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Vertical Farming: An Innovative Technology

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Abstract

Vertical farming is an advanced level of agriculture technology that must be used when land and other requirements for a perfect farming structure are unavailable. This is a new way or approach at the advanced level, and this paper discusses the methodology, harvesting technique, water management, and crop cultivation and yielding process. And other natural renewable resources are used, such as windmills, solar panels, and so on. While these are not typical agricultural techniques, some other practises must be followed for a healthy yielding process.

Introduction

Vertical farming is a unique method of cultivating crops in which plants are artificially stacked vertically above each other, either in skyscrapers or by utilising the third dimension of space. Dickson Despommier, a Columbia University professor of public and environmental health, created the contemporary concept of vertical farming in 1999. This could aid in the resolution of many future issues such as malnutrition, contaminated food, and other issues that may arise as a result of food scarcity. When compared to traditional farming and other options such as permaculture, biodynamic, and agro-ecological farming, this type of farming enables for a significantly larger number of crops to be grown in a much smaller space, resulting in a reduction in the usage of agricultural land. As plants grow in soil-free media, this approach recycles and reuses other natural resources such as water and nutrients while also producing less waste (Birkby, 2016). As a result, vertical farming has a lower carbon footprint and produces far less pollution. Many biotechnology businesses and startups have taken this concept to the next level, making vertical farming a financially viable paradigm for pollution-free or organic farming. Environmentalists, sustainable developers, and futurists promote growing crops in cities utilizing vertical farming buildings because of the benefits of this farming technique.

Types of Vertical Farming

Type and processes used classifies different vertical farming systems. There are three types of vertical farming systems *i.e.*, 1) Despommier Skyscrapers; 2) Mixed Use Skyscrapers; and 3) Stackable Shipping Containers (Despommier, 2010).

In addition to these, there are three processes usually adopted in the vertical farming systems *viz.*, 1) Hydroponics, 2) Aquaponics and 3) Aeroponics. The details of the above types and techniques are discussed in the below sub-

Figure 1: Vertical farming in Singapore

sections.

1. Despommier Skyscrapers

Dickson Despommier, a microbiologist at Columbia University, argues that traditional farming practices, which presently occupy 41% of the planet's land, will not be able to meet the growing population's food demands. As a result, he sees skyscrapers with vertically stacked shelves where crops can be mass produced in confined and regulated conditions that are not affected by the weather. As a result, skyscrapers can be constructed in any location, regardless of agronomic constraints. Vertical farming, according to one school of thinking, uses less energy and produces less pollution than traditional farming methods because it can be combined with renewable energy technologies. To meet the energy needs of these structures, solar panels, wind turbines, and hydroelectric power can be used individually or in combination. Because local residents can work in these vertical farms to make a living, vertical farming has the potential to offer a large number of job opportunities.

2. Mixed Use Skyscrapers

Ken Yeang, an architect, is the creator of these skyscrapers. Traditional agricultural activities are combined with the vertical farming concept in these towers. In these skyscrapers, crops are grown in natural sunlight, such as the top floors of an office building that receive the most sunlight, rather than in a completely controlled and closed environment. Mixed Use Skyscrapers have an advantage over Despommier Skyscrapers in that they demand a lower initial investment. Despommier Skyscrapers, on the other hand, require the entire environment within the structure to be regulated and monitored according to the crop's requirements.

3. Stackable Shipping Containers

Shipping containers are used to cultivate leafy green vegetables, gourmet mushrooms, and strawberries in this vertical farming system. In metropolitan areas, these stacked recycled cargo containers might be employed. Shipping containers are fitted with hydroponic components, LED lighting, temperature control heating and ventilation systems, and sensors to monitor the environmental condition within the containers by companies like Freight Farms and Podponics.

Techniques Used in Vertical Farming

1. Hydroponics

Hydroponics refers to the technique of growing plants without soil. 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 (Resh, 2016). The advantages of hydroponics include the ability to increase yield per area and reduce water usage. A study has shown that, compared to conventional farming, hydroponic farming could increase the yield per area of lettuce by around 11 times while requiring 13 times less water (Barbosa *et al*., 2015). Due to these advantages, hydroponics is the predominant growing system used in vertical farming.

Figure 2: Indoor Hydroponics of Morus, Japan

2. 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. 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. Nutrient-rich wastewater from the fish tanks is filtered by a solid removal unit and then led to a bio-filter, where toxic ammonia is converted to nutritious nitrate. While absorbing nutrients, the plants then purify the wastewater, which is recycled back to the fish tanks. Moreover, the plants consume carbon dioxide produced by the fish, and water in the fish tanks obtains heat and helps the

greenhouse maintain temperature at night to save energy. As most commercial vertical farming systems focus on producing a few fast-growing vegetable crops, aquaponics, which also includes an aquacultural component, is currently not as widely used as conventional hydroponics.

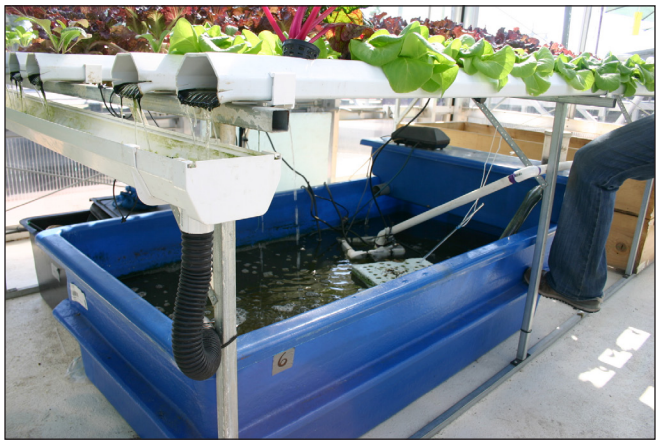

Figure 3: Aquaponics with catfish

3. Aeroponics

The invention of aeroponics was motivated by the initiative of NASA to find an efficient way to grow plants in space in the 1990's (Spinoff, 2006). Unlike conventional hydroponics and aquaponics, aeroponics does not require any liquid or solid medium to grow plants. 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, as it uses up to 90% less water than the most efficient conventional hydroponic systems and requires no replacement of growing medium. Moreover, the absence of growing medium allows aeroponic systems to adopt a vertical design, which further saves energy as gravity automatically drains away excess liquid, whereas conventional horizontal hydroponic systems often require water pumps for controlling excess solution. Currently, aeroponic systems have not been widely applied to vertical farming, but are starting to attract significant attention.

Advantages

1. Reliable year-round crop production.
2. Unaffected by adverse weather conditions.
3. Better use of space.
4. Minimise water usage.
5. Environmentally friendly.
6. No chemicals or pesticides.
7. Reduce transport costs.
8. Highly energy efficient.

Figure 4: Aeroponically-grown chives

Conclusion

Crops in traditional farming systems are vulnerable when it comes to global warming, natural calamities, and weather changes. Vertical farming is surely a solution to critical issues in Indian farming like an absence of providing or oversupply of farm produce, too much use of pesticides, too much use of fertilizers, weaken soils and even the unemployment. So, vertical farming is the solution for reducing arable land.

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