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The role of urban agriculture for a resilient city

Vai trò của nông nghiệp đô thị cho một thành phố có sức chống chịu tốt

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Humans are simultaneously facing challenges as climate change, epidemics and scarcity of food and water. It is estimated that by 2021 over 690 million of people will face hunger; by 2050 the global population will increase up to 10 billion with 68% of the population living in urban areas. By providing 30% of self-sufficient food in 2030, urban agriculture will be a practical concept to face these challenges. The work studies the role of agricultural land as a critical part for a resilient city. Parameters related to food production are also explored. As study case, this work aims to investigate the current food security of the Ho Chi Minh city (HCMC), offering productive green solutions at different scales from land-use planning, urban design to green roofs. For a production of 6.7 kg/day of vegetables a day, the costs of are approximately $10,000 for nearly 5.6 square meters of land; this points out A-Go-Gro technology as an effective measure for vertical farming. For example, 0.18 ha of green space can produce 2 tons of vegetables per day in the Lake View settlement (district 2 in HCMC). Moreover, due to green roofs, stormwater volumes directed into the sewer system are decreased by 65% and the penetration of electromagnetic radiation is reduced by 99.4%.

Loài người đang đồng thời đối mặt với những thách thức như biến đổi khí hậu, dịch bệnh, khan hiếm thực phẩm và nước. Ước tính đến năm 2021 có hơn 690 triệu người đói và đến năm 2050 dân số toàn cầu tăng lên gần 10 tỷ người, với 68% sống ở khu vực thành thị. Được sử dụng để tự cung tự cấp 30% lương thực vào năm 2030, nông nghiệp đô thị là một khái niệm hiệu quả cho những thách thức. Bài báo là nghiên cứu đất nông nghiệp như một phần quan trọng cho một thành phố có khả năng phục hồi. Các thông số liên quan đến sản xuất lương thực được nghiên cứu. Bài báo cũng tìm hiểu an ninh lương thực của thành phố Hồ Chí Minh hiện nay. Hơn nữa, bài báo đưa ra các giải pháp phủ xanh hiệu quả trên các quy mô khác từ quy hoạch sử dụng đất, thiết kế đô thị đến mái nhà xanh tại các hộ gia đình. Với chi phí 10.000 USD và gần 5,6 mét vuông đất trồng 6,7 kg rau mỗi ngày, công nghệ A-Go-Gro là một biện pháp hữu hiệu cho canh tác theo chiều dọc. Như vậy 0,18 ha không gian xanh có thể sản xuất 2 tấn rau mỗi ngày tại khu dân cư Lake View ở quận 2. Hơn nữa, bằng cách làm mái nhà xanh, nước mưa giảm đến 65% vào hệ thống cống và sự xâm nhập bức xạ điện từ giảm 99,4%.

Keywords: urban agriculture, resilient city, food security, food self-sufficiency

1. Introduction

The global population is expected to significantly increase from 7.8 billion to 9.7 billion in 2050, wherein nearly 68% will be settled in urban areas (World Population Projections, n.d.). According to Our World in Data (2017), agriculture area per capita decreased notably from 1.5 hectares to 0.7 hectares from 1961 to 2013. The effects of climate change on agriculture such as flooding, droughts and sea level rising, make urban areas fragile due to health, safety and social well-being problems. In the context of climate change and the rapid growth of the urban population, solutions to supply food in sufficient amounts and cope with environmental problems are essential for cities around the world (Dubbeling *et al.*, 2019). During the COVID-19 pandemics, many countries have tried to maintain agriculture safe in order to keep food markets well served, providing easy access to products despite movement restriction and income losses (Food Security and COVID-19, 2020). A "Resilient city" is becoming an outstanding concept to urban planners and policymakers because of the positive benefits of reducing natural and man-made disaster risks. Resilient city is a city of ability for resisting, absorbing, accommodating, adapting, transforming and recovering from climate-related hazard effects and the community (Patel *et al.*, 2016). The ten essentials to make a city resilient are: (1) organize for disaster resilience (2) identifying risk scenarios; (3) strengthening financial capacity for resilience; (4) pursuing resilient urban development and design; (5) safeguarding natural buffers to enhance ecosystems' protective functions; (6) strengthening institutional capacity for resilience; (7) understanding and strengthening societal capacity for resilience; (8) increasing infrastructure for resilience; (9) ensuring effective disaster response and (10) recovery and built better (The Ten Essentials for Making Cities

