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Vertical Farming System Based on IoT

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Abstract:- The comprehensive analysis of an Internet of Things (IoT)-integrated vertical farming system, focusing on the monitoring and optimization of environmental parameters critical for plant growth. Real-time data on variables like flow rates, water quality, temperature, humidity, and moisture levels are provided by the system. It uses a variety of sensors, including as flow, pH, turbidity, ultrasonic, and DHT11 (Digital Humidity and Temperature Sensor) sensors, to achieve this. The system can maintain optimal growing conditions, according to sensor data insights, but they also highlight the necessity of precise irrigation control to account for differences in moisture content. The study demonstrates how IoT-driven vertical farming systems have the potential to transform conventional agricultural processes, promoting sustainability and productivity.

Keywords:- *Internet of Things (IoT), Sensors, Actuators, Node MCU, Vertical Farming, Sustainable Practices, Crop Yield, Automation, Technological Advancements, Precision Agriculture.*

I. INTRODUCTION

Growing plants vertically redefines traditional agriculture, and vertical farming appears as a promising option. This novel method maximizes the use of existing land, which makes it especially appropriate for urban settings with limited arable land. The principles of Controlled Environment Agriculture (CEA), which precisely regulates environmental factors including temperature, humidity, and moisture, are applied to vertical farming. However, this paper suggests using Internet of Things (IoT) technologies to further improve the productivity, sustainability, and efficiency of vertical farming. Real-time monitoring and management of important environmental parameters can be made possible by the Internet of Things (IoT), which is made up of connected physical devices, sensors, and actuators. This has the potential to completely transform vertical farming. The use of IoT in vertical farming helps to solve a number of issues that conventional agricultural methods have. The use of IoT in vertical farming helps to solve a number of issues that conventional agricultural methods have. Growers can automate critical portions of the growing process in addition to monitoring it by utilizing Internet of Things sensors and actuators. By automating tasks, vertical farming becomes more financially feasible by saving labor costs and gaining time. This work makes use of sensors that transmit data to a cloud-based server for remote access, storing and displaying system characteristics.

II. LITERATURE REVIEW

[1] An IoT-based automation system for hydroponics utilizing Node MCU interface to optimize resource utilization and enhance crop yield. [2] Emphasized the integration of IoT sensors and actuators to automate nutrient delivery and environmental monitoring in hydroponic farming. [3] Introduced a solar-smart hydroponics farming system integrated with an IoT-based AI controller and mobile application for sustainable farming practices. [4] Developed an automated hydroponics greenhouse farming system utilizing IoT technology for efficient monitoring and control of environmental parameters. [5] Discussed the integration of IoT technology with hydroponics for monitoring and accelerating plant growth. [6] Presented an automated hydroponics nutrition system using Arduino Uno microcontroller and Android-based control. [7] Explored the concept and advantages of vertical farming as a sustainable agricultural practice, discussing benefits such as space efficiency, reduced water usage, and year-round crop production. [8] Discussed vertical farming as the agriculture of the future, emphasizing its potential to revolutionize food production. They examined advantages including increased crop yield, reduced environmental impact, and utilization of advanced technologies for sustainable farming practices. [9] Presented an IoT implementation for an indoor vertical farming watering system, focusing on automated watering control based on environmental parameters. They explored how IoT technology can optimize water usage and enhance crop growth in indoor vertical farming environments. [10] Introduced an IoT-based home vertical farming system, aiming to promote urban agriculture and selfsustainability. They discussed the integration of IoT sensors and actuators for automated monitoring and control of home-based vertical farming setups, enabling efficient resource management and crop cultivation.

➢ *Proposed System*

An IoT-based automated vertical farming system is presented in this study. As the main controller, the Node MCU ESP32 is at the heart of this system. It communicates with important sensors, such as turbidity, pH, soil moisture, ultrasonic, and humidity sensors, to track current environmental conditions. By acting as a bridge for remote monitoring and control, the Blynk IoT platform allows the user to communicate with the Node MCU through a mobile application. The proposed vertical farming system's design and components are shown in Fig. 1. Proposed System Design.

