

IoT-Based Vertical Farming System

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Abstract- The IoT Based Vertical Farming System is designed to automate the monitoring and control of environmental conditions required for plant growth. The system uses the NodeMCU ESP8266 Development Board to collect data from sensors such as the DHT11 Temperature and Humidity Sensor, soil moisture sensor, and water level sensor. Based on the sensor readings, devices like a water pump and cooling fan are automatically controlled to maintain suitable conditions. The data is sent to the Blynk IoT Platform for remote monitoring through a smartphone or webpage. This system improves water efficiency, saves space through vertical farming, and supports smart agriculture practices.

Key Words: Internet of Things (IoT), Smart Agriculture, NodeMCU ESP8266, Blynk IOT platform, Soil Moisture Sensor, DHT11 Temperature and Humidity Sensor, Automated Irrigation, Remote Monitoring.

1. INTRODUCTION

1.1 Industry Domain Background

The agriculture sector is facing challenges such as limited land, water scarcity, and climate change. To improve productivity and efficiency, modern technologies like the Internet of Things (IoT) are being used in smart agriculture. IoT allows real-time monitoring of environmental conditions such as soil moisture, temperature, and humidity using sensors and automated systems.

Vertical farming is an innovative technique where crops are grown in vertically stacked layers, making efficient use of limited space, especially in urban areas. By integrating IoT with vertical farming, farmers can automatically control irrigation and environmental conditions, improve crop yield, and reduce water and energy consumption.

1.2 Importance of the Problem

Traditional farming methods often depend on manual monitoring and irrigation, which can lead to inefficient use of water, labor, and other resources. In many areas, farmers face challenges such as water scarcity, unpredictable climate conditions, and limited agricultural land. The lack of real-time monitoring of soil moisture, temperature, and humidity can negatively affect plant growth and crop productivity. Additionally, urban areas have limited space for traditional

farming, making food production more difficult. Implementing an IoT-based vertical farming system helps

address these issues by enabling automated monitoring, efficient water usage, better environmental control, and improved crop yield while utilizing limited space effectively.

1.3 Project Overview

This project develops an IoT-based vertical farming system designed to automatically monitor and control the environmental conditions required for healthy plant growth. The system utilizes various sensors such as a soil moisture sensor and a temperature and humidity sensor like the DHT11 Temperature and Humidity Sensor to continuously measure important parameters including soil moisture level, temperature, and humidity in the farming environment. These sensors send real-time data to the NodeMCU ESP8266 Development Board, which acts as the central controller of the system.

Based on the sensor readings, the microcontroller automatically controls devices such as a water pump and a cooling fan to maintain suitable conditions for plant growth. For example, when the soil moisture level drops below a predefined threshold, the system automatically activates the irrigation pump to provide water to the plants. Similarly, if the temperature rises above the optimal level, a cooling fan is activated to maintain a favorable temperature for plant development. This automation reduces the need for constant manual monitoring and ensures that plants receive the proper care at the right time.

The system also integrates Internet of Things (IoT) technology using Wi-Fi connectivity. The collected sensor data is transmitted to the Blynk IoT Platform, where users can monitor real-time environmental conditions through a smartphone application or web interface from any location. This remote monitoring feature allows farmers or users to easily track the system performance and ensure that the plants are growing under optimal conditions.

By combining vertical farming techniques with IoT technology, the system makes efficient use of limited space by growing plants in vertically stacked layers. It also helps in reducing water consumption, improving crop productivity, and supporting sustainable agriculture practices. The proposed system is cost-effective, energy-efficient, and suitable for urban farming, greenhouses, and small-scale agricultural applications, making it a practical solution for modern smart agriculture.

2. LITERATURE REVIEW

The increasing demand for efficient food production and sustainable agriculture has led to significant research in IoT-based smart farming systems. Many studies highlight that continuous monitoring of environmental conditions such as

soil moisture, temperature, and humidity helps improve crop productivity and reduce resource wastage.