Resilient, n.d.). The urban agriculture concept, is acknowledged as the growing of plants and raising of livestock in intra-and peri-urban areas for multiple purposes; among them, to supply food to citizens, to generate jobs, to reduce and recycle waste and to make cities more resilient. Besides, urban agriculture can reduce poverty and guarantee sufficient food to feed cities; it is also an effective tool in managing and using urban space and land use.

A resilient food system allows self-supply of safe and sustainable food in all of the unforeseeable situations (Dubbeling *et al.*, 2019). A "Green infrastructure" or "Blue infrastructure" refers to a network of multi-functional natural and unnatural spaces with many features such as trees, wetlands, green roofs, parks, woodlands and coastal lands for the main purpose of maintaining a sustainable environment (Naumann *et al.*, 2011). The benefits from green infrastructure embrace removing pollution, improving water quality, reducing the volume, velocity, and temperature of stormwater runoff, mitigating urban heat island effects, strengthening the local economy and enhancing infrastructure resiliency.

A "Green roof" is known as a system including three main parts: a waterproofing membrane, growing medium (soil) and vegetation (plants) overlying a traditional roof. Green roof benefits greatly the mitigation of urban temperature, water treatment and the renovation of the environment. It is an effective tool to enhance sustainability and biodiversity decreasing energy consumption and negative impacts on the surrounding the environment (GSA, 2011). "Vertical farming" is a specialized technology form of stacks above each other for the cultivation of plants, trees and vegetables under controlled environment conditions and nutrients (Kalantari *et al.*, 2018). Based on the previous definitions, food can be grown in multiple not common places. The productivity can be improved, protecting the food supply system for local cities. Globally, many countries have already implemented this as a comprehensive solution on a large scale to deal with food security issues. This article focuses on the Ho Chi Minh City, providing solutions for food supply problems based on self-agriculture for both, large scale across the city and small scale in settlements.

2. Materials and methods

Agricultural land is often separated from the city due to the high demand for land to develop residences, commerce, institutions and industry, however, open spaces can be still used for agriculture purposes. A productive use of open spaces, based on availability and accessibility, is its use for urban agriculture. Either in the long-term or in the short-term, it brings opportunities for households and groups having need. Disregarding the urbanization degree, any open space can be used for agriculture including backyards, rooftops, terraces, vacant public, semi-public or private lands.

Self-producing households can achieve food security. As an example, in Nairobi, these strategies produce from 20 to 25 percent of their food needs (World Bank, 2013). Urban agriculture has many effects on the economy at different levels. The agricultural production in urban households is considered according to two aspects: benefits and costs at the household level. In the city, urban agriculture ensures benefits for urban farmers who can be assisted for extension, training and quality control. Moreover, benefits are shared for the urban poor by greening, recycling of wastes and improving nutrition. At the national level, urban agriculture ensures efficiency of the national food system and makes cities to avoid dependence on rural agriculture and imported products. Furthermore, urban agriculture provides products with a rapid delivery, those that rural areas cannot supply so easily (FAO, 2007).

2.1 Lack of data

According to recent studies, detailed and certain data are not given, descriptions of urban agriculture and household are incomplete displaying only short time trends. However, the costs and prices of food change over time and urban agriculture, as a recent research topic, present some problems such the lack of uniform and evident data and indicators happening at the city level (FAO, 2007).