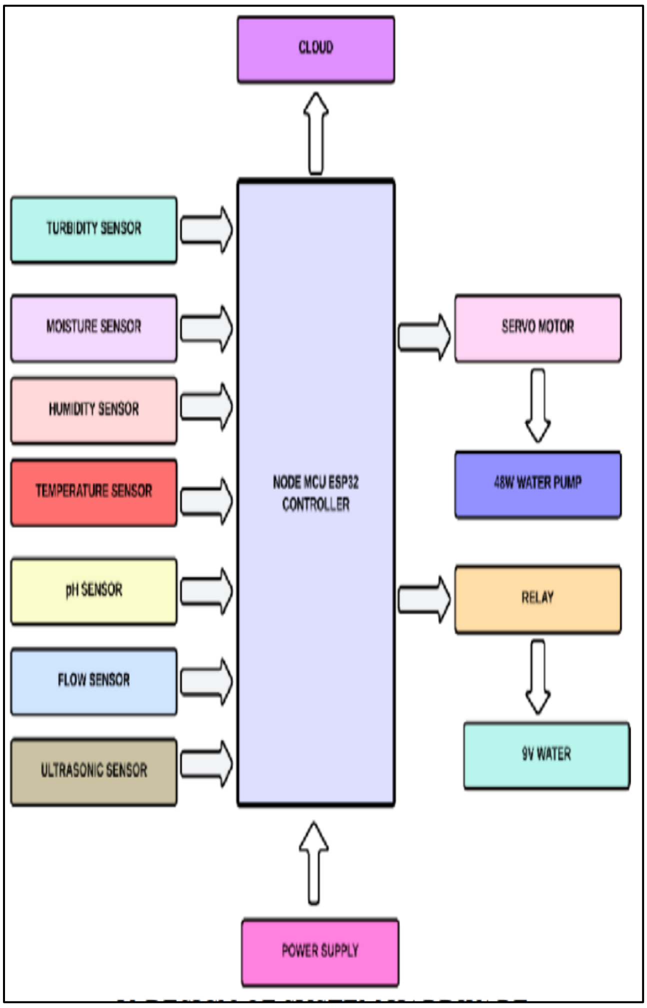

Fig 1 Proposed System Design

III. METHODOLOGY

❖ *Design of System Hardware*

A. The Following are the Elements of the Suggested System, each of which is Essential to its Operation:

➢ *Node MCU Controller (ESP32)*
➢ *Ultrasonic Sensor*
➢ *Moisture Sensor*
➢ *Turbidity Sensor*
➢ *Humidity and Temperature Sensor*
➢ *pH Sensor*
➢ *Power Supply*
➢ *48W Water pump*
➢ *Relay*
➢ *9V Water Pump*

➢ *Node MCU Controller:*

Fig 2 Node MCU ESP32

This design strategy for our IoT-integrated vertical farming system was influenced by several cited papers. Our understanding of IoT integration and sensor deployment has been impacted by concepts from Dr. A. Beno et al.'s work on "IoT based Automation of Hydroponics using Node MCU Interface". The paper "Internet of Things (IoT) Based Automated Hydroponics Farming System" by Arun P. and Manoj Challa provided insights into system architecture and automation procedures. The research on "Solar-smart hydroponics farming with IoT-based AI controller with mobile app" by Pallavi Khare et al. influenced our approach to user interface design and remote monitoring capabilities. The concepts from earlier articles, such as "Monitoring and accelerating plant growth using IoT and hydroponics" by Abhishek Kumar and Dr. Savaridassan P, served as the foundation for decisions concerning data analytics and decision support. Combining concepts from this research allowed us to Fig. 3. Pinout configurations of ESP32 optimize farming methods and promote sustainability in our vertical farming system through a rigorous design process.

