Vertical Farming

D. Rameshkumar*, N. Jagathjothi, S. Easwari, R. Rajesh, R. Muthuselvi, P. Naveen Kumar, B. Krishnakumare, R. Minithra and R. Suresh

INTRODUCTION

In 1915, Gilbert Ellis Bailey coined the term "Vertical farming" and wrote a book titled "Vertical Farming". In the early 1930s, William Frederick Gerick pioneered hydroponics at the University of California at Berkley. In the 1980s, Ake Olsson a Swedish ecological farmers, invented a spiral-shaped rail system for growing plants and suggested vertical farming as a means for producing vegetables in cities. Using advanced greenhouse technology such as hydroponics and aeroponics, the vertical farm could theoretically produce fish, poultry, fruit and vegetables (Despommier, 2010). His concept was to grow the food in urban areas itself utilizing less distance and saving the time in bringing the food produced in rural areas to the cities. He intended in growing food within urban environments and thus have fresher foods available faster and at lower costs.

Why vertical farming?

Vertical farming could enable food production in an efficient and sustainable manner, save water and energy, enhance the economy, reduce pollution, provide new employment opportunities, restore ecosystems, and provide access to healthy food. In a controlled environment, crops will be less subject to the infestation, the nutrient cycle, crop rotation, polluted water runoff, pesticides and dust (Touliatos *et al*., 2016).

Vertical farms also utilize advanced technologies and intensive farming methods that can exponentially increase production. Researchers have been optimizing indoor farming by calibrating, tuning and adjusting a wide-range of variables including light intensity, light color, space temperature, crop and root, CO2 contents, soil, water, and air humidity (Padmavathy *et al*., 2016). In addition, vertical farming provides an opportunity to support the local economy. Abandoned urban buildings can be converted into vertical farms to provide healthy food in neighborhoods where fresh produce is scarce.

World Scenario

Vertical farming involves growing crops vertically in controlled atmosphere using technology like LED lighting, heating, ventilation and air-conditioning (HVAC) systems,

sensors and smart software, Internet of Things (IOT), drones, mobile apps to maintain total control over the environment. Food crops can be cultivated easily in urban areas by planting in vertically stacked layers in order to save space and use minimal energy and water for irrigation. Sparks and Stwalley, 2018 tested the Nutrient film technique hydroponics system was by growing lettuce plants and monitoring energy use throughout the growth period..

Various experiments are being done about vertical farming all over world. It has already been introduced in the US and Europe, Spain, Japan and Singapore. Several tech-enabled vertical farms like Aerofarms and Green Sense in the USA, Delicious in The Netherlands, Sharp's strawberry farm in Dubai, Spread, Toshiba and over 100-plus vertical farms in Japan, Packet Greens of Singapore, the EU funded INFARM in Berlin are proven examples of successful vertical farming. INFARM is now operating more than 50 farms across Berlin in supermarket aisles, restaurant kitchens and distribution warehouses. The National Aeronautics and Space Administration (NASA) researchers have seen hydroponics as a suitable method for growing food in outer space. They have been successful in producing vegetables such as onions, lettuce, and radishes. In Columbia, Association for Vertical Farming is working on its sustainability.

Categories of vertical farming systems

Vertical Farming systems can be broadly divided into two categories those comprising multiple levels of traditional horizontal growing platforms and grown on a vertical surface. Horizontal growing system are stacked horizontal systems and multi- floor towers, Balconies. Vertical growth surfaces are green walls and cylindrical growth units.

General Structure of Vertical Farming

The vertical farm is planned to be totally using artificial light or both artificial and natural light should be taken into account. The same issues need to be considered in designing the facility. There are two options available LED (light emitting diode) or HPS (high-pressure sodium). When choosing the crops to grow considering which plants can be better bred indoors. Because of limitations imposed by height, plants that grow on trees such as bananas, olives, avocados, and nuts are hard to grow inside. But, there is another chance to grow tree crops and that is to grow them in an outer area as much as there is space provided. This way, more than three dozen types of vegetables can be chosen to grow inside the building hydroponically (Ankri, 2010). The most common products now produced in vertical farms are lettuce, tomato, chinese cabbage, eggplant, green onion/chives, kale spinach and cucumber.

SYSTEMS OF VERTICAL FARMING

1. Hydroponics

"Hydroponics" is the growing of plants in a liquid nutrient solution with or without the use of artificial media. Commonly used mediums include expanded clay, coir, perlite, vermiculite, brick shards, polystyrene packing peanuts and wood fiber.

Hydroponics has been recognized as a viable method of producing vegetables (tomatoes, lettuce, cucumbers and peppers) as well as ornamental crops such as herbs, roses, freesia and foliage plants.

