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IoT Based Smart Green House System

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Abstract: *The growing need for sustainable farming practices and optimized resource management has led to the adoption of the Internet of Things(IoT) technologies in greenhouse farming. An Internet of Things-based smart greenhouse system is presented in this research.*
designed to monitor, analyze, and regulate key environmental parametersvital for plant growth, such as light intensity, soil moisture, temperature, and humidity. By integrating multiple sensors and actuators, the system ensures ideal conditions for growth while minimizing resource wastage.
The setup ispowered by an ESP32 microcontroller, which collects real-time sensor information andtransmits it to a cloud-based platform for remote access. Users can monitor greenhouse conditions and actuators for control such as exhaust fans, ventilation systems, water pumps, as well asfogging mechanisms via a mobile or web application using the Blynk IoT platform. The system operates in both automatic and manual modes, allowing seamless control even when WiFi connectivity is unavailable. Additionally, an LCD display provides real-time updates on system status, including control mode and WiFi connection.
By implementing automated decision-making algorithms, the system enhances resource efficiency by reducing water consumption, optimizing energy use, and minimizing manual labor. A prototype implementation demonstrates significant improvements in crop yield and quality, validatingTheefficiency of the suggested approach. The study emphasizes the possibilities ofIoT-based smart greenhouses in addressing challenges such as climate variability, labor shortages, and sustainable food production, making it a promising solution for modern precision agriculture

Keywords: sustainable farming

I. INTRODUCTION

The global population growth and the subsequent demand for food have intensified the need for efficient and sustainable agricultural practices. Greenhouses, as controlled environments,offerAn encouraging approach to improving cropproductivity and quality by offering ideal conditions for growth independent of external weather fluctuations. However, traditional greenhouse management methods often rely on manual intervention, which is time-consuming, labor-intensive, and likely to inefficiencies.

The introduction of the Internet of Things (IoT) has transformed a number of sectors, including agriculture.IoT enables the interconnection of devices, sensors, and actuators through the internet, allowing for real-time monitoring, data analysis, and automated decision-making. Integrating IoT technologies into greenhouse systems presents a transformative opportunity to overcomeThe drawbacks of traditional approachesby automating the keeping an eye on and managing important environmental factors like light intensity, temperature, humidity, and soil moisture.

This paper introduces an IoT-driven intelligent greenhouse system that leverages advanced sensors, microcontrollers, and cloud platforms to optimize crop growth conditions. The system monitors environmental parameters, sends real-time data to a cloud server, and employs actuators to adjust conditions based on predefined thresholds or user inputs. A mobile or web-based interface provides remote IoT-driven intelligent greenhouse system options, enabling users to manage their greenhouses efficiently from anywhere.

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The primary goals of this research are:

- **To create alow-cost, scalable Internet of Things-**based greenhouse monitoring and control system
- **To enhance resource efficiency**, such as reducing water and energy usage, through precise control mechanisms.
- **To increase crop yield and quality** by maintaining optimal growing conditions.

The paper explores the architecture, implementation, and testing of the proposed system. The results demonstrate its potential to significantly improve greenhouse farming practices by addressing challenges like climate variability, labor shortages, and resource management.

Agriculture is essential to ensuring global food security, yet it faces significant challenges such as climate variability, inefficient resource utilization, and increasing labor costs. Traditional greenhouse farming requires continuous monitoring and manual intervention to maintain optimal environmental conditions, making it labor-intensive and prone to human error. The integration of the IoT (Internet of Things) technology offers a transformative solution by enabling monitoring in real time and automation of greenhouse operations. IoT-based smart greenhouses utilize sensor networks, cloud computing, and wireless communication to regulate critical variables include light intensity, soil moisture, temperature, and humidity.

This essay provides an IoT-enabled intelligent greenhouse system designed for automated environmental control and remote monitoring. The setup is centered around an ESP32 microcontroller, which collects real-time data from sensors, including DHT22 and DHT11 for temperature and soil moisture and humidity sensors, and an LDR forbrightness of the light. The. The collected data is processed and displayed on an LCD screen while being transmitted to a cloud-based platform via the Blynk application for remote access. The system operates in two modes: automatic and manual. In automatic mode, the microcontroller controls actuators such as exhaust fans, ventilation systems, water pumps, foggers, and lighting based on predefined threshold values. In manual mode, users can override automation and control the actuators remotely through the Blynk mobile or web application. Additionally, if the system loses WiFi connectivity, it seamlessly switches to automatic mode to ensure uninterrupted operation.

The primary objective of this research is to develop a cost-effective, scalable, and energy-efficient greenhouse automation system that optimizes water and energy usage while enhancing crop yield and quality. By automating climate control, the system reduces manual intervention, minimizes water wastage, and ensures stable growing conditions. The expected outcomes include improved energy efficiency, reduced dependency on human labor, increased productivity, and sustainability in greenhouse farming. The successful implementation of this system demonstrates IoT's potential in revolutionizing agriculture by providing smart, data-driven solutions to existing challenges.

