

## Vertical Farming: Scope and Future Aspects

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### Introduction

Advancement in science & technology and global urbanization are considered as major contributing factors for driving the course and evolution of agricultural research. In order to ensure a continuous and adequate food supply, the agricultural production levels have to be boosted by at least 70 per cent by 2050 (Shubham *et al.* 2020). Changes in dietary preferences and increased worries about food quality have become alarming issues in urban countries. In India, agricultural production majorly influenced by climatic, social and soil related problems like climate change, water scarcity, labour scarcity, desertification, acidity and salinity problems. Therefore, identifying new agricultural systems which will consume less space and ensure higher yields have become the area of priority (Alexandratos and Bruinsma, 2002).

Vertical farming is basically stacking of crops in vertical manner rather than horizontal and thus can be utilized to get more production out of small piece of land. Gilbert Ellis Bailey coined this term in his book 'Vertical Farming' in 1915. He talked about the utopian concept of vertical farming. He popularised the notion of subsurface vertical farming which is now used throughout the Netherlands. Generally, vertical farming is a method which involves producing crops under controlled indoor conditions *i.e.* light, nutrients and temperature. Vertical farming involves stacking growing plants in vertical layers in order to accommodate more plants. The vertical farming approach is an advanced version of green house based cultivation, however, it involves harnessing the resources in vertical arrays and thus has a potential to meet the food demand by using megacity resources. Farmers living in underdeveloped nations are unable to access and adapt to contemporary intensive agriculture techniques due to lack of financial resources and poor understanding of technological improvements and thus remain isolated from global links (Al-Chalabi, 2015). Long distance food commerce, nutritional changes and expansion in food-based retail businesses are clear evidences that globalisation has altered food systems worldwide to a great extent

(Anonymous, 2022). However, more advanced techniques like sensor based irrigation systems, see & spray technology, robotics in agriculture are still on its way.

### **Approaches of vertical farming**

- 1. Hydroponics:** A growth technology commonly practiced in vertical farms, which involves growing the plants in soilless nutrient solutions. The plant roots are immersed inside the nutrient solution, which is constantly checked and cycled to maintain the proper nutrient and chemical composition like pH and total soluble salts (TSS). Hydroponic emphasises on producing crops in water without the use of soil by employing mineral fertiliser solutions for plant growth. The primary benefit of this strategy is that it lowers the chances of soil borne diseases attacks such as soil-borne insects, pests and illnesses.
- 2. Aeroponics:** The NASA (National Aeronautics and Space Administration) is in charge of developing this novel indoor growth method effectively. NASA was interested in discovering the alternate ways to grow plants in space since 1990's, so they have invented this approach namely 'Aeroponics' which means growing the plants in an air/mist environment without soil. But still practice of aeroponics is still rare in the realm of vertical farming. By far the most efficient plant-growing techniques for vertical farms, an aeroponic system proved its superiority by utilizing up to 90% less water than hydroponic system.
- 3. Aquaponics:** An aquaponic system expands on integration of plants and fishes in same habitat under hydroponic system. This is basically a bio-system which establishes a symbiotic relationship between plants and fish. In this approach, fishes are raised in indoor ponds, generating nutrient-rich excrement utilised for fulfilling the nutritional demands of plants. In turn, the plants in hydroponic beds act as bio-filters, removing gases, acids, and chemicals from the water such as ammonia, nitrate and phosphates. At the same time, the gravel beds offers home to nitrifying bacteria which plays important role in nitrogen cycles and water filtering. Therefore, in this way the cleansed water gets re-circulated back into the fish tanks.

### **Benefits and Drawbacks of vertical farming**

#### **Benefits:**

1. Ability to produce extra-ordinarily high yields per land available.

2. Produce food throughout the year without any fear of natural disasters such as floods, strong rains, uneven showers, hail and snow, drought, dry seasons, extreme high temperatures, cold waves, pest and disease outbreaks.
3. Water saving approach, as the vertical farming consumes 70 to 95% less water as to conventional agricultural systems.
4. Vertical farming requires 90% less or no soil, resulting in no insect and disease infestations.
5. Pesticide-free or organic food can be produced.
6. Because of the shorter food supply chain, consumers receive fresh produce with all of its inherent nutritious properties.

**Drawbacks:**

1. High initial cost of creating the vertical farming system. As establishing the unit requires constructing of building as well as their automation such as computerised and monitoring systems, remote control systems and software, automated racking and stacking systems, programmable LED lighting systems, temperature control systems.
2. High energy costs because the plant is grown entirely using artificial lighting.
3. Excess nutrients from vertical farming may interfere with and contaminate the main municipal water supply if not properly managed.
4. LED lighting systems release heat which despite its tiny amounts can cause problems with temperature maintenance particularly during the summer months and therefore may overwhelm air conditioning systems resulting in high energy costs.
5. With vertical farming a lot of rubbish plant residues and other waste will be created around the structures which must be appropriately disposed off.
6. Skilled labour will be scarce at first and will require training.