[1]. Patel et al. (2020) developed an IoT-based smart irrigation system using NodeMCU and soil moisture sensors to automatically control water supply to plants. The system improved water efficiency, but it was limited to irrigation control and lacked environmental monitoring features.

[2]. Singh and Sharma (2021) proposed a smart farming system using temperature and humidity sensors with cloud-based monitoring through mobile applications. The system provided real-time monitoring but required stable internet connectivity for continuous operation.

[3]. Ahmed et al. (2019) designed an automated greenhouse monitoring system using IoT sensors and microcontrollers to maintain optimal conditions for plant growth. Although effective, the system had higher implementation costs and complex setup.

[4]. Rao and Kumar (2022) implemented a vertical farming system integrated with IoT technology to monitor plant growth conditions. The system improved space utilization and crop yield but lacked automated alert mechanisms for critical environmental changes.

2.1 Problem definition

Traditional farming methods rely heavily on manual monitoring and control of environmental conditions, which often leads to inefficient use of resources and reduced crop productivity. Farmers face difficulties in continuously monitoring factors such as soil moisture, temperature, and humidity, resulting in improper irrigation and unsuitable conditions for plant growth. This lack of real-time monitoring can cause water wastage and negatively affect crop quality and yield.

In addition, increasing urbanization has reduced the availability of agricultural land, making traditional farming less practical in many areas. Conventional farming systems also lack automation and remote monitoring capabilities. Therefore, there is a need for an intelligent solution that can automatically monitor environmental parameters and control irrigation systems. An IoT-based vertical farming system helps optimize resource usage, improve crop growth conditions, and support sustainable agriculture.

2.2 Objectives of the project

- To design and develop an IoT based vertical farming monitoring system.
- To monitor environmental parameters such as temperature, humidity, soil moisture, and water level.
- To automate irrigation using a water pump based on soil moisture conditions.

- To control a cooling fan automatically when temperature increases.
- To send SMS alerts to the user through a GSM module.
- To display real-time sensor data on an LCD screen.
- To monitor the farming system remotely using the Blynk mobile application.
- To improve crop growth conditions using automated monitoring and control.

2.3 Methodology

1. Power Supply Setup

A regulated power supply is used to provide stable power to the entire system including the microcontroller, sensors, and other connected devices.

2. Sensor Data Collection

Sensors such as the soil moisture sensor, DHT11 Temperature and Humidity Sensor, and water level sensor are used to continuously monitor environmental parameters like soil moisture, temperature, humidity, and water level in the vertical farming system.

3. Data Processing using Microcontroller

The collected sensor data is sent to the NodeMCU ESP8266 Development Board, which acts as the central controller. It processes the sensor readings and determines the required actions based on predefined threshold values.

4. IoT Connectivity and Remote Monitoring

The NodeMCU uses its built-in Wi-Fi capability to send sensor data to the Blynk IoT Platform. The data is displayed on a mobile application or web dashboard, allowing users to monitor the farming conditions remotely.

5. Automatic Control of Actuators

Based on sensor readings, the system automatically controls devices such as the water pump and cooling fan. If soil moisture falls below a set level, the pump is activated, and if the temperature becomes too high, the cooling fan is turned on.

6. Alert Notification System

A GSM module is integrated into the system to send SMS alerts to the user when specific conditions occur, such as pump activation, high temperature, or low water level.

7. Efficient Plant Growth Management

This automated monitoring and control system ensures optimal environmental conditions for plant growth, reduces manual effort, saves water, and improves overall farming efficiency.

Table 1: Hardware Components

Sr.	Component	Description
1	NodeMCU ESP8266 Microcontroller	A Wi-Fi enabled microcontroller used as the main controller to read sensor data and control devices.