II. LITERATURE SURVEY

[1]. In Review of IoT Applications in Smart Agriculture and Greenhouse Management, Ali, Raza, and Hussain (2023) analyze how IoT technology enhances greenhouse agriculture by enabling Automatic oversight and management of key environmental factors, like humidity, temperature, and light. Their review highlights that IoT devices enable remote management, improving crop productivity while reducing manual labor. Integrating solar power with IoT devices also promotes sustainability and lowers costs. They imply that upcoming advancements focus on enhancing network reliability, data security, and accessibility for small-scale farmers, along with expanding AI-driven predictive capabilities to optimize greenhouse operations further. [2]. The document by Bharati et al. (2023) explores the use of IoT technologies in smart greenhouses to improve the cropyields. It highlights the role of sensors in monitoring environmental factors like soil moisture, temperature, and humidity, and lightsupplying info in real time for optimal crop growth. IoT-based automation systems regulate these factors by controlling irrigation, ventilation, and lighting, thus improving resource efficiency. Data analytics, including machine learning, are used to predict crop health and optimize conditions for better yields. The benefits include increased yield, cost reduction, and sustainable farming practices, though challenges such as high implementation costs, data security, and scalability remain. Future research aims to improve sensor accuracy, AI integration, and predictive farming methods. [3]. The paper by Sharma and Singh (2022) reviews the use of IoT in automating greenhouse systems. It discusses the incorporation of sensors and actuators

to monitor and control environmental elements for ideal plant growth, such as soil moisture, humidity, and temperature. The review discusses Cloud computing's function in data storage and remote control, highlighting the benefits of energy efficiency and sustainability. It also addresses challenges like connectivity and cost, while outlining potential future directions research to enhance the effectiveness of smart greenhouse technologies. [4]. The paper by Parra et al. (2021) explores the application of IoT for greenhouse environment monitoring and control with an emphasis on improving agricultural productivity and sustainability. It reviews various existing systems that integrate sensors (such as soil moisture, temperature, and humidity) for gathering data in real time and employ control mechanisms for tasks like irrigation, ventilation, and lighting. Cloud and edge computing are discussed for storing data and real time decision-making, while AI and data analytics are employed for improving resource 9 PREC, Department of Electronics and Telecommunication Engineering, Loni management and predicting optimal growing conditions. The paper identifies challenges such as high sensor costs, energy consumption, and connectivity issues but proposes A scalable, modular system that incorporates IoT with automation to maximize greenhouseconditions, reduce resource waste, and improve crop yields.

III. PROPOSED METHOD

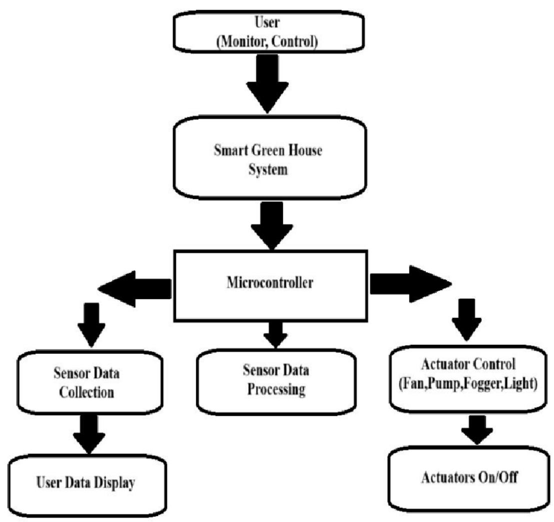

Fig.1. Flow Chart

This Data Flow Diagram (DFD) represents your IoT-based Smart Greenhouse System:

Explanation of Components and Flow:

1. User (Monitor, Control)

The user can monitorsensor information and actuators for control (fans, pumps, fogger, lights) via the Blynk App.

2. Smart Greenhouse System

Represents the entire system, including sensors, actuators, microcontroller,and correspondence with the user.

3. Microcontroller (ESP32)

The core processing unit of the system.

It collects data from sensors and decides whether to automate actions or wait for user input (manual mode).

If WiFi is disconnected, it automatically switches to Auto Mode.

4. Sensor Data Collection

Collects data from:

Temperature & Humidity Sensors (DHT22 & DHT11)

Soil Moisture Sensors

LDR (Light Sensor)

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This data is sent to the microcontroller.

5. Sensor Data Processing

The microcontroller analyzes the collected data.
It checks whether environmental conditions require actuator activation.
If in Manual Mode, it waits for user input from the Blynk app.

6. Actuator Control (Fan, Pump, Fogger, Light)

Based on the processed data, the microcontroller activates or deactivates the actuators.
If temperature is too high, the fan turns ON.
The water psump activates if the soil moisture content is low.
If humidity is low, the fogger turns ON.
If light levels are low, the LEDs turn ON.

7. Actuators On/Off

The system sends signals to the actuators to turn ON/OFF as required.
Ensures the greenhouse maintains optimal conditions.

8. User Data Display

Sensor readings are sent to the user via Blynk (if WiFi is connected).
The LCD screen on the ESP32 also shows system status.

