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Vertical Farming: A Modern Future Technology in Agriculture for Crop Production

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SUMMARY

Vertical farming is exactly what it sounds like farming on vertical surfaces rather than traditional, horizontal agriculture. By using vertically stacked layers, farmers can produce much more food on the same amount of land. Often these layers are integrated into buildings such as skyscrapers, housed in warehouses or shipping containers, greenhouses or placed in spaces that would otherwise be unfit for farming. Yet vertical farming is much more than just stacking plants and hoping for the best. The practice requires artificial temperature, light, water, and humidity control. If a delicate balance is not maintained, it's possible to lose an entire crop the way a traditional farm might in the event of a drought or flood. With the help of our hydroponic vertical farming technology, gardeners may nurture crops in tower-like structures using stacked plant locations. These hydroponic towers are unique devices that allow farmers to grow their crops all year long by creating the ideal microclimate.

INTRODUCTION

The term Vertical Farming is coined by Dickson Despommier. Dickson Despommier came up with the modern idea of vertical farming in 1999. The term "father of vertical farming" refers to his pioneering work in this area. Growing food vertically has some similarities to the use of metal reflectors and fluorescent lighting in greenhouses. Vertical farming is the practice of growing crops in vertically stacked layers. It often incorporates controlled-environment agriculture, which aims to optimize plant growth, and soilless farming techniques such as *hydroponics*, *aquaponics*, and *aeroponics* (Birkby and Jeff, 2016). Rapid urbanisation, natural disasters, global warming, as well as the uncontrolled use of chemicals and pesticides have all taken a toll on the fertility of the soil. Additionally, soil productivity has significantly reduced, soil fertility has declined, and the amount of land available to each person has decreased.

Concept of vertical farming

- Farming involves growing crops throughout structures (such as a skyscraper or an old warehouse) rather than in the ground, which saves water and eliminates the need for soil.

- A wide variety of plant species can achieve optimal growth rates year-round when grown in controlled environments with constant monitoring and manipulation of environmental factors like light, humidity, and temperature
- Temperature, light, humidity, and gases can be artificially controlled to enable indoor food and medicine production. Chemicals are kept out of the environment because closed growing systems are used.
- Rapid urbanization and industrialization are reducing cultivable land, but they are also reducing the effectiveness of traditional farming methods, which have a wide range of adverse effects on the environment.
- Sustainable production and conservation of land and water resources can be achieved through the use of modified growth media.

Need of vertical farming

Food Security: Food security has become a major concern. According to demographers, the number of people living in cities is expected to rise significantly over the next few decades. The United Nations (UN) predicts that by the year 2050, the global population will have risen by 40%, to more than 9 billion people (USDA, 2017). We will require 70 percent more food by 2050 in order to feed an additional 3 billion people on the planet (Thomaier *et al*., 2015))There are numerous benefits associated with vertical farming, including the ability to produce food in an eco-friendly and sustainable manner, to save energy and water, to reduce the pollution as well as pollution, to increase the economy, and to provide access to nutritious food. Climate, pests, nutrients, runoff, contaminated water and dust will have less impact on crops grown in a controlled environment.

Climate Change: As a consequence of climate change, there is a reduction in the amount of arable land. Flash floods, hurricanes, storms, and drought have destroyed vast tracts of productive farmland, which has had a negative impact on the global economy (Muller *et al*., 2017 and Kalantari *et al*., 2017). Weather-related disasters are expected to become more frequent and severe as a result of man-made global warming. Because of these events, vast swaths of arable land will be rendered unusable for farming.

Urban Density: Compared to "horizontal" urban farming, "vertical" urban farming allows for more urban activities (including more people, services, as well as amenities) to be housed on the land (Despommier 2010). Urban agriculture has been shown to lead to longer commutes by reducing density of population, according to studies (Blaustein-Rejto, 2011) Lower density living requires more energy as well as produces more pollution in the air as well as water than higher density living. In accordance with the National Highway Traffic Survey (NHTS), “If we decrease urban density by 50%, households will purchase an additional 100 gallons of gas per year.

Health: WHO research shows that more than half of the world's farms still use raw animal waste as fertilizer, which can be an attractive food source for flies and a source of weed seeds or disease that can be spread among plants (AlKodmany, 2018). People's health suffers as a result of consuming such food. In addition, the use of pesticides and herbicides, which result in polluting agricultural runoff, could be reduced if crops were grown in a controlled indoor environment (Cho, 2011).