2	Temperature and Humidity Sensor	Measures the surrounding temperature and humidity of the farming environment.
3	Soil Moisture Sensor	Detects the moisture level in the soil to determine when irrigation is required.
4	Water Level Sensor	Monitors the water level in the tank to prevent pump operation when the tank is empty.
5	Relay Module	An electrically operated switch used to control high-power devices like pumps and fans.
6	Water Pump	Supplies water to the plants automatically when soil moisture is low.
7	LCD Display	Displays sensor readings and system status for local monitoring.
8	GSM Module	Sends SMS alerts to the user for important events such as high temperature or low water level.
9	IoT Platform (Blynk)	A cloud platform used to monitor sensor data and control the system remotely via a mobile app.

2.4 Block Diagram

The block diagram shows the working of the IoT-based vertical farming system controlled by the NodeMCU ESP8266 Development Board. Sensors such as the DHT11 Temperature and Humidity Sensor, soil moisture sensor, and water level sensor send environmental data to the controller. Based on the sensor readings, the system automatically controls the DC fan and water pump. The data is displayed on the LCD and uploaded to the Blynk IoT Platform for remote monitoring. Users can view the system status through a webpage or mobile device, and the GSM module sends alert messages when needed.

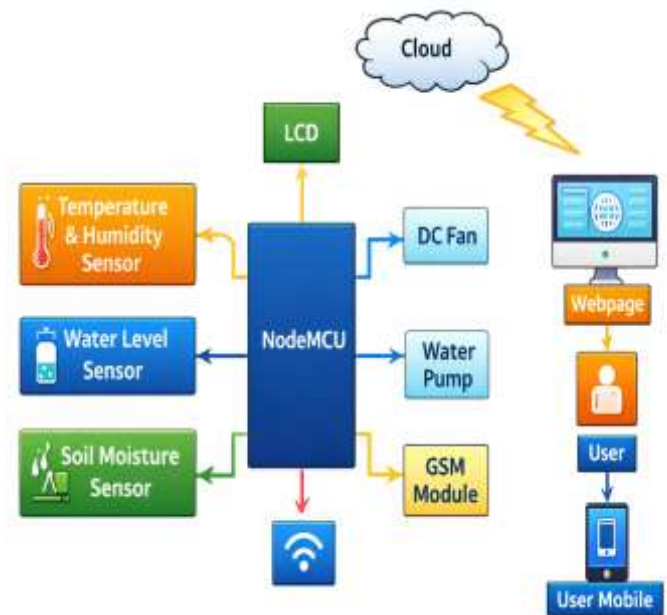


Fig. 1- Block Diagram — IOT Based Vertical Farming System.

2.6 Circuit Diagram

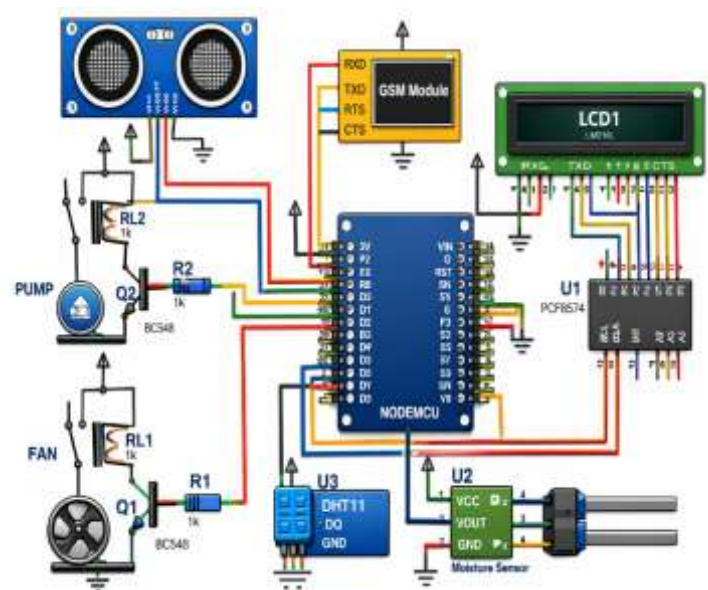


Fig. 2- Circuit Diagram — IOT Based Vertical Farming System.