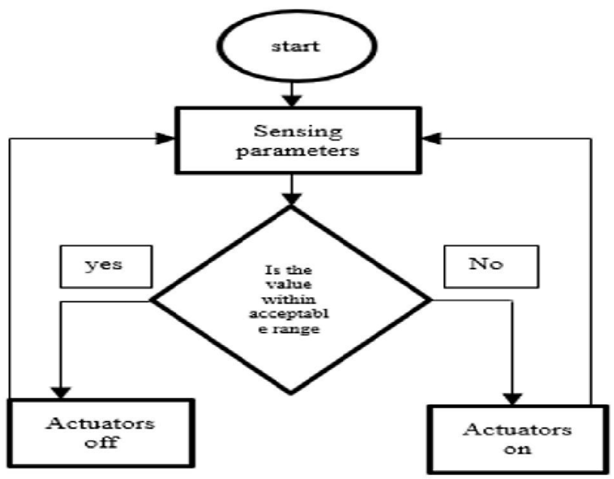

Fig.2. Algorithm Flow

1. **Start:** The system begins operation.
2. **Sensing Parameters:**Temperature, humidity, and soil moisture sensors provide data to the microcontroller, light, etc.).
3.**Decision Point:** It checks whether the measured values are **within the acceptable range** for optimal plant growth.

Yes: If values are within range, the actuators (fan, pump, fogger, lights) are **turned off** to save energy.
No: If values exceed or fall below the set thresholds, the actuators are **turned on** to maintain proper greenhouse conditions.
The process **loops continuously**, ensuring real-time monitoring and control.
Key Purpose: This flowchart represents the system's **automatic mode**, where actuators operate based on sensor values without manual intervention.

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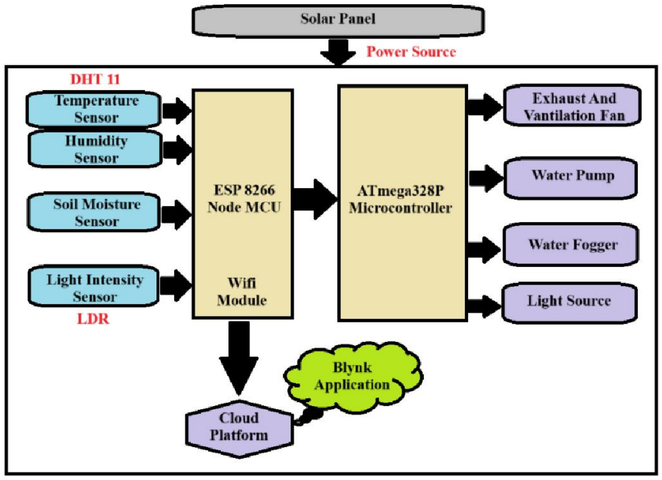

Fig.Block Diagram

IV. WORKING

In order to maintain ideal growing conditions, the Smart Greenhouse System continuously monitors environmental data and regulates actuators. The ESP32 microcontroller initializes and makes an effort to establish a WiFi connection at starting.If the connection fails, the system automatically switches to**Auto Mode**. In this mode, sensors such as **DHT22 & DHT11 (temperature and humidity), soil moisture sensors, and an LDR (light sensor)** collect real-time data. The microcontroller then determines if these values fall within reasonable bounds.If the temperature exceeds **30°C,** the**exhaust and ventilation fans** are activated. If humidity drops below **50%**, the **fogger motor** turns on, and if soil moisture falls below **1000**, the **water pump** is triggered. Similarly, in low light conditions, the **lights** are turned on. If all parameters are within the set range, actuators remain off to conserve energy.

When WiFi is available, users can enable **Manual Mode** via the **Blynk app**, allowing them to directly control the **fans, fogger, water pump, and lights** as needed. An **LCD display** shows the current **mode (Auto/Manual) and WiFi status**, ensuring real-time system awareness. The process continuously loops, adjusting actuator states based on changing environmental conditions. This system ensures efficient, automated greenhouse management while providing flexibility for manual intervention when needed.

V. CONCLUSION

Modern agriculture has advanced significantly with the deployment of an IoT-based smart greenhouse system, which allows automated

environmental control and real-time monitoring. By integrating sensors for light intensity, soil moisture, temperature, and humidity

with actuatorslike fans, pumps, foggers, and lighting systems, With little physical labor, the suggested technique guarantees ideal growing conditions.The ability to operate in both automatic and manual modes, along with seamless switching to automatic mode in case of WiFi disconnection, enhances the system's reliability and efficiency.

This smart greenhouse solution not only improves resource management by reducing water and energy wastage but also increases productivity and crop quality. The real-time data transmission and remote control capabilities provided by the Blynk platform offer convenience and accessibility to farmers, enabling timely interventions and precise adjustments. Furthermore, the cost-effectiveness and scalability of the system make it suitable for both small-scale and large-scale agricultural applications.

Overall, the research highlights the transformative potential of IoT in agriculture, addressing challenges such as climate variability, labor shortages, and sustainable food production. By leveraging automation and data-driven decision-making, the smart greenhouse system contributes to efficient and environmentally friendly farming practices, paving the way for a more sustainable and technologically advanced future in agriculture.

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