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Smart Agriculture System for Greenhouse Management

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Abstract— **Although greenhouse agriculture guarantees a controlled environment for higher crop yield, labor-intensive environmental factor monitoring has been prone to inefficiencies and resource waste. In order to automate greenhouse control, the current work presents a Smart Agriculture System that combines cloud infrastructure, low- cost sensors, and Internet of Things (IoT) principles. NodeMCU microcontroller-based sensors, such as DHT11/DHT22 for temperature and humidity, LDR for light intensity, and soil moisture and pH sensors, are used by the system to monitor critical parameters. For offsite accessibility, the data is shown on the Blynk dashboard after being sent over Firebase. Irrigation, lighting, and ventilation can all be programmed to maximize input use, minimize labor costs, and promote sustainability. For small- to medium-sized farmers, the system envisioned here shows scalability, but it also lays the groundwork for future improvements like predictive analytics and AI-driven decision support.**

I. Introduction

Agriculture is still the main part of India's economy, and growing crops in greenhouse is along-term way to improve crop yields by creating a controlled environment .Traditional greenhouse operations require constant human input to measure things like temperature, humidity, water content of the medium, and light because they are hard to do and can be wrong. Recent developments in the Internet of Things (IoT) have made it possible to automate and measure things in real time in agriculture. This is thanks to cheap sensors, wireless transmission, and cloud connectivity [1], [3].

IoT-based smart farming systems provide efficient irrigation, water conservation, and maximizing crop yield, which are all important for meeting the growing need for food production [2], [5]. Farmers can manage and monitor their greenhouse setups from anywhere in the world using microcontrollers like the NodeMCU and cloud-based platforms like Firebase and Blynk [11]–[13]. An IoT-based greenhouse management system has been created and put into use with an eye on cost-effectiveness, scalability, and long-term viability.

II. Related Work

Using IoT in farming has also been shown to make monitoring and resource use much more effective. Khanna and Kaur [1] discussed the evolution of the Internet of Things(IoT)in precision agriculture ,emphasizing its role in enhancing decision-making and promoting sustainability. Gubbietal.[3] presented an architectural perspective on the application of IoT, highlighting its capacity for real- time monitoring of agricultural systems.

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Researchers are also looking into smart greenhouse automation. Kumaret al. [2]made a greenhouse monitoring and control system based on the Internet of Things (IoT)that used real-time environmental data to boost crop yield. Mouleesh and Srinivasan [7] also showed a smart irrigation system that used the NodeMCU and worked with cloud services to use less water with little need for hands-on interaction. Roy and Nayak also examined cyber-physical deployments that improved greenhouse operations through the use of sensors, clouds, and automation [4]. Intelligent agriculture has also relied heavily on the deployment of wireless sensor networks. Applications of wireless sensor technologies for agriculture, specifically the use of sensors for soil, humidity, and temperature monitoring, were mentioned by Ruiz-Garcia et al. [6]. IoT-enabled intelligent irrigation management systems for water-efficient irrigation were covered by Sharma and Gupta [5]. In order to expand the automation potential at the greenhouse, Jawarkaretal.

[8] looked into microcontroller-based mobile monitoring. Agricultural IoT systems are now more efficient thanks to cloud and edge computing architectures. A hybrid edge- cloud IoT platform was developed by Zamora-Izquierdo et al.[9]to improve scalability and responsiveness. Prasadand associates. [10] gave a thorough look at IoT- and cloud- enabled agriculture, including problems like interoperability and security. Platforms such as NodeMCU [11], Firebase [12], and Blynk [13] are also widely used in practice for integrating sensors, storing data in clouds, and visualizing real-time data for greenhouse usage in parallel work. Together, these studies demonstrate the progression from early monitoring systems to extensive IoT-cloud platforms that unleash the potential of smart agriculture technologies for higher yields, reduced resource losses, and sustainable greenhouse use.