### 2.2 Indicators and measuring methods

Economic indicators such as income, employment, urban food supply and share in markets are essential to assess the economic impact of urban agriculture on households. In this article, based on statistic data of land-use plans for the past five years, agricultural land's annual shrinkage rate is estimated. Moreover, total agriculture products in any city can be collected and surveyed in business associations to generate data. Potential production per hectare of agricultural land is quantified. In this way, it can be estimated how significant is the decrease in agricultural land and the negative effects on total production for the coming years. The population is expected to increase and so the food consumption; an important question is whether future agriculture land can generate sufficient foods to meet the demands in the future. Productivity is derived from the number of products by a square meter and the investment cost. This data is collected and surveyed from technology companies of vertical farming and green roof. The quantity of food from green roofs and vertical farming is also quantified according to the different scales of areas.

3. Case study and results

On a large-scale case, the Ho Chi Minh City (HCMC) is the most populated city with 8.6 million inhabitants and it is predicted to reach around 12.2 million in 2035 (Ho Chi Minh City, Vietnam Population, n.d.). Furthermore, HCMC

is one of the six most vulnerable cities to climate change with since 2 meters of sea-level rise would submerge about 70% of its residents. The area of new residents increased by 7% in HCMC, and compared to 1997, the number of farming households declined to 1/6 (Schaefer *et al.*, 2019).
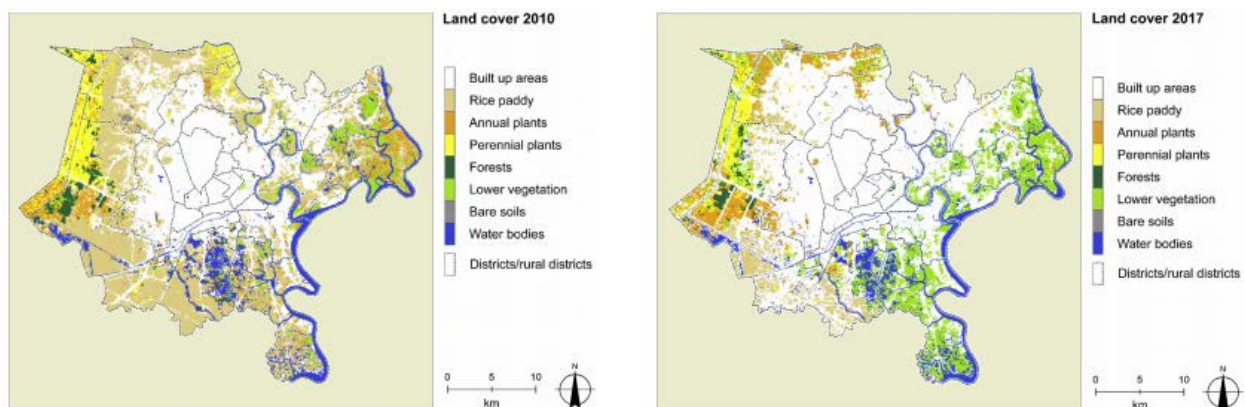
Figure 1. Land classification of Ho Chi Minh City (Schaefer et al., 2019)

In the adjustment of land use planning to 2020 and land use planning (2016-2020) of the HCMC, the agricultural area decreased by 26% (from 118,052 ha in 2010 to 88,005 ha in 2020). Rice cultivation area declined significantly from 27,594 ha to 3,000 ha (Government, 2018). In contrast, the built-up area has increased from 53,841 ha to 62,704 ha. In average, the annual agricultural area has decreased by 4,800 hectares. By 2035, it is predicted to have a decrease of nearly 16,600. In 2018, agriculture production reached 384,034 tons corresponding to 4.15 tons per ha; this is forecasted to decrease down to 68,890 tons in 2035 (General Statistics Office, 2018).

