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Vertical Farming: Controlled Environment Agriculture

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Introduction:

The method of planting crops in vertically stacked layers is vertical farming. Controlled environment agriculture, which seeks to maximise plant growth and soil amendment farming techniques such as hydroponics, aquaponics and aeroponics, is also included. Dickson Despommier, professor of Public and Environmental Health at Columbia University, proposed the modern idea of vertical farming in 1999. Prime land for agriculture can be scarce and costly. The need for both more food and more land to grow food is growing with global population growth. But some corporate executives and growers are starting to look up, not out for space for more food to expand. Vertical farming, with precise illumination, nutrients and temperatures, includes growing crops in regulated indoor environments. Growing plants are stacked in layers that can reach several levels tall in vertical farming. The interest in this modern agricultural technology is growing rapidly nowadays and entrepreneurs worldwide are taking a massive look at this innovative agricultural method.

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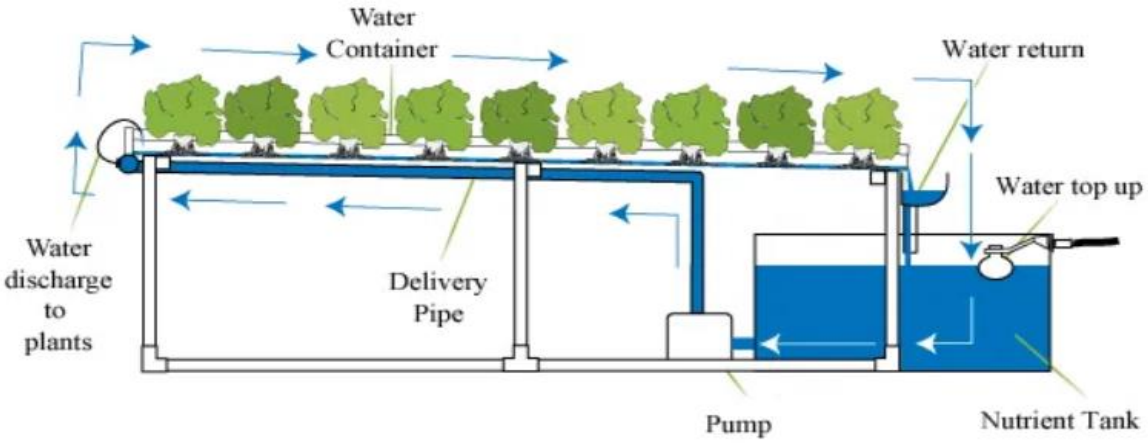
History:

Professor Dickson Despommier laid the foundation of the principle of vertical farming. In 2009, at Paignton Zoo Environmental Park in the United Kingdom, the first pilot production device in the world was built. The project brought vertical agriculture to the fore and established a strong foundation for research into sustainable urban food production. In 2010, at the 36th World Zionist Congress, the Green Zionist Alliance submitted a resolution calling on Keren Kayemet L'Yisrael (Jewish National Fund of Israel) to establish vertical farms in Israel. The world's first commercial vertical farm, built by Sky Greens Farms, was opened in Singapore in 2012 and is three storeys high. The Association for Vertical Farming (AVF) in Munich was established in 2013 (Germany). A Japanese firm, Mirai, started marketing its multi-level vertical farming system in 2017. Kroger partnered with the German start-up Infarm in 2019 to instal modular vertical farms in two grocery stores in the Seattle area.

Techniques of vertical farming:

Vertical farms come in various shapes and sizes, ranging from basic two-level or wall-mounted structures to many storeys high in massive warehouses. But all vertical farms use one of three soil-free systems, hydroponic, aeroponic, or aquaponic, to provide plant nutrients. The following information explains these three structures that are growing:

1. Hydroponics: The method of growing plants without soil refers to hydroponics which is predominant growing system used in vertical farms. Plant roots are submerged in liquid.



solutions containing macronutrients such as nitrogen, phosphorus, sulphur, potassium, calcium and magnesium and trace elements such as iron, chlorine, manganese, boron, zinc,

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copper and molybdenum in hydroponic systems. In addition, to provide protection for the roots, inert (chemically inactive) media such as dirt, sand, and sawdust are used as soil substitutes. The benefits of hydroponics include the potential to increase the yield per region and decrease the use of water. A study has shown that hydroponic farming could increase the yield per area of lettuce by about 11 times as compared to traditional farming, while consuming 13 times less water. Due to these benefits, the predominant growing method used in vertical farming is hydroponics.