**World scenario**

Vertical farming is the practise of growing crops vertically in a controlled environment using technology such as LED lighting, heating, ventilation, air-conditioning (HVAC) systems, sensors, smart software, the Internet of Things (IoT), drones and mobile applications to maintain total control over the environment (Kluko and Milan, 2015). Food crops may be easily grown in urban environments by planting in vertically stacked layers which ultimately saves space and requires little energy and water for irrigation. Sparks and

Stwalley in 2018, put the nutrient film technique (NFT) hydroponics system to the test by producing lettuce plants and tracking energy use during the growth period. Alternative energy scenarios revealed possible energy consumption savings of up to 53% and an increase in whole system crop production efficiency of up to 55% over the baseline (Sparks and Stwalley, 2018). Vertical farming experiments are being conducted all over the world. It has already been launched in the United States, Europe, Spain, Japan, and Singapore. Aero farms and Green Sense in the United States, Delicious in the Netherlands, Sharp's strawberry farm in Dubai, Spread, Toshiba, and over 100 vertical farms in Japan, Packet Greens in Singapore, and the EU-funded INFARM in Berlin are all successful instances of vertical farming. INFARM now has over 50 farms in grocery aisles, restaurant kitchens, and logistics facilities around Berlin. Hydroponics has been identified by National Aeronautics and Space Administration (NASA) experts as a viable technology for growing food in space. They had success growing vegetables like onions, lettuce, and radishes. The Association for Vertical Farming in Columbia is focusing on its sustainability (Shomefun *et al.* 2018).

### **Vertical farming in India**

India is a major producer of vegetables, fruits, and a variety of other agricultural goods. Vertical farming has been adopted in India. Scientific experts at ICAR, New Delhi are developing the concept of 'vertical farming' in soil-free settings, in which food crops may be grown even on multi-story buildings in metros such as New Delhi, Mumbai, Kolkata, and Chennai without the need of soil or pesticides (Kalantari *et al.* 2018). Researchers at the Bidhan Chandra Krishi Viswavidyalaya, Nadia have already had some success with hydroponically vertical gardening on a modest scale. Vertical farming on a small scale has been observed in Nadia, West Bengal, and Punjab. Bidhan Chandra Krishi Vishwavidhalaya in Nadia has had initial success with brinjal and tomato cultivation. Punjab has also been successful in generating potato tubers using vertical gardening. Ideafarms, an Indian design-in-tech firm grows vertical farms and is liked because their food is organic, of high quality, and the supply is dependable. Greenopia, a Bengaluru-based firm, sells packages that include smart self-watering containers, enhanced soil, and the appropriate seeds. The sensor-embedded pots replace soil moisture as needed and alert you when you need to refill water outside. U-Farm Technologies, a Mumbai-based start-up, is customising a modular farm for an individual housing complex or a supermarket using hydroponic growing techniques. In

India, a growing number of vertical farming start-ups are emerging (Graamans *et al.* 2018; Zhang and Schulman, 2017; Chin and Audah, 2017; Lee and Chuang, 2017; Khandaker and Kotzen, 2018)

### **Can Vertical Farms Be Organically Certified?**

Farmers cherish the USDA Certified Organic mark and customers are generally ready to pay a premium for certified organic products. The vertical farming community and the organic authorities that determine the organic certification requirements are engaged in a certification controversy. Because there is no "soil biological activity" in vertical farming production (which comprises of hydroponic, aeroponic, or aquaponic systems), a vertical farm would have trouble fitting this rigorous definition of organic agriculture. However, the NOP is also permitting some organic certification organisations to issue organic certification to hydroponic enterprises that can demonstrate they utilise solely organic inputs and fulfil other certification standards. Some national certification organisations (such as California Recognized Organic Farmers) have previously certified organic hydroponic operations, whereas other regional certification organisations refuse to certify hydroponic and other non-soil-based growing methods. The controversy over whether vertical farm crops may be certified organic is certain to continue (NOSB, 2020)

### **Conclusion**

Vertical farming is definitely a solution to critical problems in Indian farming. But there are challenges like acceptance of vertical farming by Indian farming community. Indian farmers are facing various problems like lack of electricity supply throughout the day, assurance of minimum support prices, no control over market glut and water scarcity. Vertical farming and organic farming can be adopted as viable alternatives for the conventional agriculture to meet the changing demands and needs of mankind. Further, constraints in adoption of such practices should be addressed and linkages between researchers and farmers should be created for suitable measures to ensure their adoption.

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