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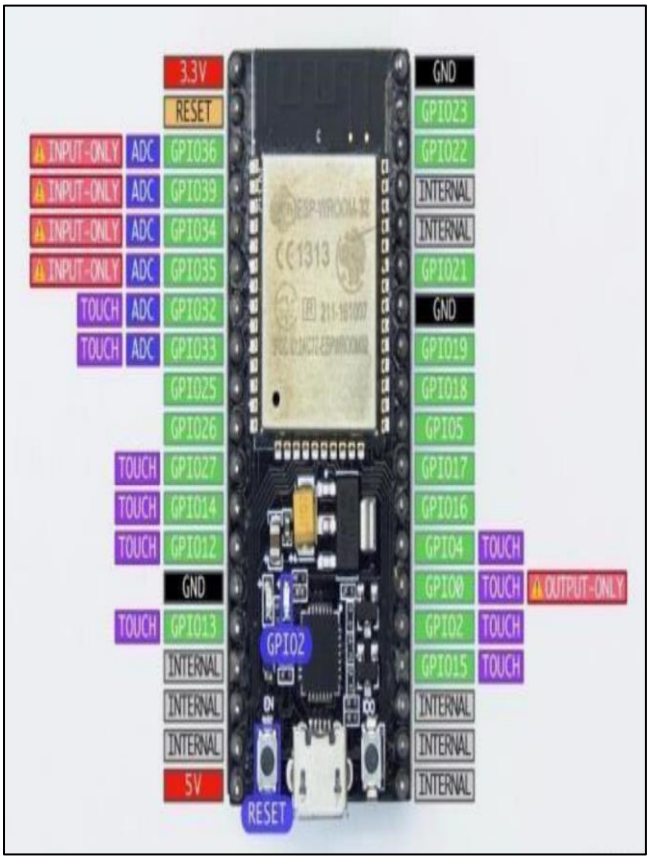

Fig 3 Pinout Configurations of ESP32

The ESP32 microcontroller features a flexible pinout configuration, offering numerous GPIO pins for interfacing 8.Servomotor A development board built around the ESP32 microprocessor is called the Node MCU ESP32. It combines the ease of use of the Node MCU firmware and form factor with the capabilities of the ESP32. Similar to other ESP32 boards, the Node MCU ESP32 board has built-in Bluetooth and Wi-Fi connectivity. Its assortment of GPIO pins, analog inputs, and communication ports make it adaptable to a wide range of uses.

With external devices. These pins can be configured for digital input or output, analog input, PWM output, and various communication protocols such as SPI, I2C, UART, and CAN. Additionally, some pins have special functions like touch sensors or built-in peripherals like DACs and ADCs.

- *Ultrasonic Sensor:*

Ultrasonic sensors play a crucial role in vertical farming systems by providing real-time data for monitoring and controlling. They are commonly used to measure distances between plants and the sensor, enabling precise monitoring of plant growth and spacing.

- *Moisture Sensor:*

The water content present in the soil can be measured using a device called soil moisture sensor. The user can be reminded to water the plants with the help of this sensor. A voltage proportional to dielectric permittivity is created.

- *Turbidity Sensor:*

A turbidity sensor measures the cloudiness or haziness of a liquid caused by suspended particles. In vertical farming systems, turbidity sensors can be used to monitor the clarity of nutrient solutions. High turbidity levels may indicate the presence of contaminants or organic matter, which can affect plant growth and health. Monitoring turbidity allows farmers to take corrective actions such as adjusting filtration systems or changing nutrient solutions to maintain optimal growing conditions.


Fig 4 Turbidity Sensor

- *Humidity and Temperature Sensor:*

The DHT11 is a basic digital temperature and humidity sensor. It provides accurate readings of temperature and humidity levels. With its simple interface and low cost, the DHT11 is commonly used in various IoT projects and environmental monitoring systems.

- *pH Sensor:*

A pH sensor assesses solution acidity or alkalinity by detecting hydrogen ion concentration. Its sensitive electrode generates voltage proportional to pH level. Typically, it features pinout configurations: VCC for power, GND for ground, and OUT for signal output. This sensor finds extensive use in various fields, including environmental monitoring, agriculture, and chemical analysis, due to its precision and versatility.

- *Power Supply:*

Integrating a 12V lead-acid battery provides reliable power, necessitating proper charging and voltage regulation for sustained system performance and longevity. Adhering to safety protocols and monitoring battery health ensures uninterrupted operation of the vertical farming system.