2. Aeroponics: The National Aeronautical and Space Administration (NASA) is in responsible for developing this revolutionary technique for indoor development. In the 1990s, NASA was interested in discovering efficient ways of growing plants in space and coined the word "aeroponics," defined as "growing plants without soil and very little water in an air/mist environment." Aeroponic systems in the vertical farming world are still an exception, but they are gaining considerable interest. With up to 90% less water than even the most effective hydroponic systems, the aeroponic system is by far the most efficient plant-growing system for vertical farms. It has also been shown that plants grown in these aeroponic systems consume more nutrients and vitamins, making the plants healthier and potentially more nutritious. Aeroponic systems have not been widely applied to vertical farming at the moment, but are beginning to attract considerable interest.

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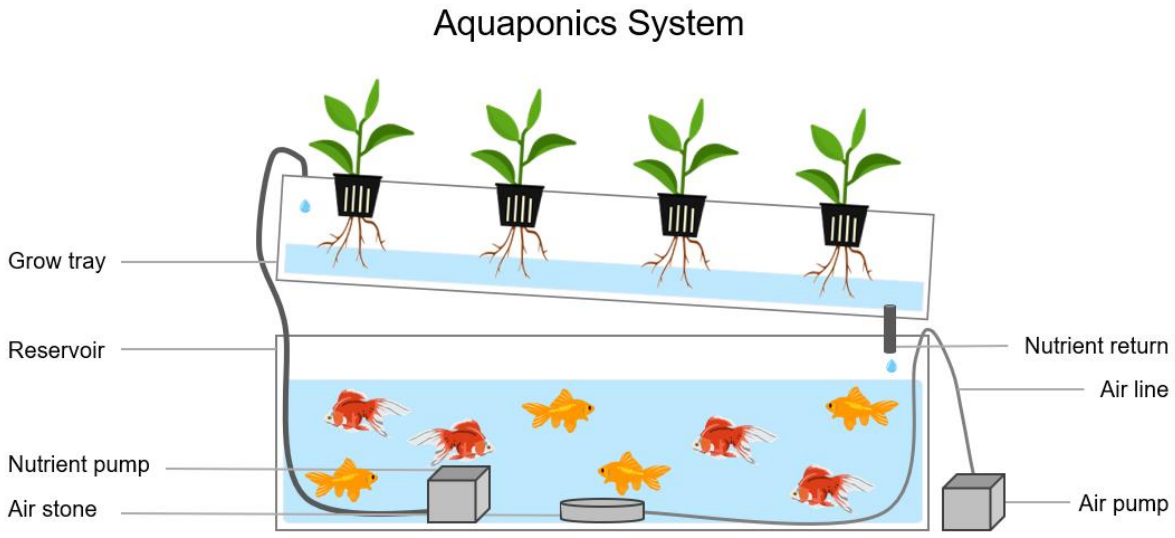
3. Aquaponics: The term aquaponics is coined by the combination of two words: aquaculture, referring to fish farming, and hydroponics, the technique of soil-free growing plants. An aquaponic system takes the hydroponic system a step further, integrating the same habitat with plants and fish. In indoor ponds, fish are raised to produce nutrient-rich waste that is used as a feed source for vertical farm plants. In addition, the plants extract and purify the waste water that is recycled into the fish ponds. While aquaponics are used in smaller-scale vertical farming systems, only a few fast-growing vegetable crops are developed by most commercial vertical farming systems and do not include an aquaponic portion. The economic and output problems are simplified and productivity is maximised. New standardised aquaponic systems, however can contribute to making this closed-cycle system more common. It is possible to further identify vertical farming systems by the type of structure which houses the system.



4. Controlled-environment agriculture: The alteration of the natural environment to increase crop yield or prolong the growing season is controlled-environment agriculture (CEA). Usually, CEA systems are hosted in enclosed structures such as greenhouses or buildings, where environmental factors such as air, temperature, light, water, humidity, carbon dioxide, and plant nutrition can be monitored.

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CEA is often used in vertical farming systems in combination with soil-free farming techniques such as hydroponics, aquaponics, and aeroponics.

