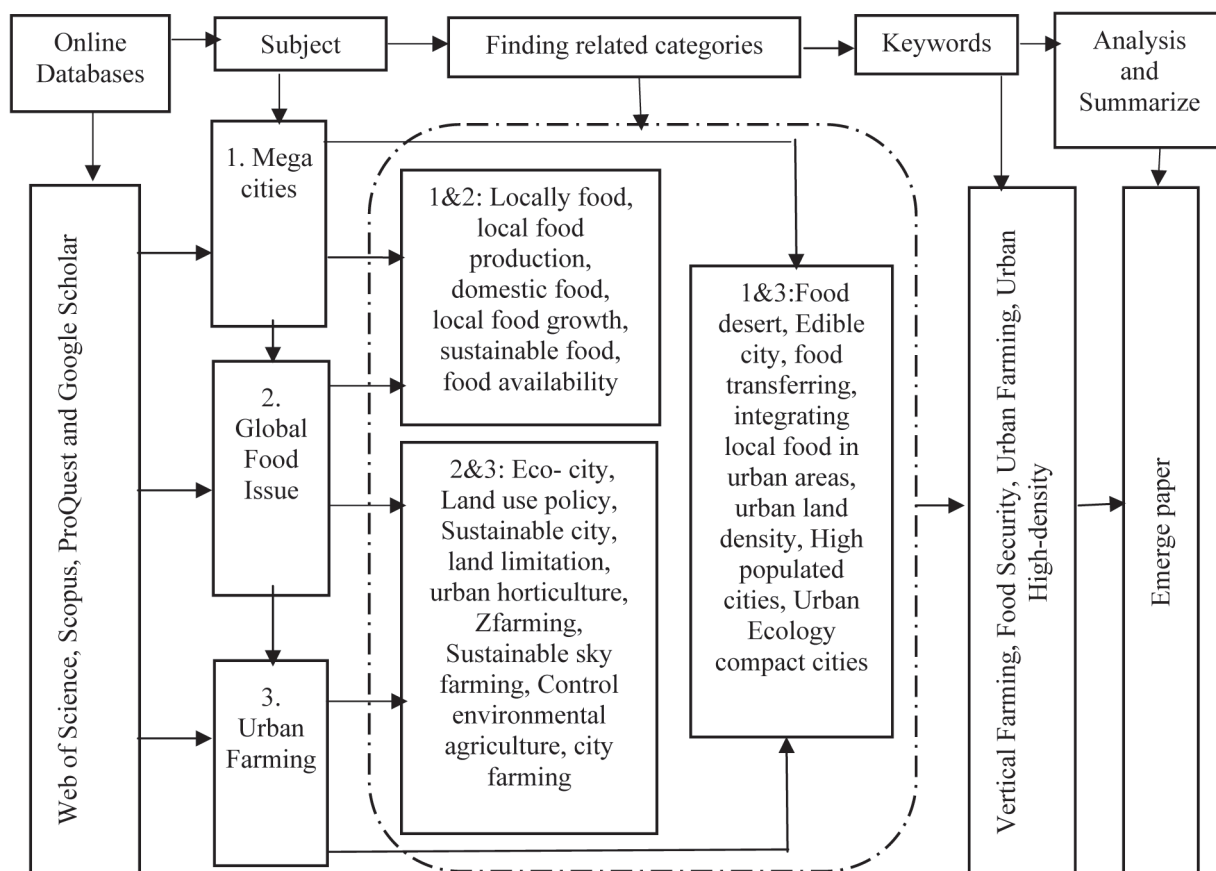


FIGURE 3. Research process

Therefore, all the input it takes is urban and is marked by urban rules and regulations, circumstances, land competition and the target market. It is affected by such other factors as the price, effects of food security, reduced life conditions, health matters and the ecological states (Menezes et al. 2017). Urban farming is capable of dealing with the insecure food production in cities which is ever growing along with the secularization of urbanized poverty and high population in developing areas. Eventually, the scenarios which have been suggested could increase the total quality of the city landscape and encourage regulations adapted to the change of weather. Agriculture still plays a significant role in many cities. It causes thousands of acres of forests to be plowed which would put an end to thousand acres of land. Endmost, it appears that the concept of a vertical farm in the city center of urban areas could solve a lot of real issues related to food production and environmental degradation (Lu and Grundy 2017). VF is a true indicator of urban ecology. It adopts an incorporating approach. It does not convert nature to fit in with human's needs. It does the opposite. It can use many spaces by making them suitable for agriculture. VF is a turning point of the millennium in urban designing but not limited to that (Suparwoko and Taufani 2017).

In large distant cities which are highly dense and transporting products seems to be a problem, VF is a proper solution. It helps to increase production and decrease traces of farming. The foremost idiosyncrasy of VF has been its

close link to the social, ecological and economic state of cities. The concept entails the production of a variety of plants in populated regions (also called megacities) that accommodate most of the global population now and in the future far from the country. Once the products are sold in the local market in the same place they are grown, there is low demand for transportation which is involved in the traditional forms of farming. Then, no harvest would fail by severe weather phenomenon like droughts, floods, and hurricanes, etc. Hence, what VF provides for a sustainable city environment encourages people to live there for a safe and healthy environment, cleaner air, safe drinking water, safe usage of public liquid waste, new employment chances, and less abandoned lots and construction. VF has the benefit of seasonally wet and warm weather. They can easily minimize cooling and heating water, use of indoor temperature and artificial light and also have a plentiful amount of natural resources such as long hours of sunlight and enough water from daily rain to cultivate. Not only do vertical farms act as hospitals for food but they also serve ecologically to the city which strongly needs novelties in infrastructures such as the management of waste and hydrological services, water management system and so on. Both flexibility and stability are catered for by vertical farms.

However, VF requires particular care as a technique for either very populated cities with restricted areas for land-based farming or metropolises not limited to enough farming

land to form local food systems (Menezes et al. 2017; Specht et al. 2016). Endmost, it appears that the concept of a vertical farm in a high-density city-center could solve a lot of real issues related to food production and environmental degradation (Benke and Tomkins, 2017; Suparwoko and Taufani, 2017). VF also has basically involved it as technical elements within the superior phenomenon of urban or local agriculture with different food production (Pinstrup-Andersen 2018).

Moreover, in urban areas, the space-related and social distance between urban residents and agriculture is increasing, and the majority of people have less experience or knowledge of cultivation. It is essential for cities to produce food for themselves as their participation would affect the change.

The conclusion of this study can contribute to the importance of the concept of VF in urban high-density areas related to food security. As a result, investigators look for solutions to separate fertile land from production only and produce more food above buildings located within highly dense city areas. The 21st-century urbanism has produced certain conditions that challenge our cities. Vertical farms can be one solution (Pinstrup-Andersen 2018). If these objectives are combined, the approach helps to global food safety, and we can make sure that international sustainability criteria of environmental compatibility and public acceptability are met.

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