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A REVIEW STUDY ON VERTICAL FARMING TECHNOLOGY

Divya Prakash Singh*

*Assistant Professor,
Department of Seed Science & Technology,
Faculty of Agriculture Science,
Teerthanker Mahaveer University,
Moradabad, Uttar Pradesh, INDIA
Email Id- dpsingh.agriculture@tmu.ac.in

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ABSTRACT

In vertical farming, crops are produced inside, under artificial conditions of light and temperature. Crops are cultivated inside, under artificial circumstances of light and temperature. It aims at greater productivity in fewer areas lately, the application of Vertical Farming into cities has grown. Vertical farming is a growing vegetable vertically using modern agricultural techniques, which integrates the design of building and farms all together in a high-rise building within the cities. This technology has to be apparent both in the agricultural method and architectural technology combined, however, nothing has been written on the technology of Vertical Farming. In this research, technology as one of the key component of Vertical farming is addressed and evaluated using qualitative method. In the first, identifying current and prospective VF projects in Europe, Asia, and America from 2009 to 2016. Then a complete literature examined on technology and methods that are utilized in VF projects. The research materials were generated from 62 distinct sources from 2007 to 2016. The technologies provided may be a guide for implementation development and planning for creative and agricultural industries of Vertical Farming in cities. In reality, it may serve as a foundation for assessing future agriculture and architecture together. The integration of food production into the urban areas had been viewed as a link to the city and its inhabitants. It simultaneously helps to decrease poverty, contributes to food safety, and improves contextual sustainability and human well-being.

KEYWORDS: *Agriculture, Food Production, Farming, Technology, Vertical Farming.*

1. INTRODUCTION

Due to the restricted availability to land for farming, there is a requirement for maintaining agricultural activities so as to prepare the way for adding to food demands. Many aspects press on food industry and processing such as: growth of population and its growing needs accordingly, reduction of natural sources due to growing cities, earth erosion, different forms of contamination, advent of biofuels, restrictions imposed on food production techniques affected by customers and rule providers which requires better quality, less use of chemicals and many useful environmental attempts from farm to fork. Recently, environmental concerns have been combined with increasing preoccupation with health as architectural design is concerned. Therefore, it has led to greater interest in supplying nutritious food and integrating it in the sustainable development project[1]–[4].

The solution to these problems is Vertical Farming (VF) (VF). VF has developed as a project which integrates the design of building and farms all together in a high-rise structure. VF is a method of growing crops in skyscrapers, to optimize the utilization of land by having a vertical architecture wherein plants, animals, fungus and other living forms are grown for food, fuel, fiber… by intentionally stacking them vertically over each other . Vertical farms are currently utilized in a number of nations. At now, these farms are mainly developed and produce various kinds of crops within cities[5]–[8].

1.1.Vertical Farming Technology:

1.1.1. General Structure of Vertical Farming:

The vertical farms differ from one city to another. More general tips on the structure as well as The vertical farms vary from one city to another. Additional basic suggestions on the structure as well as more designs and ideas of VF are discussed in the next part. For an instant as to feed 15000 people with food, this high-rise structure is built with these properties: size of the vertical farm: 93 hectares (approximately the size of a block), 37 levels, 25 of which are solely for growing crops and 3 for aquaculture. Moreover, 3 levels of the same distribution are for regulating the atmosphere and 2 situated underground are utilized for storing the trash. Furthermore, one level is dedicated to the cleaning of growing trays, displaying as well as germination. One level is for the packaging and processing of the vegetables or seafood. One additional level is for the sale of the goods situated underneath. This makes the total height of the structure 167.5 meters and its length and breadth equal to 44 meters. The aspect ratio will be 3.81. The building is fitted with a large elevator in the center big enough to accommodate a forklift truck. This helps to carry the harvest down to other levels. Each day, approximately 217000 water is required for the system. 14000 of that quantity is absorbed and exits the building with the water waste. The water not absorbed by the veggies is then cycled again in a system in charge of recycling water. It is processed and sprayed once more and the loop is closed[9], [10].

