Challenges of Growing Staple Crops in Vertical Farms

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ABSTRACT

Vertical farming an innovative agricultural technique, involves cultivating crops in vertically stacked layers under a controlled environment, optimizing parameters like temperatures, light, humidity, and nutrients. This method ensures year-round high-quality produce, addressing challenges posed by limited arable land, urbanization, and environmental changes. In India, where staple crops like rice, wheat, and millet are essential for food security, economic stability, and livelihoods, vertical farming offers potential as a supplementary approach to traditional agriculture. Vertical farming has promising potential due to its efficient resource utilization, reduced reliance on pesticides, and adaptability to the urban environment. Advances in climate–resilient crops, efficient technologies, and supportive policies are critical to scaling up vertical farming for staples.

INTRODUCTION

The definition of vertical farming is the technique of growing crops in layers. All growth parameters, including light, temperature, humidity, carbon dioxide content, water, and nutrients, are carefully regulated in vertical farming, an indoor plant production system that produces large amounts of fresh, high-quality produce all year round, regardless

of soil and other environmental factors. Still, nutrient solutions are provided, as well as other outdoor conditions (Kozai *et al*., 2020). The concept of sustainability will be dealt with, and vertical farms will meet food demand. When the population crosses a billion by the year 2050, more arable land is expected to be needed to produce 50% of the food. With increased urbanization, about 75% of the world's population is settled in urban areas. Food production is the major threat that is going to be faced by the coming generations. Vertical farming methods can be a supplementary approach to help address the scarcity of fertile arable lands and water. In India, the staple crops include rice, wheat, maize, pulses, and millet, which are crucial for food security, economic stability and livelihood generation.

Importance of staple crops in India

1. Food Security

Staple crops are an important source and backbone of Indian diets, and they supply adequate carbohydrates, proteins, and calories. These crops are inexpensive and accessible, ensuring regular supply for people worldwide.

2. Economic importance

Many small and marginal farmers depend on the cultivation of staple crops for their income and sustenance. India is a leading exporter of staple crops like rice, contributing to foreign exchange earnings.

3. Adaptation to diverse climates

India's diverse climate supports the cultivation of various staple crops such as rice, wheat and millet.

4. Role of sustainable development

Diversifying staples like millet, which require fewer resources for their Growth, promotes better nutrition and addresses malnutrition. Some staples resist climate change and require less inputs for their Growth and development.

Some of the Provocations of Staple Crop Production:

1. ENVIRONMENTAL CHALLENGES

- **Climate change:** Temperature fluctuations, irregular distribution of rainfall patterns, and varying climatic conditions like drought, cyclone, and flood can cause changes in productivity.
- **Water scarcity:** Over-dependence on underground water resources for irrigation and the depletion of these water resources in states like Punjab and Haryana hinder sustainable production of these crops.
- **Soil Degradation:** Overuse of chemical fertilizers, fertilizers, monocropping, and deforestation have reduced soil fertility and increased salt levels in the soil, which lessen the Growth of these crops.
- **Pest and disease outbreaks:** Crops like rice and wheat are vulnerable to pests and diseases, reducing yields.

2. TECHNOLOGICAL CHALLENGES

- **Access to modern techniques is limited:** Small and marginal farmers often lack access to advanced farming techniques such as precision agriculture, high-yielding seed varieties, and farm mechanization.
- **Post-Harvest Losses:** Poor storage facilities and an improper supply chain infrastructure mean loss when transporting and storing.

3. SOCIO –ECONIMIC CHALLENGES

- **Small landholdings:** Most Indian farmers work on small and fragmented landholdings, which makes them unable to achieve economies of scale.

- **Lack of credit access:** Many farmers lack access to affordable and reasonable credit sources, which forces them to rely on informal moneylenders.

- **Migration:** Rural–to–urban and reasonable migration reduces the availability of agricultural labor, especially during peak periods like sowing and harvesting seasons.

4. POLICY AND MARKET CHALLENGES

- **Pricing and MSP problems:** the MSP policy, as it is highly beneficial for certain crops, allows other staples, such as millets and pulses, to go under-incentivized.

- **Market access:** Small farmers cannot access the market and fair prices due to domination by intermediaries.

5. ENVIRONMENTAL SUSTAINABILITY

- **Overuse of resources:** There has been over-exploitation of inputs such as water, fertilizers, and pesticides, resulting in environmental degradation over long periods.

- **Loss of biodiversity:** Monoculture cropping pattern tends to reduce crop diversity, making the agricultural system more susceptible to climate shocks and reducing soil fertility levels.

POTENTIAL SOLUTIONS

1. Adoption of climate-resilient crop varieties.

2. More investment in irrigation infrastructure and efficient water management practices.

3. Crop diversification and organic farming.

4. Strengthening agricultural credit systems and market linkages.

5. Improved post-harvest and storage infrastructure to minimize losses.

Why Vertical Farms?

