OPPORTUNITIES AND CHALLENGES OF VERTICAL FARMING - A SURVEY

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ABSTRACT

A new method that has been proposed to address the issue of sustainability and growing food demand is vertical farms. Vertical farming is the practice of planting the plants in vertically stacked layers which optimize the land usage. This study is a critical review survey from related published papers from relevant journals and scientific online databases. The main idea of vertical farming is to use a controlled-environment agriculture (CEA) technology, where all environmental factors can be controlled. Vertical farms were conceptualized to provide food security and as renewable energy source is an essential component. With photovoltaic cells as the main source, sufficient power storage will make sure to provide all power needed by plants. Vertical farming is a concept that involves cultivating plants with livestock on vertically inclined surfaces such as in skyscrapers in urban areas, where there is a lack of available land and space. This is one of the ideal decisions in modern agriculture technique when the land area for the plantation activities have become the major concern especially in the urban area. Vertical Farming can be potentially beneficial in increasing food production, maintaining high quality and safety and contributing to sustainable urban farming.

Keywords—Vertical Farming, renewable energy, urban agriculture, food security.

1 Introduction

Vertical farming is the practice of growing produce in vertically stacked layers. The practice can use soil, hydroponic or aeroponic growing methods. **Vertical farms** attempt to produce food in challenging environments, like where arable land is rare or unavailable. The term **vertical farming** was **coined** by American geologist Gilbert Ellis Bailey in 1915. In 1999, Dickson Despommier, a professor at New York's Columbia University, popularized the modern idea of **vertical farming.** Fundamental changes are predicted to occur in the upcoming 50 years accompanied by higher demand for food, all across the world as the world population continues to grow exponentially. Due to the growing food demand, a new method that could be designed and developed is vertical farms. Vertical Farming (VF) is an agricultural technique involving large-scale food production in high-rise buildings that enables fast growth and planned production by controlling environmental conditions and nutrient solutions to crops based on hydroponics, using cutting-edge greenhouse methods and technologies. There are four basic technological innovation needed for this ecosystem made possible - usage of renewable energy to reduce consumption of fossil fuel, utilization of green technology like LED lighting and using waste as fertilizer to reduce environmental impact, using alternative medium and the cultivation, processing and distribution be implemented on a single infrastructure to reduce wasted products due to spoilage, infestation, refrigeration and transportation. The efficient use of **vertical farming** may perhaps play a significant role in preparing for such a challenge. Increased and Year-Round Crop Production: **Vertical farming** allows us to produce more crops from the same square footage of growing area. The indoor vertical farming system, has been implemented globally by most farming industries to multiply their plant production in the buildings or warehouses. this technique also encourages the people to grow their own vegetables with the minimal usage of space such as living in the small apartments or houses which have land or yard that are very limited or almost none. Vertical farming can take advantage of the available and limited spaces that are idle or unused in the developed and advanced city. Other benefits of vertical farming include the creation of a sustainable urban environment that encourages good health for all who choose to live there; new employment opportunities, fewer abandoned lots and buildings, cleaner air, safe use of municipal liquid waste, and an abundant supply of safe drinking water. Also, it can create an environment that encourages sustainable urban life and good health for those who have chosen to live in the city.

2 Literature Survey

Cornelio G. Labrador II1 et.al. [1] proposed this system for development and design of optimized power generation and distribution of vertical farms. These vertical farms provide food security, power and renewable energy as an essential component. Photovoltaic cells provide power needed by plants. During rainy seasons and calamities automated main grid switching provide required energy to operate. Using these excess energies, it supports the lessening of carbon footprint. Two-way communication between node and controller is provided by Wireless Sensors Network (WSN).

Sharifah Syafinaz Syed Yusof1 et.al. [2] proposed system for indoor vertical farming for domestic or commercial purposes. This is suitable in the urban areas and purpose of this project is to study effects of artificial lights which is a critical element for the plants. Here, they use daylight compact fluorescent light (CFL), blue and red colours of light emitter diode (LED). Blue light enhances the height of plant and contains the water in the leaves whereas red light encourages the production of chlorophyll in the leaves.

Jun-Ho Huh [3] proposed this system for the development and implementation of smart green houses and vertical

farms. The light weight Intrusion Detection System (IDS) was proposed in this system as they use common PC and peripherals. Jpcap library is used to capture the transport packets. The results are stored in the database for latter applications.

Muhammad Ikhwan Hanif bin Ismail et.al. [4] the main purpose is to build a system to monitor the soil moisture and to control the water content through the web browser on laptop or mobiles. In this project the automatic system, which consists of Internet of Things (IOT) is implemented in providing the controlled environment for vertical farming. Here, they use soil moisture sensor to detect the moisture or water content of soil in vertical farming. The monitoring is done through the web browser which is helpful for the growth of the plants.

3 Methodology

In the current study, a systematic review was performed on previous literature on the primary research question: what are the opportunities and challenges of Vertical Farming mentioned in these academic and scientific papers? Subsequently, relevant papers included in the search, were perused for their relevance and eventual results. These papers were examined, explored and compared in order to identify multiple merits and demerits of Vertical Farming.