1.2. Material:

Usually, the skin façade of the building is constructed of a self-cleaning and transparent material for example ETFE (Ethylene Tetra Fluoro Ethylene). Also, a substance with wonderful transparency and the thermal rate are required to increase the quantity of sunshine that reaches the structure. ETFE has only 1 percent of an equal-sized piece of glass weight yet allowing for 95 percent light transmission. Between the ETFE layers have a varied pressure, these pressures allow the screens shut and open to alter the sunlight transmission. As a standardized building material, ETFE has covered a large area of ethereal domes at the Eden Project located in the south of England.

1.2.1. Lighting:

Lighting is a major problem with VF. To control the production line, whether the vertical farm is intended to be completely utilizing artificial light or both artificial and natural light should be taken into consideration. The same problems need to be addressed in constructing the facility. There are two choices available: LED (light emitting diode) or HPS (high-pressure sodium) (high-pressure sodium). The range of light intensity required for promoting the development of vegetation is dependent on the setting and time, product, heat and CO_2 content of the air surrounding plants. Considering all factors, the typical range of light intensity used is 50-200 mol/m2/s or approximately 4100-16400 lx including high-pressure sodium lamps. The light needed in confined area for plant development is approximately 18 hours a day. In order to optimize how much light penetrates (and at the same time reduce how much light needs to be generated), they employ light shelves. Every window has got the highest height up to 3.5 meters which are really the height of each level.

1.2.2. Natural Lighting:

The architecture of the structure is such that absorbs as much light as possible. Especially the roof may be built so as to receive the maximum amount of energy from the sun in all seasons in areas where the weather is mild. Other sections of the structure may get sunshine too which is a feasible alternative. In conventional one-floor greenhouses, the primary source of energy for illumination is the sun. In a vertical farm, every reduction in the density of stacking within the structure is matched by an increase in building cubature. Although natural daylight is the primary source of energy obtained from the outside, there has to be daylight concentration, direction and distribution methods developed so as to utilize sunshine efficiently across seasons.

The concept of the vertical farm may be used to many various locations and kinds of weather with diverging quantities of light. Since this concept is very adaptable, it typically leads to modular building designs and utilizes various concepts in architecture. It also makes use of various façade components that incorporate concepts that direct lighting. Clearly, stacking solar panels on top of each other has not been proposed by anybody before. Similarly, layers of plants cannot be piled on top of each other if there is not a suitable substitute for the light needed. Though piled atop each other even when the farm has glass walls and allows the maximum light in, there is not enough light reaching all layers particularly those below. During the day, the quantity of light entering numerous windows of a room may damage our eyes yet this amount is not even part of what a plant needs to thrive. Much of the light energy is reflected when hits the glass. So little light may penetrate to reach plants until the sun is low enough (especially when two stacks of plants are placed on one level) (particularly when two stacks of plants are inserted in one floor). Even at that moment, the light hits plants at a low angle and thus less light are absorbed in every square inch of the leaf as opposed to when the light shines from directly above. Consequently, there has to be artificial lighting utilized to provide the energy of vertical farms.

1.2.3. Solar Cell:

All activities inside the system need to be extremely efficient particularly the photosynthesis of plants. In order to utilize the energy of the sun optimally in vertical farms, non-PAR waves should be filtered because they are not absorbed by chlorophyll. These waves need to be filtered by chosen solar cells and need to be utilized for generating photovoltaic energy. Recently various semi-transparent cells are developed. But less efforts have been made to make such cells especially transparent for photosynthetically active wavelengths. The utilizing red/purple hues with the greatest degree of absorption (535 nm) as the foundation of desensitized solar cells may be a helpful method to create chosen solar cells. Since in VF the area of the vegetation growth is multiplied by the number of stories, PAR, as received from natural sources, is not sufficient. In order to cut down on the requirement for supplementary artificial light, solar energy has to be collected via a system of mirrors from the buildings surrounding the city. This would assist to increase the result of selected photovoltaic generators and also enhance PAR in a vertical farm.