Vertical farming is an innovative agricultural method of growing crops where vertically stacked layers are used in the controlled environment agriculture technique. It helps save the land area, a lacking factor in urban areas. It can use more advanced techniques like hydroponics and aquaponics to reduce water usage and help use recycled water, making this system more efficient (Kodmany, 2018). This can also reduce the long–distance transportation of food and lower the emission of greenhouse gases. It is having a setup of a controlled environment where the use of pesticides and herbicides is minimized, which results in healthier products (Mukherji and Morales, 2010). It can be an alternative option for traditional agriculture in limited cultivable areas with limited resources, extreme climates, or rapid urbanization, contributing to global food security.

Key Environmental Factors in Vertical Farming

1. **Light:** Artificial light sources can provide the range of light necessary to support photosynthesis. The intensity and duration of these sources can help fulfil the crop-specific requirements (the leafy crop requires less illumination than the grain).

2. **Temperature:** Usually maintained within proper ranges for the specific crop type

3. **Humidity:** Usually between 50 to 60%. This depends upon the crop variety. Some crops are tolerant, but some are susceptible to humidity.

4. **Nutrients:** Fertiliser replaces the soil in fertility and even eases its way of offering nutrients in a solution for plants to pick up quickly.

6. **Water:** The water supply should be regular and free of salts as they are of prime importance in the Growth of crops.

Challenges for Staple Crops in Vertical Farming

- **Space Constraints:** Tall and root crops require a lot of vertical or horizontal space.
- **Pollination:** Since natural pollinators are absent, staple grains and legumes require artificial or manual pollination.
- **Energy Costs:** Temperature and lighting control for long–term crops like rice or wheat can be expensive.
- **Yield Optimization:** Crop breeding for short growth cycles requires compact size and higher yield for economic viability**.**

Ideal Characteristics of Vertical Farming Crops

- **Short Growth Cycles:** Crops with short harvest cycles maximize efficiency.
- **Compact Growth:** compact Growth, very low plant height, and space efficiency.
- **High Yield per Plant:** The crops with high calorie or nutrient density per space unit are preferred.
- **Resource Utilization:** Plants that grow with less water, light, and nutrients

Challenges Of Growing Staple Crops

1. Space and scalability

Staple crops require ample space compared to leafy vegetables and herbs; staple crops often have extensive root systems, need more space for growth, and have a long maturation period. In vertical farms, there will be limited space for Growth, and it will limit their Growth, which will affect their yield.

2. Energy costs

Staple crops are photosensitive, requiring sunlight for photosynthesis throughout their growth stages. Artificial lighting can drastically increase the energy consumption. Also, the humidity and temperature fluctuations can affect their Growth. All these factors we provide artificially can lead to energy consumption rather than help in Growth.

3. Water and nutrient management

Vertical farming mainly depends on hydroponic and aquaponics systems, which mainly use nutrient solutions to maintain fertility. As soil is a storehouse of nutrients, we need to provide the reduced or additional nutrients, but in this system, we are entirely dependent on this solution for the Growth of plants (Muller, 2017). It is essential to ensure the optimal nutrient delivery for crops with complex root systems, which is technically more challenging in soilless systems.

4. Time to harvest

Staple crops have crop duration, which reduces the frequency and cropping intensity compared to crops growing in fi. This will affect the overall productivity of staple crops. Another limitation is crop rotation, which is used in fields to increase the soil fertility level, but that is lacking in vertical farming.

5. Economic viability

Staple crops are low-value, as they are challenging to grow in vertical farms. also, it cannot justify the cost of setting up the vertical farm infrastructure. Traditional farming for staples is more cost-effective than vertical farming due to economics (Kalantari, 2017).

6. Mechanical and structural issues

The staple crops mainly have more extended root systems, and they increase in biomass,

which can add strain to the vertical farm structures. Harvesting and processing can also be problematic as mechanization for harvesting staple crops is less developed for vertical systems than in traditional fields.

7. Pollination and reproduction

Some staple crops require pollinators, which must be done manually and will be challenging to manage in such controlled environments.

CONCLUSION

The challenges and exciting opportunities of technology in growing staple crops in vertical farms are uniquely different. The balance in growing crops in vertical farming lies in using less available resource input for crop growth with constraints and opportunities of controlled environment agriculture. The primary staple crops cannot be grown on a large scale compared to traditional crops grown in the fields. In brief, it is a promising field that can give high returns in the future. Some of the barriers to the large-scale scaling of this method for staple crop production are the high initial setup costs and the technological expertise needed to achieve optimal crop management in vertical systems. Vertical farming of staple crops is not a replacement for traditional agriculture but an integral part of the future food system.

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