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Vertical Farming—Current Practices and Its Future †

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Abstract: The depletion of usable agricultural lands has brought up a scenario of vertical farming. This type of farming is mostly considered soil-less farming in the vertical direction. Three of the commonly used soil-less ways for vertical farming include hydroponic, aeroponic, and aquaponic. Although it is not very popular in developing countries, investment has been made by many European counties and efforts to use vertical farming as a commercial product are on the path to success. Food security issues can be addressed through this farming type as well.

Keywords: soil-less agriculture; vertical farming; food security

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1. Introduction

The growth in population around the globe is demanding living space and land to grow food and food products. The fertility of agricultural land is decreasing day by day due to the excessive use of synthetic chemicals such as fertilizers, pesticides, insecticides, etc. Researchers are working on soil-less and less space-consuming solutions to grow plants. One of the solutions consists of vertical farming in which plants can be grown in a space that is not of particular advantage, such as used shipping containers, buildings on damaged lands, or warehouses [1]. Although this kind of farming does not require a large space to develop, the environmental parameters need to be strictly monitored. The controlled environment for vertical farming needs to be fulfilled with monitored nutrients, temperature, and light.

Vertical farming practices do not require soil particularly, so plantation can go in an upwards direction in the form of layers and sometimes reach up to multistory levels (Figure 1) [2]. There are several types of vertical farming but three of them are commonly used soil-less methods including hydroponic, aeroponic, and aquaponic. Hydroponic farming is the technique of growing plants in water. The nutrients are continuously monitored and are provided only in calculated amounts. Aeroponic farming systems do not even need a water medium to grow plants. This system only uses a mist or spray of nutrients in the root growth chamber. Aeroponic farming can even save up to 90% of the water as compared to hydroponic. Aquaponic systems are only used for fast-growing crops because this system combines hydroponic farming and fish farming at the same time. Fish growth is reliant on nutrients and fish farming waste, rich in nutrients, is used as a

recycling component for plant growth which results in economically viable and efficient plant growth [3].

Figure 1. The vertical agriculture growing in several layers and less space [2].

2. Vertical Farming System

2.1. Crop Selection

There is no hard and fast rule about the selection of crops to grow in vertical farming because the environmental conditions are controlled artificially. However, to choose the best crop that can grow under artificial light and less space is the best tactic for this style of farming. Long, heightened plants such as avocado, olive, banana, and other trees are limited to growing indoors; however, other controlled techniques such tunnel or greenhouse farming can be applied for tree farming. Vertical farming, especially hydroponic, offers the production of more than three dozen various vegetables indoors. Vegetables such as lettuce, spinach, leafy greens, strawberries, cucumber, herbs, tomatoes, etc., are now the crops most grown under vertical farming. However, other crops such as maize, wheat, biofuel, and herbal medicinal crops can also be grown under a vertical cropping system [4].

2.2. Environment Control System

Heating, cooling, and proper air ventilation are very important in vertical farming to keep the best air quality, save energy, and keep a consistent moisture content. Reusable energy resources such as solar energy, geothermal equipment, and ground water usage can help to maintain the low energy cost and keep the environment clean. Control of the indoor environment such as dehumidification can be maintained by natural ventilation, the use of desiccant, and the condensation process. Water chambers to circulate water can be used to lower the temperature in the vertical chamber.

2.3. Waste Management System

In an aquaculture system, the yearly biowaste produced is estimated as 527 t. Biowaste is comprised of dead leaves, parts of stems, fibrous roots, dead fruits, and vegetables and can be converted into organic fertilizers, biofuels, and liquid organic nutrients. Waste water treatment can also make water in reusable conditions using a SlurryCarb machine [5].

2.4. Smart Devices

The vertical farming system operating with automated services without human interventions needs to be operated by sensors and smart devices. The sensory system collects information about the environment, crop health, nutrients, and water requirements and forwards it to interconnected devices. The data are analyzed and a quick decision is made through the decision support system. The requirements of plants are fulfilled by an automatic system without human involvement in agricultural practices [6].

3. Related Work

Although developed countries have many resources to fulfill the feeding needs of their community, European countries and private organizations are working on the efficient use of free spaces such as restaurants, metro stations, supermarkets, and in-store farming. Agricool, a company based in France, is working on container vertical farming for strawberry cultivations [7]. An Estonian company named Click and Grow is working on a novel idea of appliance farms, also called small indoor gardens (Figure 2) [8,9].

Figure 2. An appliance farm for indoor farming [9]; Copyright permission: License Number: 5423060894672; License date: 6 November 2022; Licensed Content Publisher: Elsevier.

An in-store aeroponic farming setup was tested in Italy under the joint venture of Agricooltur and Auchan retailers. The same setup was organized in a supermarket in Luxemburg. In Madrid, in-farm vertical farming was adopted for the purpose of the fresh supply of lettuce to the customers [10]. Another German retail chain, Metro, collaborated with Infarm to grow vertical agriculture within the store and provide fresh herbs and vegetables to the customers [11].

4. Benefits, Challenges and Future Perspective of Vertical Farming

Feeding the world in the 21st century is not an easy task due to several issues of uncontrolled population growth, uneven distribution of resources, depletion of natural resources, overburdened urbanization, loss of fertile soils, etc. Vertical farming can be seen as an opportunity to mitigate food security risks. Vertical farming can provide continuous crop production and is much more efficient; one acre of vertical farming can cover the food production of 30 acres of farming on the land. Due to the controlled environmental conditions, there is less chance of diseases and insects/pest attacks which can eliminate the chance of chemical use during farming practices. Many environmental factors such as hail, flood, drought, etc., that cause crop failure are also eliminated due to controlled environmental conditions. Moreover, vertical farming helps to reduce carbon emissions generated during agronomic practices and reduce water losses by 70% [12].

Although this cropping system can deal with food security issues, it comes with some challenges to deal with. The main challenge to deal with is the cost–benefit analysis. The land and building costs may vary from region to region but cost in urban areas does not allow vertical farming in big cities. The use of energy and operational cost to maintain and control the internal environmental conditions of a farming setup can challenge cost efficiency. A limited number of crops can only be grown through vertical farming and also require pollination by hand during crop growth. However, the system lacks some economic efficiencies, but in the future, to avoid food scarcity, vertical farming will become a trend and the reuse of necessary building structures will reduce the cost of the system.

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