III. METHODOLOGY

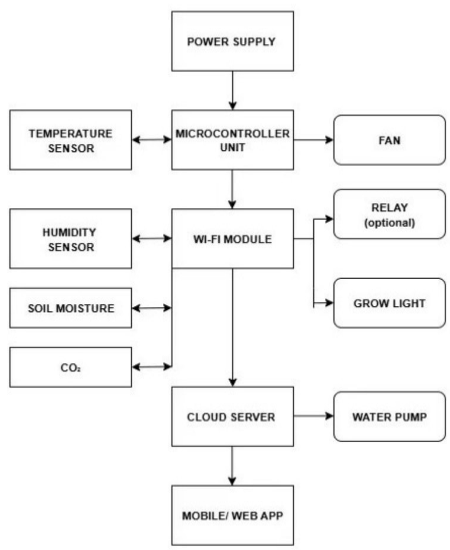

Fig.1 Block Diagram

In order to achieve real-time measurement and automated environment control, the Smart Agriculture System of greenhouse control incorporates inexpensive sensors, microcontrollers, actuators, and cloud platforms. Fig. 1 (henceforth not shown) depicts the overall system architecture.

A. Power Supply

An electric supply for the system's components is provided by a controlled DC supply. For sensors, controller NodeMCU, and actuators to function properly, it converts AC mains voltage or battery voltage into a steady DC voltage.

B. Micro controller Unit

The central processing unit of the system is the NodeMCU microcontroller. It processes environmental parameters, reads sensor data, and starts control operations. In order to integrate the system with clouds, the MCU additionally offers Wi-Fi connectivity.

C. Sensor Module

To measure greenhouse conditions, a number of sensors are installed:

- DHT11/DHT22 Temperature and Humidity Sensor: This sensor measures the air's temperature and humidity to regulate fans and ventilation.

D. Soil Moisturizer Sensor:

It checks how much water is in the soil and waters it when the water level drops below a certain point.

E. PH Sensor

In this we are using pH Sensor to know they how acidic or alkaline the soil is and also it helps to checking the soil is suitable for the plants to grow properly. When the PH level is not in the right range. It shows plant is not taking nutrients effectively. In this project the PH Sensor keeps monitoring the condition of the soil and sends the data so that we can maintain the right Balance for healthy plant growth.

F. Light Dependent Resistor

The Light Dependent Resistor, or LDR, is used to sense the amount of light present in the greenhouse. the resistance of light changes with light intensity. When there is more light, the resistance becomes low, and when the light is less, the resistance becomes high. In this project LDR helps to know whether sufficient sunlight is available .if the sunlight is not sufficient the system decide when to turn on the light.

G. CO2 Sensors

The CO2 sensor were it used to check the level of the carbon dioxide present in the greenhouse air. Plants need CO2 to accomplish photosynthesis and helps plants to grow well. If the level of CO2 is very low ,it can affect the growth of the plant. using this sensor to monitor CO2 level and it helps plants to grow efficiently.

H. Actuator Module

The actuator module is responsible for accomplishing action based on the data which is received from sensor. It handles different devices .that helps to maintain suitable conditions inside the green house. Some of the actuators that are used in this project are:

- Fan: It helps to keep cool. When it is too hot inside the greenhouse.
- Water pump: It helps to provide water to the plants .when the soil becomes dry, based on taking reading from the soil moisture sensor.
- grow light: it provides artificial light to the plants when the sunlight is not sufficient ,such as during cloudy days or night.
- Relay unit: It is use to connect high-power devices like fan, pump and lights with the microcontroller and it control all the component without damaging the circuit.

I. Connectivity And Cloud Integration:

In this project we used NodeMCU which is main micro controller. It has built-in-Wi-Fi ,and it helps to sending data to the cloud. It collects data from the all sensors and actuators and uploads it to the Firebase cloud. And it can be only viewed by the Blynk IoT app using phone or computer and the user can control the device remotely. This setup makes a system to work smart, automatic and easy to monitor from anywhere.

IV. System Operation

Greenhouse monitoring System has three stages:

A. Data Acquisition

in the first phase, sensors continuously measures the environmental variables. These sensors collects the real time data on temperature, humidity, soil , moisture
light intensity which are essential for effective greenhouse management.

B. Decision making

The microcontroller unit processes the collected data. It compares each parameter against set threshold values to find any deviations. Based on this review, the MCU determines the necessary actions to maintain an optimal environment.