2.5 Advantages

1. Reduces manual labor in farming.

The system automatically monitors soil moisture, temperature, and humidity using sensors, reducing the need for constant manual checking by farmers.

Devices like the water pump and cooling fan are automatically controlled by the NodeMCU ESP8266 Development Board,

minimizing the need for manual irrigation and environmental management.

2. Automatic irrigation system.

The system automatically turns on the water pump when the soil moisture level drops below the required level, ensuring plants receive sufficient water. • Remote emergency cutoff allows staff to deactivate equipment without physical access.

The irrigation process is controlled by the NodeMCU ESP8266 Development Board using soil moisture sensor data, helping prevent overwatering and saving water.

3. Low cost and easy to implement.

The system uses affordable components such as the NodeMCU ESP8266 Development Board and basic sensors, making it economical for small-scale farming.

The setup is simple and can be easily installed in homes, greenhouses, or small farms without complex infrastructure.

2.6 Applications

- **Research laboratories:** Automated monitoring and control of environmental conditions for plant growth experiments.
- **Urban farming:** Automated monitoring and irrigation for efficient crop growth in limited urban spaces.
- **Smart agriculture:** Automated monitoring and control of environmental conditions to improve crop productivity and resource efficiency.

2.7 Future Scope

1. Integration of Additional Sensors

More sensors such as light intensity, pH level, and nutrient sensors can be added to monitor additional environmental parameters for better plant growth.

2. AI-Based Crop Monitoring

Artificial Intelligence and Machine Learning can be integrated to analyze plant growth patterns and automatically optimize irrigation and environmental conditions.

3. Automated Nutrient Delivery System

The system can be upgraded to include an automated nutrient dosing system to provide plants with the required fertilizers and nutrients.

4. Solar Power Integration

Solar panels can be integrated to make the system more energy-efficient and suitable for sustainable farming.

5. Data Analytics and Cloud Storage

Cloud-based data storage and analytics can be implemented to track long-term farming data and improve crop productivity.

2.8 Expected Outcomes

- I. Fully functional IoT-based vertical farming system with real-time monitoring and automatic control of environmental parameters.
- II. Improved plant growth through controlled temperature, humidity, and soil moisture conditions.
- III. Reduction in water wastage through an automatic irrigation system based on soil moisture levels.
- IV. Remote monitoring of farming conditions through the Blynk IoT Platform using a smartphone or web interface.
- V. Automated alerts and notifications through the GSM module to inform users about critical conditions such as high temperature or low water level.

3. CONCLUSION

The IoT Based Vertical Farming System provides an efficient and intelligent solution for modern agricultural challenges. By integrating sensors, automation, wireless communication, and cloud monitoring, the system enables precise control of environmental conditions required for plant growth.

The system successfully monitors key parameters such as temperature, humidity, soil moisture, and water level, ensuring optimal conditions for plants. Automatic control of irrigation and ventilation reduces human effort and improves resource efficiency.

The integration of IoT technology allows farmers to monitor their farms remotely through smartphones or computers. Real-time data visualization and SMS alerts help farmers make informed decisions quickly.

This system also promotes sustainable agriculture by reducing water wastage and improving crop productivity. The use of vertical farming further maximizes land utilization, making it suitable for urban areas and regions with limited agricultural land.

Overall, the proposed system demonstrates how modern technologies can significantly improve agricultural practices and contribute to the development of smart farming solutions.

ACKNOWLEDGEMENT

The authors express sincere gratitude to Mr. J. I. Tamboli for expert guidance and continuous support throughout this project. They also acknowledge the Department of Electronics & Computer Engineering and the management of Ashokrao Mane Polytechnic, Vathar , for providing the necessary resources and laboratory facilities.

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