Types of vertical farming:

Building-based vertical farms: Abandoned structures, such as a Chicago farm named "The Plant," which was converted from an old meatpacking plant, are frequently reused for vertical farming. New buildings, however, are also often built to house vertical farming systems.

Shipping-container vertical farms: An increasingly common alternative for housing vertical farming systems is recycled shipping containers. Often fitted with LED lighting, vertically stacked hydroponics, smart climate controls, and monitoring sensors, the shipping containers serve as standardized, modular chambers for growing a range of plants. In addition, farms can save even more space and achieve greater yield per square foot by stacking the shipping containers.

Deep farms: A "deep farm" is a vertical farm constructed from underground tunnels or abandoned mine shafts that have been renovated. As underground temperatures and humidity are usually temperate and constant, deep farms need less heating energy. Deep farms may also use groundwater nearby to minimize water supply costs. According to Saffa Riffat, chair of Sustainable Energy at the University of Nottingham, deep farming can generate 7 to 9 times more food than traditional farming above ground on the same land area, despite low costs. These underground farms, combined with automated harvesting systems, can be completely self-sufficient.

What Are the Pros and Cons of vertical farms?

Pros:

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Continuous crop production: In non-tropical areas, vertical farming technology will ensure crop production year-round. And manufacturing is much more productive than farming on land. According to Despommier, when the number of crops produced per season is taken into account, a single indoor acre of vertical farming can produce a yield equivalent to more than 30 acres of farmland.

Elimination of herbicides and pesticides: The regulated growing conditions of a vertical farm allow the use of chemical pesticides to be reduced or totally abandoned. When needed to deal with any infestations, some vertical farming operations use ladybugs and other biological controls.

Protection from weather-related variations in crop production: Since crops are grown in a managed environment on a vertical farm, they are protected from severe weather events such as droughts, hail, and floods.

Water conservation and recycling: In vertical farms, hydroponic growing techniques use about 70 percent less water than regular agriculture (and aeroponic techniques, which involve the misting of plant roots, use even less water).

Climate friendly: Growing indoor crops reduces or removes the use of tractors and other large-scale farm machinery widely used on outdoor farms, thus reducing fossil fuel combustion. The implementation of vertical farms on a large scale, according to Despommier, could lead to a substantial reduction in air pollution and CO_2 emissions. In addition, carbon emissions will be minimized because, instead of being transported or exported hundreds or thousands of miles from a traditional farm to a market, crops from a vertical farm are normally shipped only a few blocks from the production facility.

Cons:

Despite the potential advantages of vertical farms, some agricultural experts are doubtful that the costs and benefits are going to be reduced. In a vertical farm, the high use of electricity to run lighting and heating cooling impacts the economy. A description of the potential drawbacks of vertical farming is given below:

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Land and building costs: Urban locations can be very costly for vertical farms. Some modern vertical farms, which can be more economical for building, are located in abandoned factories, derelict areas, or superfund sites.

Energy use: Although the cost of transport may be substantially lower than in traditional agriculture, the energy use of artificial lighting and climate control in a vertical farm may significantly increase the cost of operations.

Controversy over USDA organic certification: It is uncertain if or when an agreement will be reached as to whether organic crops produced on a vertical farm can be certified. Many agricultural experts assume that there is an entire soil ecosystem and natural system involved in a certified organic crop, not just the absence of pesticides and herbicides.

Limited number of crop species: The current vertical farm crop model focuses on high-value, fast-growing, small-footprint, and fast-turnover crops such as lettuce, basil, and other salad products. In a commercial vertical farming method, slower-growing crops, as well as grains, are not the competent table.

Pollination needs: In vertical farming, crops requiring insect pollination are at a disadvantage, as insects are typically excluded from the growing climate. Pollination-requiring plants can need to be pollinated by hand, requiring time and energy for workers.

Conclusion:

Vertical farms are a relatively recent concept in urban areas, but interest in this method is increasing, and every year the number of vertical farms in the world is growing. There are many variants of vertical farms being studied worldwide, and new developments and technologies are expected to improve these farms' energy efficiency and profit margins in the future. Most vertical farms will concentrate on high-return and short-rotation crops like salad greens in the near term, with nearby restaurants sometimes purchasing all of the harvest. It is unclear if vertical farms can become more common in the world, but urban planners and the sustainable farming community are closely watching the ground breaking vertical farms currently under construction or already in use.

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