Ecofarming (e-Magazine)

Agriculture

Ecofarming
e-Magazine for Agriculture and Allied Sciences
http://www.ecofarming.rdagriculture.in
e-ISSN: 2583-0791

Vertical Farming

Revolutionizing Urban Food Production

1. **Kumar Sathiyaseelan**
Division of Plant Pathology, ICAR-IARI, New Delhi
Email: kumarsathiya1996@gmail.com
2. **Emmadi Venu**
Division of Plant Pathology, ICAR-IARI, New Delhi
3. **Andonissamy Daniel**
Division of Plant Physiology, ICAR-IARI, New Delhi
4. **Akurathi Ramya**
Department of Plant Pathology, Junagadh Agricultural University, Gujarat

Received: August, 2024; Accepted: September, 2024; Published: October, 2024

Introduction

Urbanization and population growth have posed significant challenges to traditional agricultural practices, particularly in meeting the food demands of dense metropolitan areas. Our agricultural land footprint today equals the size of South America, but how much more will be needed in the future? Traditional farming faces critical challenges, including land degradation, water shortages, and the growing impact of climate change. One innovative solution that has gained traction in recent years is the concept of vertical farming, which involves cultivating plants and livestock on vertically stacked surfaces within urban environments. This approach offers the potential to address the scarcity of arable land and the inefficiencies associated with transporting food over long distances, while also promoting sustainable and environmentally-friendly food production (Kalantari et al., 2018). Technological advances like LED lighting, hydroponics, and automation have made this model feasible, allowing for efficient use of space and resources. This innovative approach addresses food security while reducing environmental strain, making it a key component of future urban agriculture.

The Need for Vertical Farming

Urbanization and Population Growth With over half of the world's population living in cities, the pressure on agricultural systems is increasing. By 2050, the global population is expected to reach 9.7 billion, with urban areas housing nearly 70% of people (United Nations, 2018). Traditional farming methods struggle to meet the growing demand for fresh produce in densely populated urban areas. Environmental Degradation Soil degradation, deforestation, and unsustainable farming practices have reduced arable land. Conventional agriculture consumes 70% of global freshwater resources and significantly contributes to greenhouse gas emissions (FAO, 2021). Vertical farming offers a solution to these problems by reducing the need for vast tracts of land and water resources. Climate Change and Food Security Climate change exacerbates food insecurity, as extreme weather events disrupt traditional farming. Vertical farming, with its controlled environment, allows for year-round production, independent of external weather conditions. This resilience makes it an attractive option for ensuring food security in the face of climate variability.

What is Vertical Farming?

Vertical farming is the agricultural process in which crops are grown on top of each other, rather than in traditional, horizontal rows. Growing vertically allows for conservation in space, resulting in a higher crop yield per square foot of land used (Despommier, 2010). Vertical farms are mainly located indoors, such as a warehouse, where they have the ability to control the environmental conditions for plants to succeed.

Types of Vertical Farming

Hydroponics: Crops are grown in nutrient-rich water solutions without soil. This method is space-efficient and conserves water, using up to 90% less than conventional farming (Despommier, 2010).

Aeroponics: Plants are grown in an air or mist environment, using minimal water and delivering nutrients directly to the roots.

Aquaponics: Combines hydroponics with aquaculture (fish farming), creating a symbiotic environment where fish waste provides nutrients for the plants, and plants help filter the water.

