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Vertical Farming: A Green Revolution for Urban Agriculture and Beyond

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Vertical farming is a cutting-edge method of intensive farming that can address many challenges such as water scarcity, climate change, labor shortages and reduction in arable land due to urbanization. It increases production, supports the local economy through employment, provides fresh food to disadvantaged areas and contributes to sustainable urban agriculture. Vertical farming provides environmental, social and economic benefits while increasing food security. This study is a critical review of relevant research articles from academic journals and online databases. Materials such as perlite, coir peat and vermiculite are used to grow plants to maximize growth and yields. Short-lived vegetables are ideal for vertical farming and offer a high net yield.

Impact of vertical farming

- Decreased transportation expenses through energy efficiency.
- Continuous, all-season crop cultivation with protection from adverse weather conditions.
- Selling crops within the same system reduces wastage.
- Elimination of fossil fuel emissions from crop machinery.
- Sufficient food production to compensate for lost farmland due to urbanization.
- Vertical farming yields the equivalent of four acres of traditional farming in crop output.

Advantages

1. **Space Efficiency:** Vertical farming utilizes vertical space efficiently, allowing for the cultivation of more crops in a smaller footprint compared to traditional horizontal farming. This is especially valuable in urban areas with limited space for agriculture.
2. **Year-Round Production**: Vertical farms can control environmental conditions like temperature, light, and humidity, enabling year-round production without being limited by seasonal changes.
3. **Reduced Land and Water Usage:** Vertical farming typically uses significantly less land and water than traditional farming, making it a more sustainable option, especially in water-scarce regions.
4. **Reduced Pesticide and Herbicide Use:** Controlled environments can reduce the need for chemical pesticides and herbicides, which can lead to healthier, more organic produce.
5. **Crop Protection:** Vertical farms are often protected from pests and extreme weather, reducing the risk of crop damage and loss.
6. **Energy Efficiency:** Some vertical farms employ energy-efficient LED lighting and advanced climate control systems, which can potentially reduce energy consumption compared to traditional farming methods.
7. **Local and Fresh Produce:** Vertical farms can be located close to urban centers, reducing the transportation distance and ensuring fresher produce for local consumers.

8. **Customizable Growing Conditions:** The ability to adjust environmental factors like light spectrum and nutrient delivery allows for customization of growing conditions, potentially improving crop yields and quality.

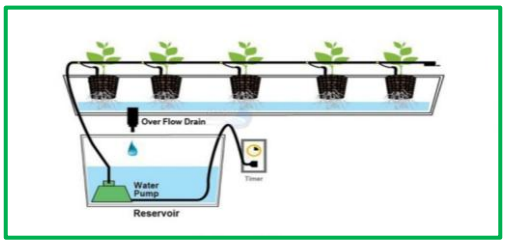
Disadvantages of Vertical Farming

1. **High Initial Costs:** Establishing a vertical farm can be expensive due to the need for specialized infrastructure, lighting, and climate control systems.
2. **Energy Consumption:** The artificial lighting and climate control in vertical farms can result in higher energy consumption, which may not be sustainable if the energy source is not renewable or efficient.
3. **Technological Challenges:** The technology used in vertical farming is still evolving, and there may be technical challenges and a learning curve for growers.
4. **Limited Crop Variety:** Vertical farming is most suitable for leafy greens, herbs, and some fruits. It may not be well-suited for all types of crops.
5. **Maintenance and Labor Costs:** Vertical farms require consistent maintenance and monitoring, and labor costs can be higher than traditional farms due to the need for specialized skills.
6. **Capital Intensive:** The high initial investment and ongoing operational costs can be barriers to entry for smaller or less financially secure farmers.
7. **Environmental Impact:** The production of materials for vertical farming infrastructure and the use of electricity can have environmental impacts, especially if the energy source is not green.