3.1 Optimization of Power Generation and Distribution for Vertical Farming with Wireless Sensor Network

In this paper, the researcher proposes a design of an optimized power distribution and generation specific for the vertical farm where an adaptive control system will be applied. To facilitate control communication, the whole network is configured as WSN using Zigbee. Here it is, demonstrated that microgrid-powered cellular base stations that are equipped with renewable energy generators and battery storage can reduce cost by sharing it excess energy. To facilitate a sharing of energy, communication between each node is a requirement. The commands and control as well as monitoring will be sent through it. There are several common communication systems that are usually employed for data acquisition and control, namely, GSM, GPRS, 3G, Wi Max, PLC (power line communication) and Zigbee. For a small system such as the vertical farm a wireless sensor network is appropriate by its characteristic to monitor, automatic/manual control and two-way communication. Zigbee can be configured to function into mesh networks which have the capability to self-configuration and self-organizing. This leads to a strong network that almost finds its way to alternative path. A WSN is composed of several nodes and a coordinator. Normally, coordinator is where the management of the communication network will occur. The sensors and necessary circuits for operation will be connected to the nodes.

3.2 Effect of Artificial Lighting on Typhonium Flagelliforme for Indoor Vertical Farming

In this paper, one of the modern agriculture practices is the indoor vertical farming system. It has been implemented globally by most farming industries to multiply their plant production in the buildings or warehouses. In addition, this technique also encourages the people to grow their own vegetables with the minimal usage of space such as living in the small apartments or houses which have land or yard that are very limited or almost none. The indoor vertical farming using an artificial light source, to stimulate the plant growth using electromagnetic spectrum to provide photosynthesis and the content of chlorophyll. One of the important processes in any plant growth is the photosynthesis process which is the process that used by them to harness energy from sunlight into chemical energy. In this case, pigments, which are the molecules that bestow the colour of the plant, are also responsible for effectively absorbing or trapping the light/sunlight. For Typhonium Flagelliforme, these pigments are the chlorophyll, which is the green pigment found at this plant. The main important feature in the chlorophyll is these green-coloured pigments are capable of trapping the blue and red light. In this work, the intensity of the light is used to refer the rate of light spreads over a surface of a given area and or the distance of the plants from the light source.

3.3 Implementation of lightweight intrusion detection model for security of smart green house and vertical farm

The lightweight intrusion detection system (IDS) proposed in this study can be an adequate solution to the cost-related problems as this system model uses an open-source Jpcap library to capture transport packets, instead of developing any exclusive programs separately. A lightweight intrusion detection system (LIDS) model has been designed to deal with cost problem. Under the environment where the typical communications protocols such as user datagram protocol (UDP), transmission control protocol (TCP) are being used, the transport packets can be captured using an open-source Jpcap library and they are then stored in the system database for later analysis. The system model largely undergoes two stages when detecting an intrusion event: adaptive stage and action stage, both of which were designed almost identical to the ones that have been designed in the preceding studies. Lightweight intrusion detection model for smart green house and vertical farm security was coded with Jpcap on the basis of Java and aimed to look at all the packets passing through user's network interface card. It was constructed in such a way that the user can grasp network situation at a glance easily, check information regarding the control and other details, and give warnings using threshold value enabling easy detection of DDoS attack possibilities.

3.4 IoT Implementation for Indoor Vertical Farming Watering System

The objectives of this paper are to develop an IoT system based on the web server to monitor and control the soil moisture of the vertical farming and to create a semi-automatic soil moisture control system for a vertical farming implementation on the selected plant. Here the rack is built with four tiers of a wooden platform that contain herbs plant. Three soil moisture sensor and one water level sensor has been used to make an analysis for a week. Soil moisture sensors are placed with a deep of 5.5 centimetres from the ground surface. The overall process of monitoring and controlling the indoor vertical plant is, once the internet connection has been established, the vertical farming system is ready to be controlled by the user through the web browser on the mobile phone or computer. In this case, the soil moisture sensor is used to detect the humidity of the soil moisture. Once the humidity data is detected by the sensor, it is stored in the memory allocated in the Arduino platform.

Then, simultaneously, the data is sent to the mobile phone or computer through the Ethernet module. There are two watering techniques which are being setup based on the lower and upper threshold values that are acquired from the soil moisture sensors. The lower threshold describes the system to be turned 'ON' based on the lower reading of the soil moisture. Otherwise, it needs to be turned 'OFF'. Soil moisture sensor is placed at every level of vertical farming to check their soil moisture range. This case will ease the user to read the value of soil moisture and to control the motor pump and water valve to release water to the plant.

4 Conclusion

We can conclude that even a little knowledge and awareness of VF can help food security and viability greatly. "We came to realize that the future of these farms really rests in the hands of artificial intelligence," "We're trying to improve both the amount that we can produce for a given cost or unit of energy as well as the quality of that product." In apartments and office buildings, creative climate management technologies and natural light management technology helped to save energy and cut down on greenhouse gas distribution. VF has provided new opportunities for architecture and urban designing. Urban designers have attested to the importance of making cities green, healthy and safe. VF has got numerous advantages over traditional farming, which includes more efficiency, adaptability, and environmental benefits, which is all made possible through carefully controlled systems of VF. All the above-mentioned benefits in a single system seems rather unbelievable, but VF has made it possible. If its use becomes common and widespread across the globe, the fear of starvation will also disappear and detrimental climate change will slow down too.

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