- *Servomotor:*

A servo motor is a type of rotary actuator that allows for precise control of angular position. Commonly, servo motor has three wires:

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- Power (VCC): Typically connected to a 5V power source. Ground (GND): Connected to the ground.
- Signal (Control): Receives PWM (Pulse Width Modulation) signals from a microcontroller to determine the desired position.

➢ *48W Water Pump:*

A water pump is a mechanical device designed to move water from one place to another. A 40-watt water pump is used and it refers to a pump with a power consumption or input rating of 40 watts.

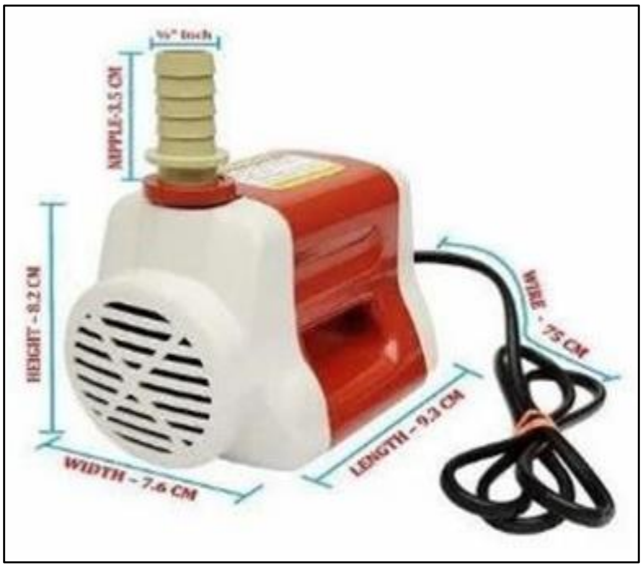

Fig 5 Water Pump

➢ *Relay:*

A relay is an electrically operated switch used to control the flow of electricity in a circuit. It consists of an electromagnet that controls one or more switches, allowing it to open or close the circuit. Relays are commonly used in automation, automotive, and industrial applications.

➢ *9V Water Pump:*

A 9V water pump is a compact, electrically powered device used to move water in small-scale applications. Operating on a 9-volt power supply, it is commonly utilized in projects requiring low-pressure water circulation, such as miniature fountains or DIY hydroponic systems.

➢ *Software Specifications*

- *Arduino IDE:*

Arduino is an open-source electronics platform based on easyto-use hardware and software. It consists of a physical programmable circuit board (often referred to as a microcontroller) and a development environment, or IDE (Integrated Development Environment), that runs on your computer. It allows for the creation of interactive electronic objects and projects.

- *Blynk Application:*

Blynk is an easy-to-use drag-and-drop interface that lets users create smartphone applications for controlling Internet of Things devices remotely. Popular hardware platforms like Arduino, Raspberry Pi, and ESP8266/32 are supported, making it easy to integrate with a wide range of Internet of Things projects.