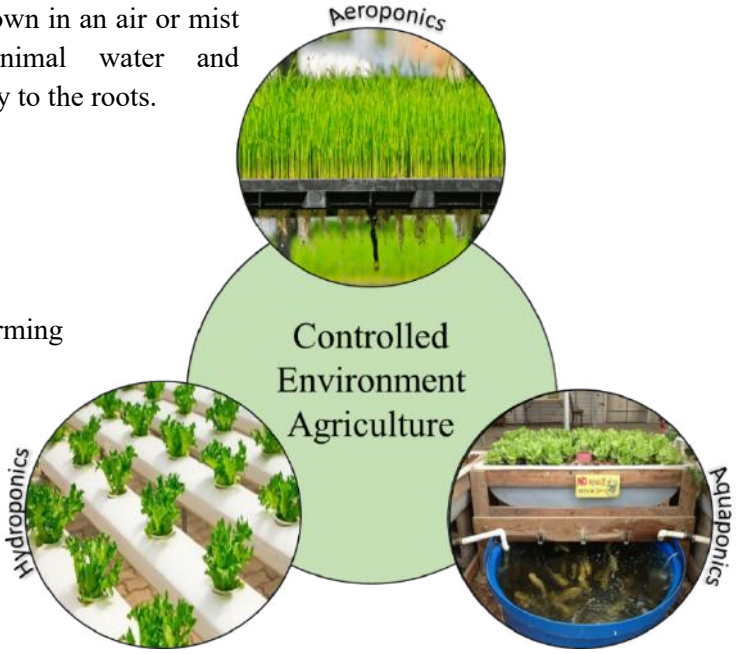

Fig.1: Types of vertical farming

Controlled Environment Agriculture (CEA): involves growing plants in structures like greenhouses or indoor setups, where factors such as air quality, temperature, light, water, humidity, and nutrients are carefully managed. Vertical farming typically integrates CEA with soilless methods like hydroponics, aquaponics, and aeroponics (fig.1). These combined techniques enhance resource efficiency and optimize growing conditions for higher productivity.

Crops suitable for vertical farming

To choose the optimum crop for vertical farming, it's critical to take into consideration factors including growth patterns, market demand, and climate. Crops that are popular in India include bell peppers, tomatoes, cucumbers, strawberries, leafy greens, microgreens (young plants gathered at an early growth stage), turmeric, and herbs (Sherief, 2023). It's interesting to note that vertical farming isn't just for plants; aquaculture, which includes crab farming, can also use it, demonstrating how adaptable it is for food production systems.

Plan and Design of Vertical farming System

A vertical farming system's layout and construction are essential for maximizing solar exposure and guaranteeing smooth operation. A well-planned building improves resource management and production.

Building Shape for Vertical farming

To maximize the amount of sunshine that enters a structure during the day, the building's design

is crucial. Because asymmetrical high-rise structures are easier to plan, design, and build, they are frequently used for vertical farming. Six growing beds should ideally be able to be supported on each floor of the building, with a 150–200 cm corridor to allow for simple transportation of farming supplies and equipment. This design makes better use of available space and enhances accessibility for harvesting and maintenance tasks (Kumar et al., 2020).

Irrigation System for Vertical farming

Most people agree that the drip irrigation technique is the most effective way to irrigate vertical farms. Water is sent directly to the plant roots via this method at a controlled, slow rate, which helps to conserve it. A water pump, filtration units, fertigation system, backwash controls, pressure regulation valves, pipelines, and tubing are among the essential parts needed for the system to work. Farmers can reduce fertilizer consumption by up to 95% by utilizing liquid fertilizers with drip systems.

Lighting System for Vertical farming

Artificial lighting and natural sunlight can both be used to provide lighting for vertical farming. Reflectors should be placed on each floor to capture and reroute sunlight during the day in order to maximize the utilization of natural light. LED lighting systems are a great option for evening illumination because of their extended lifespan, brightness, energy efficiency, and affordability (Kumar et al., 2020).

Case study: Urban Kissan

One notable example of vertical farming in India is the Urban Kisaan project, founded in Hyderabad. Urban Kisaan specializes in hydroponic vertical farming, producing fresh, pesticide-free vegetables and herbs within urban areas. By using soilless farming methods and vertically stacked layers (fig.2), Urban Kisaan maximizes the use of small spaces, helping address the challenges of limited land availability and urban population growth in Indian cities. The company has set up vertical farms in Hyderabad and Bengaluru, using climate-controlled environments to ensure year-round crop production, irrespective of external weather conditions. This allows them to reduce water consumption by up to 90% compared to traditional farming methods, which is crucial in water-scarce regions of India. Urban Kisaan's model demonstrates the potential of vertical farming to improve food security in India by producing fresh, local produce closer to urban consumers, reducing transportation costs, and minimizing the carbon footprint. The other companies are listed in table-1.