In East Asia countries, food consumption per capita is remarkably rising from 1,957 (kcal/person/day) in 1964-66 to estimations of 3,190 kcal in 2030 (FAO & Bruinsma, 2003). According to the Vietnamese Food Pyramid (2013), grown-up people needs to consume about 28 kilograms of food in monthly basis in order to ensure a healthy condition; this includes 6 kg of rich protein food group embracing seafood and meat, 10kg of vegetables and 12 kg of grains. Under this term, the HCMC must produce at least 240,800 tons of food per month. Whit a downward trend of agricultural land use and the population increasing rapidly, to secure food in future scenarios is a problem.

On the medium scale, this case study estimates a plan to provide food for a new residential group within a settlement named Lake View. This settlement is located in district 2 of the HCMC. With an area of 3.92 ha, it consists of 0.18 ha of green space and a built-up area of 2.17 ha. It includes 217 households with an expected population of around 868 (average of 4 people per family); this means 2.43 tons of food (based on average food consumed per person per month of FAO) must be consumed during a month in this area (The Vietnamese food pyramid, 2013). In developing countries, a rapid urbanization makes cities to face significant increments of urban poverty and urban food insecurity.

Data from the World Bank Group, shows that over 50% of children under the age of four are malnourished, 30% of babies underweighted and 60% of women anemic. The recent world food price crisis is a treat for poor urban citizens who buy on the food supply markets. Urban agriculture is one of the solutions for food demand and nutrition security for the urban food markets. At the household level, urban agriculture is a source of additional income and employment, providing larger amounts of food and stability of food consumption against temporary shortages (Ranjan.S.Karippai & Susha.V.S, 2017).

Regarding technology, a vertical system applied in Singapore, called "A-Go-Gro" technology, brings dual benefits of productivity and energy efficiency. Instead of conventional and traditional agriculture, this method allows varieties of local vegetables to grow. Residential organic waste is collected to make fertilizer, contributing to the farm and closing the cycle, limiting waste out the environment. Besides, after harvesting, food is delivered directly to local households, leading to a decreasing gas emission from transportation. It is active independently and without electricity thanks to a unique gravity aided water-pulley system with an A-shape-six-meters tower, including growing troughs rotating around the mainframe for absorbing sunlight, airflow, and irrigation (Figure 2).

Each tower cost around 10,000 dollars, occupies about 6 square feet (equivalent to nearly 5.6 square meters of land) and can produce 6.7 kilograms of vegetables per day (Schaefer *et al.*, 2019). Consequently, 200 kilograms of vegetables can be harvested per month from each system. As for the 0.18 ha of the settlement in our study case, it could hold about 300 towers with a yield of 2 tons per day. This accounts for almost all of the food that the local people need. In this case, land use function is transformed from common green spaces to areas of agriculture and entertainment, increasing efficiently land use in which vertical farming and conventional agriculture are combined to bring sufficient leisure activities and