C. Control and feedback

Automatically triggers the actuators for light. ventilation, irrigation. The environmental data actuators status sent to cloud platform so users can monitor remotely in a real time. The system is scalable and flexible so sensors can added easily Modular system design gives scalability and flexibility. it allows for the addition of more sensors, analytical modules without changes

D. Results and Discussion

After successful calibration and testing the greenhouse management system began operation under controlled environmental conditions. Here all the sensors , actuators are fixed at a position to get accurate data. Real time data is added to cloud via firebase on Blynk dashboard.

The automated setup allows users to monitor , control the greenhouse operations from the distance. This improved decision-making and reduces the need for manual intervention. Automatic management of irrigation, lighting, and ventilation created stable growing conditions that supports consistent plant growth. The performance of the system remains steady over multiple test cycles, and confirming its reliability and effectiveness. For better control of the systems and resource usage the modular architecture uses upgrades to system like machine learning models and analytics. Scalability is made possible because the system is modular, so adding more sensors or changing the irrigation schedule doesn't require a lot of work. The results show that the system can save resources, boost productivity, and use less energy and water, making it a good choice for small and medium-sized farms.

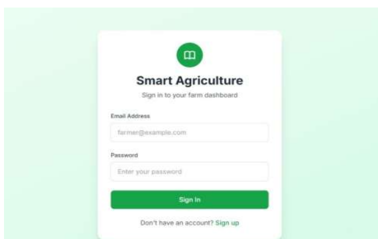

Fig.2 Login

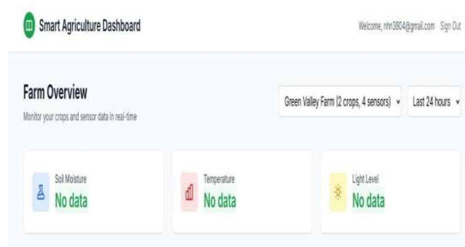

Fig.3 Dashboard Diagram

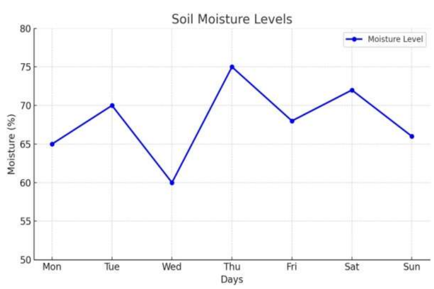

Fig.4 Soil Moisture Diagram

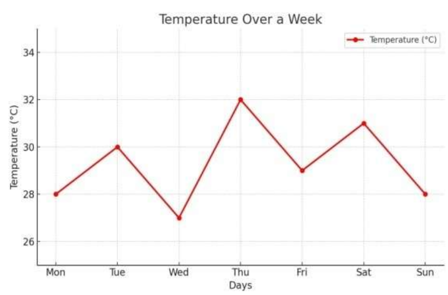

Fig.5 Temperature Diagram

The above fig 4 graph were it shows they amount of moisture in they soil were it changes from day to day.
The above fig 5 graph temperature week by showing how it changes each day.

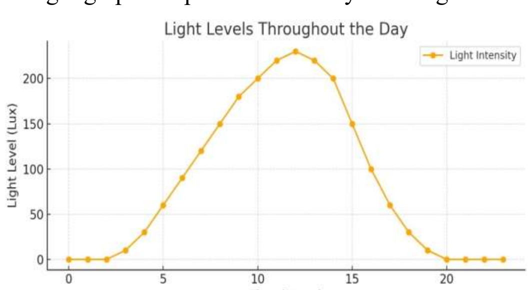

Fig.6 Light Sensor Diagram

Fig.7 Real Time Sensor Status

The above graphs were it shows they amount of light rises at day At daybreak and reaches highest point in the middle of the day and then falls down at evening.

V. Conclusion

The water and electricity and also automates green house tasks in way that helps to keeps quality of they crop in same. the system architecture is measurable to small to medium were they can use it. they can also add more sensors and make it work better. for sum possible areas in future development were using AI to plan irrigation. It sends a alert notification to farmers and also making it work in efficient way in a places without power.

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