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VERTICAL FARMING: Aprecedence to attain sustainable urban food systems

Ar. Mahima Jagadeesh

School of Architecture, REVA University

Abstract -The rapidly intensifying urban population has caused an exponential growth of cities. The peri –urban areas of a city which was used for farming to supply fresh produce to the urban dwellers, is now occupied for accommodating the growing populace. The urban population lacks the access to the fresh harvest causing health issues in humans and a disconnect with agricultural production.Today,the food culture of the city is evolving, from fast foods to processed foods which is distributed by large centralized supermarket chains that are not rooted in the life of city neighborhoods. This paper intends to address the significance of urban agriculture in this century of urbanization. There is a need to replace traditional farming with technology-driven urban farming to quantify the agricultural production in a short time. The paper explicates the concepts and technicalities of vertical farming which are tools of urban farming and the need to adopt it to attain sustainable & self-sufficient food systems in an urban environment through a case study example in order to make strategies that can be applied in the extents of anurban areas.

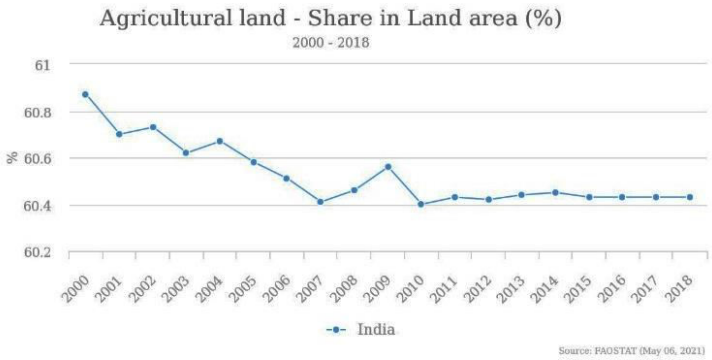
Key Words:*urban farming/agriculture, vertical farming,aquaculture,aeroponics, aquaponics*

1.INTRODUCTION

Urban agriculture has acquired a new significance due to the current trend of rapid urbanization around the world. Food has always been a part of the city's landscape. Since the 17th century farming has been strongly connected and been present in the city. Due to changes and population growth in the past years the landscape of the city has transformed. The relation with food gradually decreased. The urban population tends to be out of touch with agricultural production, and the city food culture increasingly moves towards fast food, processed foods, distributed by large centralized supermarket chains that are not rooted in the life of city neighborhoods. Many consumers, especially, those with low incomes, eat too little fruit and vegetables because of the high price and it may not be a part of their culture and habits too. Today, more than 50% of the world population lives in cities and by 2050, urban centers will gather more than 80% of the population. The current food system cannot meet this rising food demand sustainably. It results in significant environmental impacts, and social inequity in terms of access to balanced and affordable nutritious food in urban centers.

Aim: To comprehend the concepts ofurban farming and vertical farmingthrough a case study example.

Need for the study: With escalating population and affordability, demand for food and changing consumer preferences are building pressure on our resources. Agricultural land area has been declining from 2000 till 2018 by 0.4%. (Graph 1). and arable land (cultivable land) is limited and finite. (Fig. 1). Water is a scarce resource too. Thus, the need to lessen the negative environmental impacts of agricultural practices, particularly with regard to greenhouse gas emissions, soil degradation and the protection of already reducing water supplies and biodiversity arises. Therefore, it is essential to find agricultural technologies that have a neutral or positive impact on our environment. Vertical Farming, which means growing food in skyscrapers, holds the potential of addressing these issues by enabling more food to be produced with less resources used.



Graph 1: Agricultural land – share in land area (%)

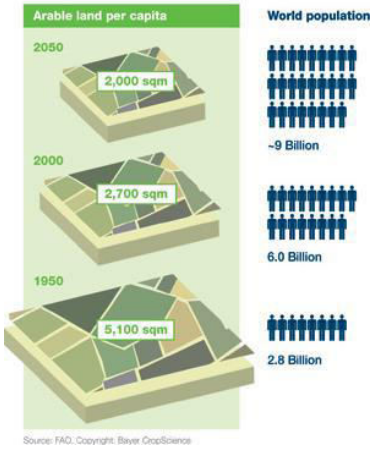


Fig -1:Decreasing arable land per capita

2.Urban farming

Urban agriculture is the growing of plants and the raising of animals for food, and the related processing and marketing activities, in and around cities and towns. (Hempstead, 2007). As urban agriculture becomes more prevalent in urban environments, it is emerging as a new area of concern for urban designers, planners, and architects. For instance, urban agriculture has many functions that allow it to play an important role in urban poverty alleviation, social inclusion, urban food security, urban waste management, and urban greening (Hempstead, 2007).

Vertical farming (VF) is the practice of producing food and medicine in vertically stacked layers, vertically inclined surfaces and/or integrated in other structures (such as in a skyscraper, used warehouse, or shipping container). The concept involves growing and harvesting of a wide range of plants in high density urban areas (mega cities) and the sale of these crops directly within the city community, reducing transportation as opposed to the standard rural farming model. The advantages of this method are the multiplication of agriculturally productive land by growing in vertically mounted stacks, the increase in crop yields (by using optimized production methods, such as light exposure variations, or additional CO2 supply), the protection of the crops from weather-related problems as well as pest and diseases (in contrast to outdoor farming), and the minimization of water requirements (through water recycling).

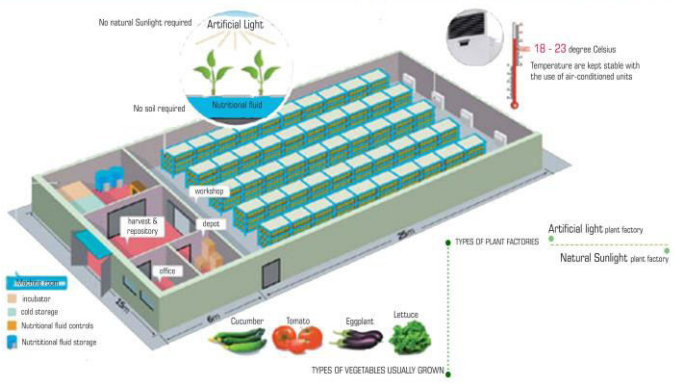


Fig- 2: Conceptual model of a floor in a Vertical farm

2.1 Types of urban farming

Fig- 3: Types of urban farming

2.1.1. Hydroponics:

Hydroponics is a subset of hydroculture, the method of growing plants without soil, using mineral nutrient solutions in a water solvent. Terrestrial plants may be grown with only their roots exposed to the mineral solution, or the roots may be supported by an inert medium, such as perlite or gravel. The nutrients in hydroponics can come from an array of different sources. Hydroponics is suitable for commercial food producers and hobbyist gardeners alike. Hydroponics possesses several advantages over a soil medium. Worldwide markets are poised to achieve significant growth as the food supply for the world starts to adopt automated process. Grow lights have become more sophisticated and less expensive to run as solar and wind energy are adopted by greenhouses and plant factories

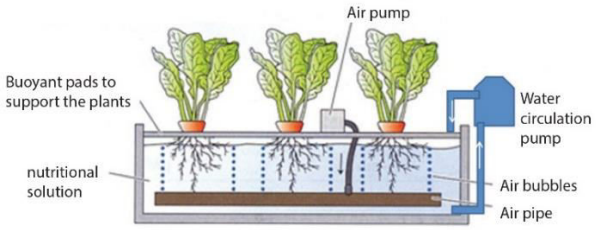


Fig-4: Hydroponic concept

Fig- 5: *Hydroponics set-up*

2.1.2.Aquaponics:

Aquaponics is a combination of aquaculture, which is growing fish and other aquatic animals, and hydroponics which is growing plants without soil. Aquaponics uses these two in a symbiotic combination in which plants are fed the aquatic animals' discharge or waste. In return, the vegetables clean the water that goes back to the fish. Along with the fish and their waste, microbes play an important role to the nutrition of the plants. These beneficial bacteria gather in the spaces between the roots of the plant and converts the fish waste and the solids into substances the plants can use to grow.Aquaponic gardening is free from weeds, watering and fertilizing concerns, and because it is done at a waist-high level, there is no back strain.

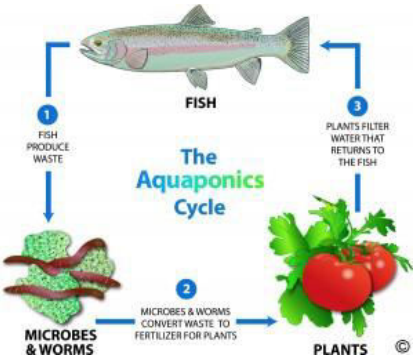


Fig- 6: Aquaponics cycle

Fig-7*:*Aquaponic set up

2.1.3. Aeroponics:

Aeroponics is an indoor gardening practice in which plants are grown and nourished by suspending their root structures in air and regularly spraying them with a nutrient and water solution without the use of soil. Aeroponics offers an efficient means to grow plants, including fruits and vegetables, without potting and repotting them to replenish their access to nutrient-rich soil. Research has found that aeroponics is the most efficient means of growing leafy greens. Greens can become contaminated with soil pathogens and bacteria like E. coli, but aeroponics greatly reduces these risks. Aeroponics research led by NASA took off in the 1980s. Aeroponics reduces water usage by 98%, fertilizer by 60% and pesticides by 100%, according to NASA.