The ecosystem: human activity is accelerating climate change by encroaching on these ancient ecosystems. Restoring biodiversity and reducing the negative effects of climate change can be accomplished through indoor vertical farming. Only 10% of the land area that cities currently use could be produced using vertical farms, which could reduce CO_2 emissions enough to spur the development of new technologies that would benefit the biosphere in the long run (Al-Kodmany, 2016).

Economics: use of cutting-edge technologies and intensive farming methods, vertical farms can boost production by an order of magnitude. The local economy can benefit from vertical farming as well. Wasted urban structures can be turned into vertical farms to provide fresh food to underserved communities.

High-Tech Vertical Farming methods:

Hydroponics

Hydroponics refers to the technique of growing plants without dirt (Resh and Howard, 2016) In hydroponic systems, the roots of plants are submerged in liquid solutions containing macronutrients, such as nitrogen, phosphorus, sulphur, potassium, calcium, and magnesium, as well as trace elements, including iron, chlorine, manganese, boron, zinc, copper, and molybdenum. Additionally, inert (chemically inactive) mediums such as gravel, sand, and sawdust are used as soil substitutes to provide support for the roots.

Aquaponics

The term *aquaponics* is coined by combining two words: *aquaculture*, which refers to fish farming, and *hydroponics*—the technique of growing plants without soil (kledal and paul, 2018). Aquaponics takes hydroponics one step further by integrating the production of terrestrial plants with the production of aquatic organisms in a closed-loop system that mimics nature itself.

Aeroponics

*Aeroponic***s** is the process of growing plants in the air or mist environment without soil or an aggregate medium. The word "aeroponic" is derived from the Greek meanings of *aer* ("air") and *ponos* ("labour"). It is a subset of hydroponics, since water is used in aeroponics to transmit nutrients. Unlike conventional hydroponics and aquaponics, aeroponics does not require any liquid or solid medium to grow plants (Mytton-Mills, Helen 2018) Instead, a liquid solution with nutrients is misted in air chambers where the plants are suspended. By far, *aeroponics* is the most sustainable soil-less growing technique (Mytoon and Helen, 2018) as it uses up to 90% less water than the most efficient conventional hydroponic systems and requires no replacement of growing medium.

Farming methods	Key Characteristics	Major benefits	Common/Applicable technologies
Hydroponics	Water as growing medium for soilless crop production.	Reduces, even eliminates, soil-related cultivation issues; Significantly reduces the need for fertilisers or pesticides.	Computerised systems for monitoring; Tablets, laptops, and smartphones; Apps for growing food Systems and software for remote management (farming from a distance systems); Automatic racking, stacking systems, moving belts, and tall towers; hightech LED lighting systems that can be programmed; Solar, wind, geothermal, and other forms of renewable energy Anaerobic digesters and closed-loop systems Necessity-based nutrient management systems AC/HVAC systems for climate control System of water circulation and recycling Rainwater harvesting devices; The use of insecticides; Robots.
Aeroponics	A hydroponics replica in which plants' roots are sprayed with nutrient solutions or mist	dditionally, aeroponics uses less water than other methods of growing plants	
Aquaponics	Aquaponics and hydroponics are combined in this system.	Creates mutually beneficial relationships among plants and fish by using fish tank refuse to "fertigate" hydroponics production beds, as well as a hydroponic bed also serves to safe water for the fish's pond.	

Challenges for sustainability of Vertical Eco-farming

- Air Quality, temperature, as well as Relative Humidity Monitoring for Optimal Performance
- Water Quality Monitoring
- Light Quality Monitoring
- The substrate of Vertical Eco-Farming
- Nutrient Management
- pH Monitoring in Nutrient Solution
- Selection of Ideal Crop for Vertical Eco-Farming

CONCLUSION

The clew of this article and focused on utilisation of vertical farms could significantly enhance food sustainability in urban areas. This is crucial when we plan for the long term and anytime it is anticipated that the urban population will increase significantly. Vertical farming has many advantages over rural farming in terms of sustainability on the social, economic, and environmental fronts. New high-tech production methods like hydroponics, *aeroponics*, and *aquaponics* are essentially posing a threat to the requirement for soil-based farming. Vertical farming is getting more and more common when it comes to enhancing crop productivity. Vertical farming allows for the year-round cultivation of crops preferred for fodder, such as maize, potatoes, and short-lived crops like vegetables, in incredibly small spaces with less labour. This is especially advantageous for areas with limited access to water and soil, as well as for the poorest and landless people.

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