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Polyhouse Nurturing And Monitoring For Effective Farming

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Abstract: An innovative solution for modern agriculture, this project presents a comprehensive IoT-based smart polyhouse system for nurturing and monitoring crops. It addresses the challenges of traditional farming, such as manual monitoring, resource wastage, and vulnerability to climate change, by providing an automated and controlled environment for plant growth. The system uses various sensors to collect real-time data on critical parameters like soil moisture, temperature, and humidity. This information is processed by a central microcontroller and transmitted to a cloud platform, enabling farmers to monitor and control the polyhouse remotely via a user-friendly dashboard. By automating functions like irrigation, ventilation, and lighting based on predefined thresholds, the system ensures optimal growing conditions, leading to improved crop yield, resource conservation, and reduced labor. The design is a cost-effective, scalable, and sustainable approach to farming, promoting greater efficiency and resilience in food production.

Index Terms **-** Greenhouse, Polyhouse, Internet of Things (IoT), Automation, Remote Monitoring, