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Vertical Farming: Feeding the Next Generation

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Abstract

Pressure on farmland is increasing with the rising global population. Per capita land size is decreasing rapidly due to the increasing population, climate change, and urbanization. Therefore, policymakers are looking for a better alternative opportunity to achieve the goals of sustaining and feeding the burgeoning population. As a result, attention is gradually shifting to vertical farming approaches which can be an effective effort to obtain higher productivity. Vertical farming is associated with new opportunities for proper resource use efficiency, precise execution processes and networks; modern farming technology includes new forms of food supply.

Introduction

Food production needs to be boosted to feed the world's ever-increasing population. But the main problem is the scarcity of agricultural land due to rapid urbanization. Additionally, the uncontrolled use of pesticides as well as fertilizers have resulted in deterioration of soil productivity and fertility which ultimately decreases the per capita availability of land (Lehman *et al.*, 2015). FAO has reported that by 2050, the population could grow up to 8900 million and to feed this ever-increasing population, food production needs to be enhanced. Therefore, to reach this goal we require more arable land, but the supply is limited (Conforti, 2011). Moreover, traditional farming practices are facing serious challenges. To combat such challenges, soil-based agricultural practices need to be supplemented more effectively by adopting eco-friendly vertical farming, which can be grown under controlled conditions. The idea of vertical farming is currently in skittery motion with the target of rising crop productivity. Right now, vertical farming is gaining popularity around the globe due to its capability of effective resource utilization as well as promising food quality. The areas having limited soil and water resources along with adverse climatic conditions can play an important role in crop or vegetable production through vertical farming under controlled conditions. This system mainly aims to reduce pressure on traditional farming land and by including a soil-less growing pattern which is particularly attractive for urban areas.

Concept of Vertical Farming

The concept was given by Prof. Dickson Despommier in 1999. In this farming system, the crops are grown vertically in a stacked layer which can remove the need for soil as well as save water compare to field conditions. Good harvests of different plant species can be achieved year-round under vertical farming grown in controlled conditions with continuous monitoring and managing of environmental factors such as humidity, light, and temperature. This approach aims

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to increase the amount of agricultural land by building uphill and increasing the efficiency rate (Benke and Tomkins, 2017). Many horticultural crops, including lettuce, tomato, kale, cucumber, basil, collard green, spinach, chives, broccoli, chard, carrot, strawberry, and pepper, are grown on a large scale.

Why Vertical Farming?

1. Urbanization

Presently urbanization is moving towards rural areas as well with the development of industries. Agricultural lands are becoming scarce and costly as a consequence of urbanization along with the increasing population. This growing population can feed themselves by adopting vertical farming, a promising alternative.

2. Climate Change

The detrimental effects of frequent climate change such as flash floods, storms, hurricanes, and drought pose a serious negative impact on productive agricultural land. Weather-related tragedies are expected to become more frequent and severe as a result of man-made global warming. So, in this context, an alternative supplementary method like vertical farming can be a better option for crop growing.

3. Food Security

Nowadays, food security has become a matter of concern as the population of the world is expected to rise significantly over the next few decades. The risk that growing food demand will outpace supply due to the scarcity of farmlands, could lead to global famine. Vertical farming can be the best option to produce additional nutritious food in a smaller area. It has several advantages including environment-friendly and sustainable food production, saving of energy and water, minimizing pollution, economically viable.

4. Restore Ecosystem

Due to the unavailability of productive land, forest area has been cleared to increase farmland. Vertical farming can be a promising approach to combat the negative impact due to deforestation by restoring biodiversity along with minimizing the adverse effect of climate change. Excessive and imbalanced chemical fertilizers and pesticides used in traditional farming could degrade the soil quality cause eutrophication as well as disrupt the ecological balance. The promise of restoring ecosystem services and functions seems to be the best reason to view transforming most food production to vertical farming.

Types of Vertical Farming

Based on types of structure vertical farming systems can be classified as follows.

1. Building-based Vertical Farming

Building, as well as abundant houses, can be used for the purpose of vertical farming. "The Plant" of Chicago city is one of the examples of a successful building-based farming system (Figure 1).

Figure 1: Building based vertical farm

2. Shipping-Container Vertical Farming

Shipping-container farms are an increasingly popular option. Three of the leading companies producing shipping-container vertical farms are CropBox, Freight Farms and Growtainers.

3. Underground Vertical Farming

Underground farming is also known as "Deep Farming". This farming is normally practiced in an underground tunnel or in a subterranean region and has the potentiality to increase the yield 5 to 7 times that of conventional farming.

Techniques of Vertical Farming

Vertical farming can be done by hydroponics, aquaponics and aeroponics which are described under the following heads.

1. Hydroponics

Hydroponics is the most followed growing system in vertical farming (Figure 2). Here plants are grown in nutrient solutions without soil. The submerged plant roots in the nutrient solution are regularly observed and

Figure 2: Hydroponics system of vertical farming

circulated to check that the correct chemical composition is maintained. Studies have found that it requires 13 times less water and produces 11 times more yield than the conventional method.

2. Aquaponics

Aquaponics is slightly more advanced technology as compared to hydroponics systems. In this process crops and fish are cultivated combinedly by mutual relationship. Aquaculture and hydroponics are combined in aquaponics to produce food.

3. Aeroponics

Aeroponics characterizes an important step toward hydroponics technique. Aeroponics system can run without soil or media and negligible water and artificial light. The primary difference between aeroponics and hydroponics lies in the absence of a growing medium.

SWOT Analysis of Vertical Farming

Strength	Weakness
• Increase per unit area production. • Provide year-round production. • Save water. • Produce nutritious crops with less pesticide residue. • Require smaller area.	• High cost of cultivation. • Pollination rate is low. • High energy requirement. • Completely reliable on modern techniques.
Opportunities	**Threats**
• No season bound. • Can regulate the weather condition. • Need only the required amount of fertilizer.	• Complete yield loss may occur with lack of monitoring process.

Conclusion

Vertical farming is a new technology aiming to increase crop productivity. Though it is an expansive cultivation practice, low-cost vertical farming and low-cost hydroponics technologies must be developed for the enhancement of commercial vertical farming. The affordability or purchasing capacity of low-income families is also a matter of concern while implementing a vertical farm. There are many factors that can affect the success of vertical farming, such as the size of the population, the amount of food needed and supply of food, cultural pattern, dietary pattern of locals, technological advancement, energy supply, and water. Hopefully, it will be a promising technology for the sustainability of agriculture as well as for future food security.

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