ensure food production for local citizens. A number of crops can be grown in this area based on diverse farming forms (Figure 3). Leaf vegetables can be grown on trays of the vertical farming model including lettuce, amaranth, spinach, mustard green, and water morning glory. Root vegetables and fruit trees that are grown by conventional methods consist of carrot, radish, beetroot, tomato, green bean, banana, orange, lime, mango, guava. Additionally, a pool at the center of the agricultural park, collects and retains stormwater to function as fish breeding or for irrigation. Regarding the community, people can gather here to relax, exercise or gardening in this eco-environment that enhances human health and narrows the gap between urban people with the nature.
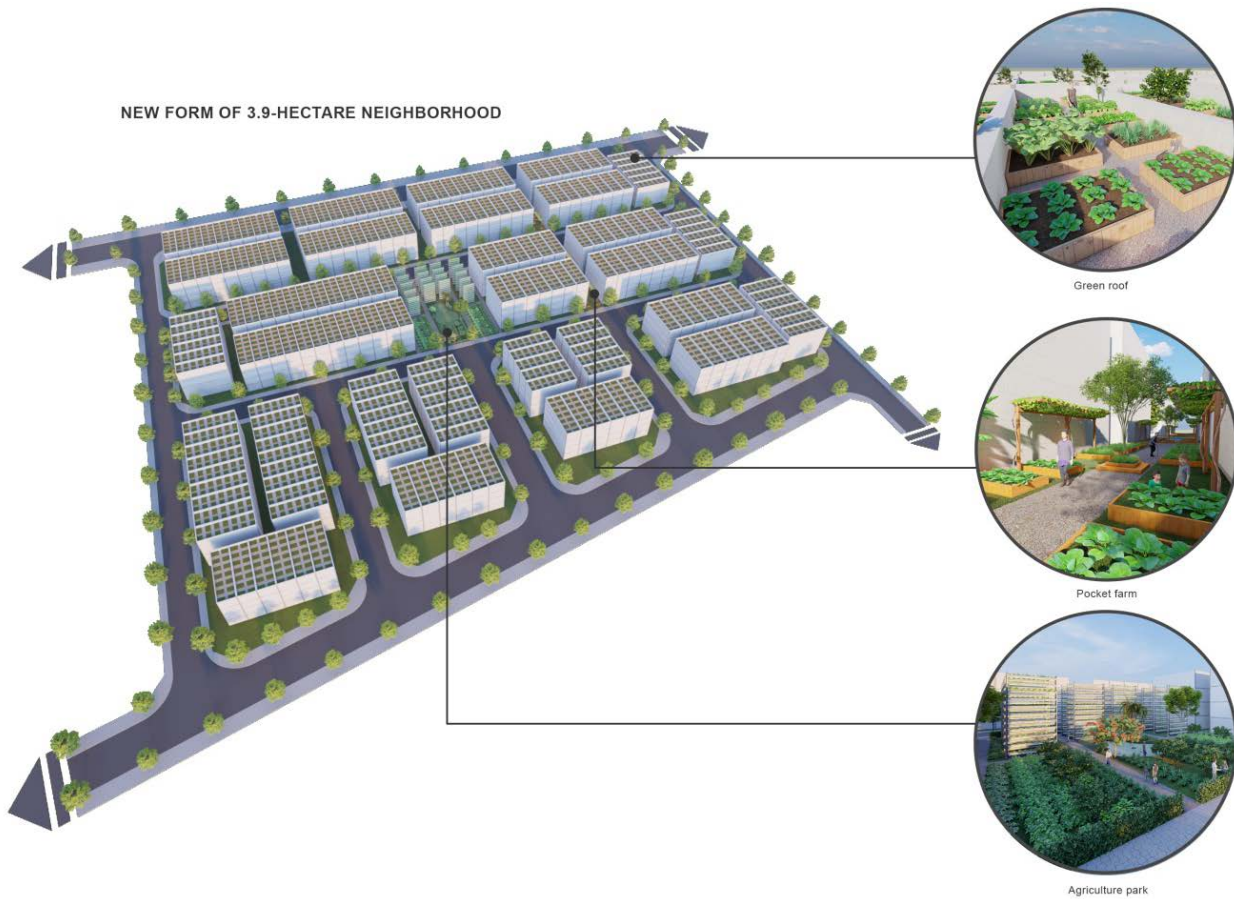

Figure 2. Lake view resident (own source)