IV. RESULTS AND DISCUSSION


Fig 6 Vertical Farming Tower

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Fig 7 Blynk Web Dash Board

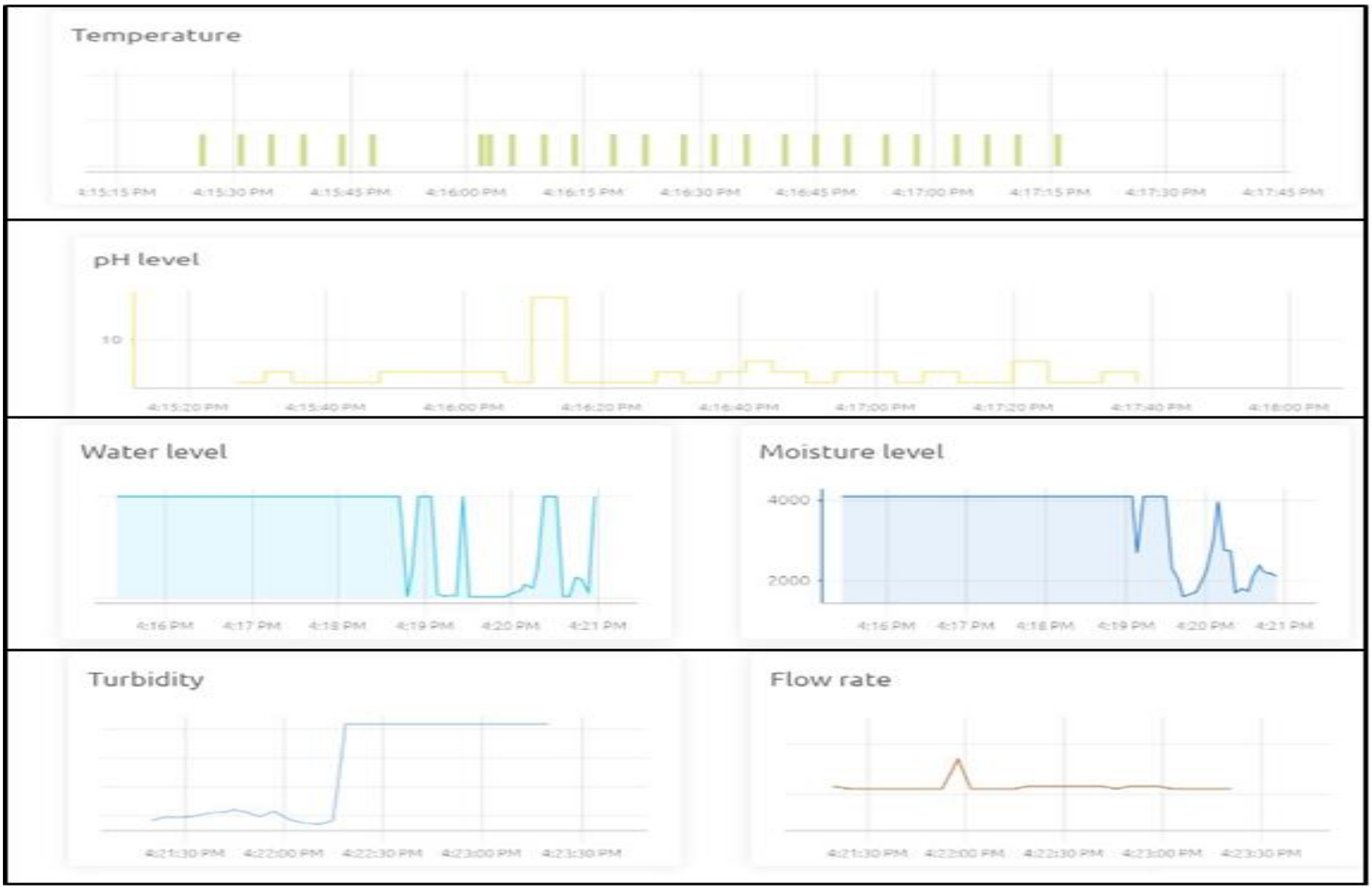

Fig 8 Blynk Web Dash Board Data Sheets

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The sensor data revealed crucial insights into the environmental conditions within the vertical farming system. Although the ultrasonic sensor measured distances precisely, it also detected variations in moisture content, which called for cautious irrigation control. The DHT11 sensor ensured that the temperature and humidity levels were within acceptable parameters, which resulted in ideal growing conditions. A good degree of turbidity and pH was indicative of water quality, which is important for plant nutrient uptake. Measurements using flow sensors revealed effective water distribution, which is essential for maintaining plant development and optimizing yield.

V. CONCLUSION

The integration of various sensors within the vertical farming system enabled comprehensive monitoring of environmental parameters crucial for plant growth. The collected data demonstrated the system's capacity to sustain ideal circumstances, with variations in moisture content highlighting the significance of accurate irrigation control. Overall, the sensor data show that the system is performing well, which highlights its potential for sustainable agriculture practices and opens the door to more improvements and developments in indoor farming technologies.

FUTURE SCOPE

Future developments in vertical farming include exploring the possibilities of urban farming, the integration of robotics for automation, precise nutrient delivery systems for efficiency, and enhanced data analytics for predictive modeling. Collaboration is also necessary for innovation and market adoption. In order to address the issues of a growing global population and finite resources, these initiatives seek to improve productivity, sustainability, and scalability, bringing in a new era of agricultural techniques.

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