The predominant growing system used in vertical farms, hydroponics involves growing plants in nutrient solutions that are free of soil. The plant roots are submerged in the nutrient solution, which is frequently monitored and circulated for maintaining correct chemical composition. This method results in more uniform and better yields the optimum combination of nutrients can be provided to all plants. It also provides less labour intensive way to manage larger areas of production. It is a cleaner process that no animal excreta are used. Easier way to control nutrient level and pH balance. In 1950 commercial farms are started at America, Europe, Asia, Africa, Japan most successfully practiced in Israel.

Liquid systems have no supporting medium for the plant roots; whereas, aggregate systems have a solid medium of support. Hydroponic systems are further categorized as open (once the nutrient solution is delivered to the plant roots, it is not reused) or closed (surplus solution is recovered, replenished, and recycled).

Liquid Hydroponic / Nutrient Film Technique

Plants are placed in a polyethylene tube that has slits cut in the plastic for the roots to be inserted. Nutrient solution is pumped through this tube.

Floating Hydroponics

Plants are grown on a floating raft of expanded plastic.

Aggregate Hydroponics

Rockwool Culture: It is the most widely used medium in hydroponics. Rockwool is ground-up basalt rock that is heated then spun into threads making wool. It is very light and is often sold in cubes. Rockwool can hold water and retain sufficient air space (at least 18 percent) to promote optimum root growth. Plants are established on small rockwool slabs positioned in channels containing recycled nutrient solution.

These system are further categorized into two:

- Passive systems use a wick and growing media with very high capillary action. This allows water to be drawn to the plant roots. The Wick System is by far the simplest type of hydroponic system
- Active systems work by actively passing a nutrient solution over your plants roots.

2. Aeroponics

The Aeroponic System is probably the most high-tech type of hydroponic gardening. A timer controls the nutrient pump. The aeroponic system needs a short cycle timer that runs the pump for a few seconds every couple of minutes. In aeroponics, there is no growing medium and hence, no containers for growing crops. In this system, mist or nutrient solutions are used instead of water. As the plants are tied

to a support and roots are sprayed with nutrient solution, it requires very less space, very less water and no soil.

Advantages of vertical farming

- The first and the major advantage of vertical farming is producing extremely high yields per available land or area.
- Producing the food throughout the year without the risk of vagaries of nature of nature like floods, heavy rains, uneven rains, hail and snowfall, drought, dry spells, extreme high temperatures, cold waves, epidemics of pest and diseases, etc.
- It reduces the cost over transporting loads of food grains from rural area to urban areas and reduce the spoilage occurring there in. Fossil fuel consumption in transporting the farm produce to cities from village places is also reduced to a greater extent.
- Vertical farming uses 70 to 95 % less water compared to traditional farming
- 90% less or no soil is needed in vertical farming and thereby no pest and disease infestations.
- Pesticide free or organic food is produced as there is no use of pesticides.

Disadvantages of vertical farming

- Initial huge cost for establishing the vertical farming system is the major problem. It will include the cost erecting the structures along with its automation like computerized and monitoring systems, remote control systems, programmable LED lighting systems, climate control system, etc.
- Huge energy cost as growing plant is entirely with artificial lights. The excess nutrients used in vertical farming may interfere and contaminate the main urban water system if not taken care of.
- LED lighting systems emit heat though small amount will create problem of maintaining the temperatures especially in summer months and may overload the air conditioning systems which will again incur high energy cost.

FEASIBILITY OF VERTICAL FARMING IN INDIA

India is one of the largest producer of vegetables, fruits and many other agricultural commodities. In India, vertical farming has been introduced. ICAR experts are working on the concept of 'vertical farming' in soil-less conditions, in which food crops can be grown even on multi-storeyed buildings in metros like New Delhi, Mumbai, Kolkata and Chennai without using soil or pesticides. Small-scale adaptations of vertical farming have been seen in Nadia, West Bengal and in Punjab. Bidhan Chandra Krishi Vishwa vidhalaya in Nadia has found initial success in growing brinjal and tomato. Punjab also has succeeded in producing potato tubers through vertical farming (Kalantari *et al*., 2018).

FUTURE THRUST

- If vertical farms were integrated in the city, they will be able to supply food for the entire population.
- There is a need for research that accurately assesses the Return of Investment (ROI)

of various types and sizes of vertical farms.

- ❖ There is a need to investigate the full life-cycle analysis (LCA) and the number of years to reach parity with a traditional farm
- ❖ Researchers should invent, advance, and further develop local farming techniques to make vertical farm projects feasible in these countries.
- ❖ For example, they may invent recycling methods that reduce reliance on water, design local systems by capturing rainwater, and may capitalize on local solar power for providing natural light and energy (Kalantari *et al*., 2015).

CONCLUSION

Vertical farming is a best alternative for the city dewellers. It can deliver food in sustainable ways to improve global food security and solve the environment degradation problems. No harvest would fail by severe weather phenomenon. It has the benefit for easily minimise the cooling and heating water by indoor temperature. It helps to reduce poverty, increase food safety and well being of human. Effectiveness of vertical gardening depends on the demand and supply of food, urban population and densities, technological development, water and energy supply and weather conditions.

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