Figure 3. Agriculture park with vertical farm (own source)
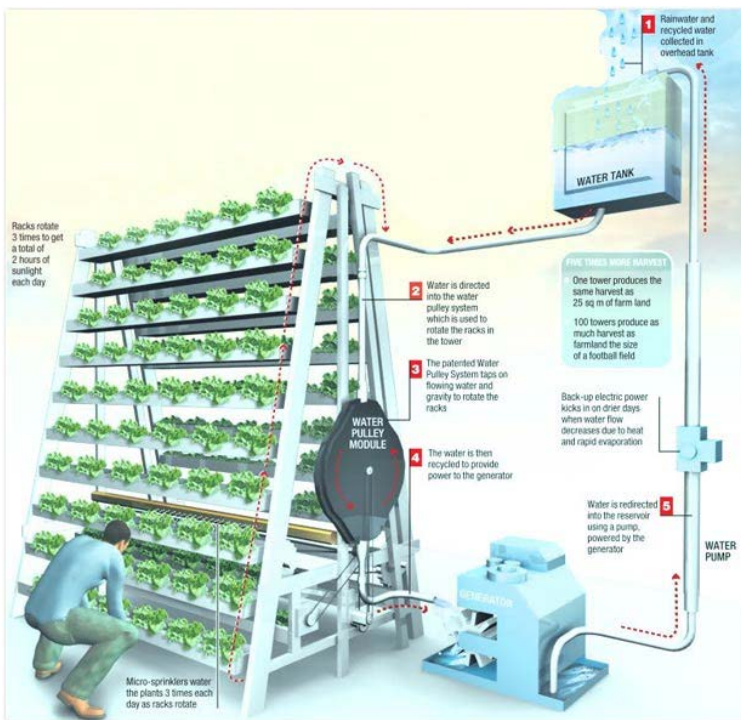
Figure 4. Pocket farm (own source)

Figure 5. Skygreen in Singapore (Krishnamurthy, 2014)

On a small scale, each household's roof performs places of aesthetic, waterproof and holding types of equipment such as conditioners, water tanks or warehouses. They generate squandering of space in cities with an enormous built-up area. In fact, the green roof is applied widely around the world because of its huge benefits. Green roofs are able to reduce electromagnetic radiation penetration by 99.4%, urban noise about 40 decibels of the extensive green roof and 46-50 decibels with an intensive green roof (About Green Roofs, n.d.) and mitigate the heat island effect; thus, enhancing the microclimate. Furthermore, they play a significant role in the management of stormwater by up to three hours, decreasing water flow pressure by up to 65% from the grey roof to the sewer system (The Vietnamese food pyramid, 2013). With a garden on the roof, a wide variety of vegetables can be grown on an average of 6-inch-deep (nearly 14.7 cm) of the soil module, especially herbs and lettuce (The Vietnamese food pyramid, 2013).

Figure 6. Green roof (own source)

4. Discussion

With the foreseeable prospects and difficulties of HCMC, protection of agriculture and farming is necessary for a long-term sustainable development plan in order to guarantee that the next generation can fulfil their needs. The deficit in cropland, makes the city more dependent on resources from other regions or countries resulting in a decreasing resilient ability. Currently, the relatively low income from agricultural works cannot cover the farmers' living costs; thus, most people abandon the land and follows well-paid jobs in other economic sectors. In this case, effective policies to stimulate farmers, generating stable-paid jobs need to be issued in order to maintain the crops productivity.

In terms of real estate investment, instead of spending monthly huge amounts to keep the landscape, combining regular parks and farms could bring benefits and a high-value market script for the owner. Furthermore, children can explore the nature and adults can exercise and perform gardening together, as a close and healthy community. Thanks to technology in conventional farms, diverse kinds of vegetables can be grown with an enhanced productivity. Furthermore, installing pocket gardens as part of settlements, reduces food transportation distance, thus decreasing gas emission. In terms of households, they must build a roof garden to get a building permit; the government can also provide financial and technical assistance to encourage people to green their own house. Households can be self-employment and benefit directly from farming on roofs by the sale of surpluses, generating extra income and food storage.

5. Conclusion

In the resilient cities, urban agriculture plays a fundamental role in increasing stability of the local food supply market and ensuring food security, as well as creating more jobs and additional income. Appropriate policies need to be given to stimulate farmers and develop more agriculture land. Technology is essential to produce more food in households and settlements by green roof and vertical farming with the A-Go-Gro technology. In addition, to food production, such solutions also address great urban challenges such as urban flooding and heat island effect.

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