Figure-2: Worker tending crops in a vertical farming facility at Urban Kisaan (source:krishijagran.com)

Table-1: list of vertical farming companies in India

S. No	Company Name	Website address
1	UGF (Urban Green Fate)	http://ugffarms.com/
2	Triton Food Works	http://www.tritonfoodworks.com/
3	365Dfarms	https://365dfarms.com/
4	Future Farms	https://www.business.futurefarms.in/
5	Letcetra Agritech	http://www.letcetraagritech.com/
6	Agricool India	https://www.agricoolgroup.com/en/

Advantages of Vertical Farming

Space Optimization: Vertical farming maximizes urban space by growing crops in stacked layers, allowing food production in confined areas.

Water Efficiency: Uses up to 90% less water through recirculated systems, minimizing waste and promoting sustainability.

Pest and Disease Control: Vertical farming's-controlled environment minimizes exposure to pests and diseases, reducing crop losses without the need for chemicals.

Reduced Environmental Impact: By regulating internal conditions, vertical farming is less affected by external environmental factors, leading to more stable and reliable crop production.

Pesticide-Free and Higher Yields: Controlled environments eliminate pesticides, producing healthier crops and yielding up to 10 times more per acre (Benke & Tomkins, 2017).

Reduction in Food Miles: Proximity to cities reduces food transport distances, cutting costs, energy use, and carbon emissions.

Challenges and Barriers to Adoption

High Initial Investment: Requires significant capital for infrastructure, including lighting, climate control, and urban real estate.

High Energy Costs: Operational costs for electricity, especially for artificial lighting, can reduce profitability.

Limited Crop Diversity: Focuses mainly on high-value crops like leafy greens and herbs, with staple crops being less feasible.

Technical Expertise: Requires skilled personnel to manage complex systems, which can be a barrier for small-scale farmers.

System Failures: Malfunctions in climate or irrigation systems can lead to crop failure, posing financial risks.

Consumer Acceptance: Vertical farming is still new in many areas, and consumer awareness is limited.

Conclusion

Vertical farming maximizes space, conserves water, and uses fewer pesticides than other agricultural practices, providing a sustainable solution to today's agricultural problems. Although there are still issues with energy costs and crop variety, technological developments are making it more viable and efficient. Vertical farming is becoming more and more important for environmental sustainability and urban food security as cities expand and the world's food demands rise. Methods including hydroponics, aeroponics, and climate-resilient farming are practiced in India to support sustainable agriculture, enhance resource efficiency, and reduce pollution. Vertical farming is expected to play a major role in urban agriculture in the future because of its large reduction in carbon footprint.

References

1. Benke, K. and Tomkins, B. (2017). Future food-production systems: Vertical farming and controlled-environment agriculture. Sustainability: Science, Practice and Policy, 13(1), 13–26.

2. Despommier, D. (2010). The vertical farm: Feeding the world in the 21st century. Thomas Dunne Books/St. Martin's Press.
3. Food and Agriculture Organization. (2021). State of the World's Land and Water Resources for Food and Agriculture: Systems at breaking point (SOLAW 2021). FAO. https://www.fao.org/3/cb7654en/cb7654en.pdf.
4. Kalantari, F., Tahir, O.M., Joni, R.A and Fatemi, E. (2018). Opportunities and Challenges in Sustainability of Vertical Farming: A Review. *Journal of Landscape Ecology.* 11(1): 35-60.
5. Kumar A, Shukla S, Dixit P, Tsewang T and Kumar K (2020). Vertical Farming Promising Cultivation for Horticultural Crops. *Int.J.Curr.Microbiol.App.Sci*. 9(6): 2491-2494.
6. Sherief, S. (2023). Vertical farming in India: Setup, advantage, suitable crops. Times of Agriculture. https://www.timesofagriculture.com/vertical-farming-in-india-setup-advantage-suitable-crops
7. United Nations. (2018). World Urbanization Prospects: The 2018 Revision. Department of Economic and Social Affairs, Population Division. https://population.un.org/wup/