

Vertical Farming – The New Future

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Abstract

In general, land and water are inevitable source for agri-aquaculture farming. The agriculture and allied sector alone use 80-90% of the water resources in India. As there is a dramatic increase in the country's population, the shortage of land and water resources is constantly increasing. Thus, in forthcoming years, many countries may face a severe land and water crisis, certainly dense population region. In this order, the concept of vertical farming was emerged in the early twentieth century and it is considered one of the most important techniques for effective utilization of resources. There are different types of vertical farming system which have their own specifications. In vertical farming, there are different modes through which the plants are grown. Among them, aquaponics helps to rear fish and plants at same time with mutual benefits to each other. The vertical farming would be a great change to the future world by bringing the positive impacts including conservation of resources, poverty alleviation, etc.,

Keywords: Vertical; Farming; Agriculture; Plants

Introduction

The tremendous increases in world population are leading to water scarcity and land shortage for humanity in the twenty-first century and posing phenomenal challenges for our globe. Effective utilization of land and water with more productivity to meet the nutritional demand can be met only through emergent techniques and is vertical farming sector. This farming type is an intensive system of crop production in vertically stacked layers in any form of vertical substrate. This evolved as an idea of modern technology which is more suitable and supports eco-friendly farming of aqua-

culture or aquariculture. Here all the environmental climatic factors can be controlled and stimulated artificially for growing plants or animals.

Types

In 1915, Gilbert Ellis Bailey has coined the term "vertical farming" and in his book described vertical farming, explained with content on the view of plant life forms in vertically arranged systems. But in the modern-day, the term vertical farming usually refers to growing plants in the vertical layer, whether in a multistory skyscraper, used warehouse, or shipping container. Three types of ver-

tical farming systems are available i.e., Mixed-use of skyscrapers, Despommier skyscrapers and Stackable shipping containers.

Despommier skyscrapers (Dickson despommier):

- These techniques emerged in 1999 at Columbia University.
- Mass-produced agriculture within the closed system and environment-controlled condition.
- It can be built anywhere in any agronomic constraints.
- Integrated with renewable energy technology.
- Needs less energy and cause less pollution than farming practices.
- This vertical farming proposes to promote the cultivation of plant life for commercial purposes in skyscrapers.
- Mixed-use of skyscrapers (Architect Ken Yeang):
- This is a combination of traditional agriculture practice with vertical farming.
- Crops are grown in natural sunlight environment (top floor of any building can use).
- Less initial investment than despommier skyscrapers.
- Stackable shipping containers (despommier, 2013):
- In this system, vegetables are used to culture in shipping containers.
- More suitable for an urban setting.
- Maintained under controlled environment conditions by using hydroponic components, lighting and ventilation etc.,
- This system is currently practised in the place of Atlanta and Oman.

History

Vertical farms were never built before at the commercial level. In 1909, *Life Magazine* has published about the vertical farm. In the year 1937, the term 'Hydroponic' was coined and published in the science magazine and also new sources indicate that hydroponic existed in Armenia before 1951. After the Second World War hydroponic system was adopted on large scale.

In Austria, during 1964, the image of a vertical farm in a glass tower model was displayed at International Horticulture Exhibition Vienna. The designed hydroponic model has been described in the canonical text of "The Glass House" by John Hix. Hydropon-

ics was developed, integrating hydroponic technology into building systems. A greenhouse farming technology has evolved from horticultural building systems and paved the way for the modern concept of the vertical farm. The year 1989, Ken Yeang is one of the most widely known architects who has promoted the idea of vegetative architecture as 'mixed-use'. Bioclimatic Skyscraper, which combines living units and opportunities for food production (1989). The concept and latest version of the vertical farm are developed Dickson Despommier's "The Vertical Farm" by Columbia University. He is the world's foremost expert on the vertical farm. By 2001 the outline of a vertical farm came into force successfully and many scientists and farmers started to adopt this technology worldwide. In 2009, the first vertical farm was built in Singapore with more than 100 towers, every 9 m in height, where vegetables were cultivated using direct sunlight and harvested rainwater.

Figure 1: Source: Vertical farming: Birkby, J. (2016). www.Freightfarm.com.

Advantages

Despommier has discussed various potentials of vertical farming. More benefits are obtained, from scaling up hydroponic or aeroponic growing methods, as follows.

Preparation for the future

The world population is expected to grow up to nine billion by 2050 (Hanjra and Qureshi, 2010). This population growth will lead to cause more pressure on existing natural resources. Through

vertical farming systems, utilization of land can be minimized and doubling the Agri production can be done. The traditional farming system causes more pollution so researchers and farmers need to take up alternative farming systems with eco-friendly technologies. According to Despommier, a vertical farm is the only possible way to make a clean environment by adopting a suitable design.

Increased crop production

The vegetable cultivation in the non-tropical area is dependent on seasonal climatic conditions but in the vertical farming system, year-round crop production and farming multiply the productivity for all seasons by depending on the crop. In addition, they would have the same infrastructures in which they are grown; they will not be hampered in production due to infertility, infestation, and other consequences. In vertical farming, minimal harvested crops are infected with infestation. When dwarf version crops are used (dwarf wheat) which is smaller in size and high nutritional, year-round crops using “stacker” plant holders are accounted for, a 30-story building (2 acres (5 acres). would yield a crop of 1000 hectares (2,400 acres) of traditional farming.