1.2.4. LED:

As stated before, alongside natural light, there is a requirement for artificial lighting also and one such source may be LEDs (Light Emitting Diodes) (Light Emitting Diodes). LEDs that have a longer life and decreasing price are excellent options. There are numerous options that may assist to provide for night interruption (NI) or Day Extension (DE) however LEDs are increasingly utilized as a source of light for plants. Among its advantages are a long life, efficiency in energy, the capacity of targeting specific light wavelengths to better control the photoperiod. This may be accomplished by utilizing LED lights that consist of multiple dimmable diodes which have a dispersed color spectrum. This kind of lamp may be set so as to generate a light suited to the needs of plants. LED technology helps to conserve energy by changing the intensity of light as well as its spectrum through a technique developed at Chalmers University. Another benefit of LEDs is that they adjust the proportion of red color (R) and far-red (FR) to obtain the optimal responses from plants. If this percentage is low, the stem elongation is likewise enhanced. This is a shadow avoidance method in which plants are shaded by others around them. The optimum combination of R/FR as well as red/blue is being study right now.

1.2.5. Water Required:

70 percent of the current fresh water would go for modern agricultural. Much of this loss is due to the artificial watering of crops. Also, most of the irrigation water is wasted owing to evaporation. This evaporation is a normal process but there exists a larger issue which is the water that flows out of fields as run-off which is unsuitable for drinking because is contaminated by fertilizers, salts, pesticides and etc. When farms are moved to indoors, less water is wasted owing to the above-mentioned causes and may be utilized in plant development instead. The quantity of water required for hydroponic agriculture was calculated to be one liter for each square foot a day (or 10.71 per square meter) (or 10.71 per square meter). Contingent on the kind of crop, 200-600 liters of water is required to produce 1 kilogram of dry product. The quantity of water provided is a major productivity constraint so how to manage crops and soil to maximize the use of water and keeping it within soil is essential to make sure of sufficient products. There are a variety of methods employed in VF to withstand the lack of water, which is introduced below:

- Water Retrieval by Means of Recycling
- Water Retrieval by Means of Dehumidification

1.3. Renewable Energy in Vertical Farming:

Why the present energy needs to be measured is to define the quantity of energy needed to empower a target building (demand) and also if reusable energy might meet the target demands of the building or not (generation) (generation). The vertical farms need the following: lighting and temperature for plants to grow, the energy needed for the technical equipment e.g. conveyors or movement of plants, fans, and ventilators, heat pump used to manipulate the climate, pumps used for diluting nutrients, agitators used to control plants.

As a rare and still increasing even, VF comes from a fascinating backdrop of renewable technology. In other words, VF was preceded by renewable technologies which appeared long ago as extremely transformative. Therefore, these technologies are dominating and there is rarely a way to push them away. There are numerous kinds of socio/economic groups that follow these technologies. In the case of VF, this has to do with innovations in agriculture and performing it inside. For example, one alternative for electricity is Switch-glass. As an illustration, each ton of dry switchgrass may generate approximately two-third the energy a ton of coal produces. A superior source of renewable energy as opposed to switchgrass is wind. Vertical farms typically utilize wind turbines. A turbine may generate twice as much power as the present energy of vertical farm models.

1.3.1. Replacing Electricity Energy with Solar Energy:

The energy originating from the sun serves as a suitable answer to energy issues. According to the assessment of studies, there are various ways to utilize solar energy, including the use of solar panels, solar walls or trump walls. The sun is the main source of energy across the world, yet its beams increase the temperature of the air and surroundings. As a consequence, this source of energy should be managed if it is anticipated not to damage the surroundings. One method to cut down on the harmful impacts of the sun radiation is to utilize plant cover as an ecological solution. Since plants are pure sources, their usage offers numerous advantages.