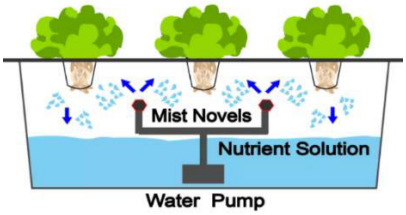


Fig- 8: Aeroponics concept

Fig- 9: Aeroponics set-up

3.Case study- The Sky Green vertical farm in Singapore

The Sky Green vertical farm in Singapore is example of successful in city, all year-round vegetable (lettuces and cabbages) production. Sky Greens is world's first low carbon, hydraulic driven vertical farm.It provides both an environmentally efficient and low-carbon, hydraulic water-driven urban vertical farm that reduces the amount of energy and land needed for traditional farming techniquesto achieve production of safe, fresh and delicious vegetables.

Fig-10: The Sky Green vertical farm in Singapore

Within a greenhouse, the three story's-high vertical systems produce five to ten times more per unit area compared to conventional farms through its agricultural and structural innovations (Foodtank, 2013).

i. **Patented vertical farming system:** Sky Greens patented vertical farming system consists of rotating tiers of growing troughs mounted on a A-shape aluminium frame. The frame can be as high as 9-meter-tall with 38 tiers of growing troughs, which can accommodate the different growing media of soil or hydroponics. The troughs rotate around the aluminium frame to ensure that the plants receive uniform sunlight, irrigation and nutrients as they pass through different points in the structure.

ii. **High quality:** The structures are housed in a controlled environment which enables stringent control of input materials to bring about food supply, food safety, food security and food quality assurances.

iii. **High flexibility:**Made of aluminium and steel, the modular structures are robust and yet highly customizable and scalable. Structures can be tailor-made to suit different crops, growing media and natural conditions, even allowing cultivation on originally non-arable lands.

iv. **Low energy use:** With the harnessing of natural sunlight, there is no need for artificial lighting. Rotation is powered by a unique patented hydraulic water-driven system which utilizes the momentum of flowing water and gravity to rotate the troughs. Only 40W electricity (equivalent to one light bulb) is needed to power one 9m tall tower.

v. **Low water use**: With the plants irrigated and fertilized using a flooding method, there is no need for a sprinkler system thereby eliminating electricity wastage, as well as water wastage due to run-offs. Only 0.5 liters of water is required to rotate the 1.7-ton vertical structure. The water is contained in an enclosed underground reservoir system and is recycled and reused.

vi. **Low maintenance:** Being housed in a protected environment ensures that the system can be relatively maintenance-free and have low manpower dependency. The rotating troughs and intensified plant to plot ratio also mean high manpower efficiency.

3. CONCLUSIONS

Growing food in Vertical Farms in urban areasis a feasible option and a necessity in near future. Markets for such a technology are found mainly in resource constrained nations and mega-cities with substantially high purchasing power. The optimization of production process for edible biomass (combination of crop cultivation and fish farming) as well as the optimization of animal farming for fostering Vertical Farms in the future, needs further research. The cost of the building, its requisite structural parameters as well as the servicing and transport equipment and power requirements are serious investigation questions that can be answered only through action-oriented research.

The growth of metropolitan cities is being controlled by the creation of new towns/townships. These new townships being proposed are going to act as nodes of attraction for people to find employment in that region and thus reduces the dependency on metropolitan cities. Since large agricultural lands will have to be acquired for establishing these townships, the existing farming activity is likely to be disrupted. Unlike the conventional methods of providing monetary reimbursement, introduction of vertical farms can be incorporated in the township since it can generate new employment opportunities for the people, requires lesser arable land area and the yield is higher than traditional farming methods.

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BIOGRAPHIES

The author, Ar Mahima Jagadeesh, isan architect and is currentlyworking as an Assistant Professorat Reva School of Architecture, Bengaluru. She has aMaster's degree in architecture(Habitat design) from BMS Collegeof architecture. Her areas ofinterests are habitat design, Urban agriculture, Urbanization, Sustainability, landscape design, art &interior design.