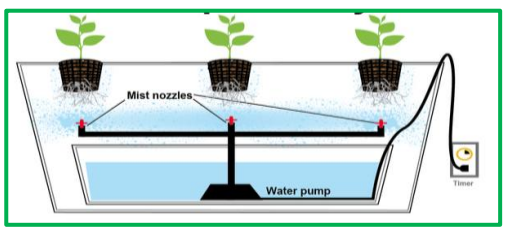
Types of Vertical Farming

1. **Despommier Skyscrapers**: Proposed by Dr. Dickson Despommier, these skyscrapers involve cultivating plant life within hermetically sealed, artificial environments, disconnected from the outside world. They can be built anywhere and aim for mass production of crops.
2. **Mixed Use Skyscrapers**: Architect Ken Yeang suggests open-air, mixed-use skyscrapers for vertical farming. These buildings integrate traditional agriculture with vertical farming, using the structure for climate control and crop cultivation. They are seen as more cost-effective than fully enclosed vertical farms.
3. **Stackable Shipping Containers**: This concept involves repurposing shipping containers for urban vertical farming. Companies like Brighter Side Consulting and Freight Farms have developed systems to grow crops like leafy greens, mushrooms, and strawberries inside these containers. They utilize vertical hydroponics, LED lighting, climate control, and environmental monitoring for efficient crop production.

Techniques of vertical farming

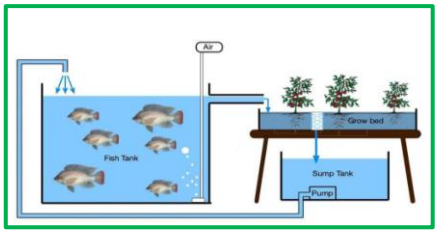


Hydroponics: Hydroponics method to produce crops by supplying required nutrient solutions instead of soil. The plant roots are grown in the nutrient solution contained in a grow tray such that the roots are submerged in the solution.**,** which is frequently monitored and circulated to ensure that the correct chemical composition is maintained.



Aeroponics: In an Aeroponic system, plants are grown in an environment where air with very little water or mist and without soil are used. This system is the most efficient vertical farming system, as it uses 90% lesser water than the most efficient

hydroponic systems. The fertilizer usage is reduced by 60%, while the crop yields increase by 45 to 75% It has been observed that plants grow quicker than in other types of hydroponic systems.



Aquaponics : It combines aquaculture (raising of fish in tanks or ponds) and hydroponics in the same ecosystem. Fish grown in fish tanks, produce waste that are high in nutrient content, which can be used as nutrient suppliant to grow the plants in a grow tray. The new standardized aquaponic systems may help make this closed-cycle system more popular. The major advantage of an aquaponics system is that it has to be carefully monitored for the first month, but once the system is established, only pH and ammonia levels have to be monitored every week .

Media Used in Vertical Farming

1. **Perlite:** Perlite is expanded volcanic rock that can be used loosely or in plastic sleeves for short-term water submersion. It improves soil drainage and has a high air-to-water ratio.
2. **Vermiculite**: This mineral retains water and enhances soil drainage and aeration, although it may not be as durable as other mediums.
3. **Coconut Coir**: Made from coconut husks, coconut coir is an organic and renewable medium that helps separate water and air in the soil.
4. **Peat Moss**: Peat moss is excellent at retaining water, making it suitable for plants that require high humidity levels.
5. **Sand**: Sand is ideal for plants that thrive in dry and loose soil conditions, such as root crops like carrots and potatoes.
6. **Rock Wool**: Also known as mineral wool, rock wool is a common medium in hydroponics. It is inert, capillary-accessible, and resistant to microbiological degradation, making it suitable for various growing systems.

Vegetable crops suitable to grow in vertical farming

Vegetable	Scientific name
Tomato	*Solanum lycopersicum*
Chilli	*Capsicum annuum*
Brinjal	*Solanum melongena*
Green Bean	*Phaseolus vulgaris*
Bell Pepper	*Capsicum annuum*
Potato	*Solanum tuberosum*
Cabbage	*Brassica oleracea var capitata*
Cauliflower	*Brassica oleracea var botrytis*
Lettuce	*Lactuca sativa*
Sweet Basil (Salad)	*Ocimum basilicum*
Parsley	*Petroselinum crispum*
Onion	*Allium cepa*
Cucumber	*Cucumis sativus*