Vertical farms typically have unclear roofs fitted with solar panels. There are solar dishes capable of converting 30 percent of the energy they absorb into electricity. There also exist pressure sodium lamps which are extremely efficient lighting in plant development. They manage to convert 12-22 percent of the electrical energy to light. As a consequence, effective solar systems in the past utilized electric lights which generate 7 percent less light than they absorb. This varies from a clear glass-made roof which sends 90 percent of the light it receives to the plants within. A solar receptor roof which sits above 10 levels which were previously utilized to light up artificial lights may also offer .7 percent lighter as supplied by a transparent roof. A solar collector placed on rooftops is not a suitable replacement for transparent roofs, because it is more expensive. There was a model developed to determine the quantity of solar panels needed to fulfill energy requirements (calculations to be done based on light and water supply estimates) (calculations to be done based on light and water provision estimations). The model next examined whether the building was large enough to accommodate the number of PVs required according to the area of the roof as well as the façade and the desired dimensions.

2. DISCUSSION

Throughout this study, VF has been recognized as having tremendous potential, but also numerous limitations and flaws. In order to properly implement VF, it is essential to examine all the limits and potentials. The following three issues have been found which is more addressed in the literature and which consequently require more thought. Globally speaking, 40 percent of the total energy is used up in building construction. To this end, architects and designers should be provided with a set of sustainability standards throughout the entire cycle of producing sustainable structures. These are coupled with designs defined by optimum energy consumption that takes use of modern technology so as to reduce the requirements for energy and usage in terms of heating/cooling services, electricity and so on. Considering the impact of buildings on the reduction of energy consumption which adversely affects the environment, a variety of methods exist such as: ‘reduced energy needs’, ‘increased energy efficiency’ as well as ‘passive design approaches applied’.

In the topic of agricultural technology perspective of VF, these efforts require to cause secure and good-quality food or other goods of farms. It may serve as the criteria to choose suitable activities in each manufacturing phase which are sustainable both ecologically and socially. However, it is demanding to integrate them in a framework which seeks to improve farming and meet nutrition and energy needs. Growing crops using such instruments as marker-assisted choosing tools as well as genetic engineering may be significant indeed as they open the way for supplying new biofuel goods. The solution to minimize this strain is to create ideally sustainable agricultural efforts which profit from harmony and homogeneity all along the route. Therefore, reusable sources of energy may be utilized safely and with no harm to the environment. There is a need for investigations to delve into the interrelations of these constituents and to be convinced of gaining the most and the best outcomes, the best-quality technologies are to be used in order to take care of the environment and cut down on waste and at the same time guarantee the quality and safety of foods.

3. CONCLUSION

Agriculture is one of the activities that play the major part in sustaining a person in the globe. However, drinking water is already in scarcity stage, however, most of the available freshwater, is already used for agricultural. More than 20 percent of the fossil fuels yearly is used for agriculture in developed nations. Farming has grown more financially concentrated over the past years. Developing the high-tech agricultural systems are the outcomes of the energy sources and innovative techniques of farming. Moreover, overcrowding of cities requires innovative agricultural techniques so as to introduce traditional farming within cities. A single technical approach cannot be a cure to the ever-growing food production system. Instead, there is a need for a combination of different methods to lead us towards the 21-century green revolution.

Vertical farming is one of the most intriguing instances of something new that may add to these solutions. Others have referred to this phenomenon as controlled environment agricultural or farm integrated building. Also have essentially included it as technological components inside the superior phenomena of urban or local agriculture with distinct food production. Vertical Farming offers the potential route for sustainable development to generate food or associated services in urban settings. The objectives and future vision have been established with the intention of creating sustainable cities throughout the globe. To sum it up, to build a city environment where most of human food requirements are supplied by self-production and recycling and reusing drinkable water would not be far-fetched because the necessary technology are currently accessible. The current conventional agricultural methods owing to a significant imbalance in the environment. In the other hand, the current environmental approach caused by concentrated traditional agricultural methods that contribute to the ecological issue has been overviewed.

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