Protection from weather-related problems

In recent decades our globe is immensely suffered from climate variation. Traditional farming systems are more influenced by climatic factor variation such as temperature, monsoons, hailstorms, tornadoes, flooding, wildfires, and severe droughts. Crop protection from climate change is increasing significantly. The United States has faced a huge loss (trillion dollars) of crop production by the flood. The vertical farming systems are practised in controlled environmental conditions, the cultivation is largely independent of the weather. Moreover, natural calamities such as earthquakes and tornadoes still pose threats to the proposed infrastructure.

Conservation of resources

A vertical population system is considered economically viable because using old buildings was creating favourable warehouses fitted with the right infrastructure for vertical farming. Crops are produced in the city or near the market so a reduction in transportation cost, fossil fuel reduction and also recover farmlands from the original flat farmlands. Vertical farming operations need skilled people for managing the farm due to this employment opportunity increased. Agriculture encroachment on the natural biome would

be avoided. Producing food indoors reduces or eliminates conventional ploughing, planting, and harvesting by farm machinery, also powered by fossil fuels.

Halting mass extinction

The vertical farming system helps to reduce the usage of a large area of earth surface and anthropogenic mass extinction of lands animals. We found that wild animals are disruptive in traditional agricultural farming. Some studies state that the wood mouse population dropped from 25 per hectare to 5 per hectare after harvest estimating 10 animals killed per hectare each year. In comparison with traditional farming would cause less harm to wildlife and would be allowed to be used to return to its pre-agricultural state.

Impact on human health

Traditional farming is hazardous occupation than vertical farming. In traditional farms the exposure to disease outbreaks (Malaria and schistosomes), exposure to toxic chemicals and use of pesticides and fungicides. The farming system is unavoidably about these risks, the American food system makes fast, unhealthy food, encouraging poor eating habits. These poor eating habits lead to health concise like obesity, cardiovascular disease and diabetes. The increased availability and subsequent cost of food would encourage healthier eating.

Poverty/destitution and culture.

In the twenty-first century food security is one of the prime factors to poverty. Rapidly growing Vertical farming system produces enough quantity of food with good nutritional value. Medicinal plants can be also produced in this system. The use of this technology without sacrificing sustainability or basic needs can be significant to the recovery of society from poverty.

Urban growth

The people are moving to the city due to this it's become forming as urbanization. When cities expand while remaining largely self-sufficient food-wise. Moreover, this technology supports more to expand or implementation into urban centres. More employment opportunities will be created for workers and as well traditional farmers in the city.

Energy sustainability

Water conservation and recycling are possible in the vertical farming system but not in the traditional farming system. Producing organic waste can be converted into biogas by a built-on methane digester. This biogas burned to generate electricity for the greenhouse. Due to this, there will be a reduction in CO₂ emission to the atmosphere. Land and building costs are minimized, unused material can be also used for producing crops.

Types of vertical farm

There are three different types of vertical farms such as hydroponics, aquaponics and aeroponics. The peculiar character of all these three systems for growth of vegetation using no soil but make sure that enriched nutrient water is availed plants roots observed by directly.

Hydroponics

Growing plants in nutrients but without soil. Plant roots get submerged in water, correct nutritional and chemical composition will be monitored frequently. The following major benefits are as follows

- Enhancing rapid plant growth
- Chance for elimination or avoiding soil-related cultivation
- Usage of pesticides and fertilizer is reduced.

Aeroponics

This farming type is varied from hydroponics, growing plants in an air/mist environment with no soil and very little water. It involves spraying the roots of plants with nutritious water. The following benefits are noted.

- Very effective plant culture system than aquaponics and hydroponics
- Using up to 90% less water than an efficient hydroponics system.
- Absorbance more minerals and vitamins and make the plant healthier.

Aquaponics

This system is an up-gradation of hydroponics of techniques. This system integrated aquaculture with hydroponics (fish and plant combination in the same ecosystem). The following benefits from this system are,

- Creating a symbiotic relationship between fish and plant
- Producing Fish waste (high nutritive value) that is used as a feed source for the cultivating plants.
- Plants help to filter and purify the wastewater.
- More viable environment-friendly farming ecosystem.
- Reduce fertilizer cost for both cultivating plants and fish.

Figure 2: Source: Aquaponic system (Gupta, M., K., and Ganapuram, S. 2019, wwwinfosys.com).

Figure 3: Source: Aquaponics (Plant and fish grow together in vertical farming - interesting engineering.com).

Conclusion

The vertical farming system is the sustainability of the way forward for eliminating the food hunger in this world in the twenty-first century. Climate change is a big phenomenal challenge to traditional farming. An overpopulation is shrinking land, water and lower yield crop production. Therefore the vertical farming (controlled environment) system is more reliable related to climate change as well one of the most preferred alternatives for sustainable food production. Vertical Farming will generate more employment opportunities further in an urban area. Hence, the vertical farming systems is significantly considered as the modern era of farming in 21 first century.

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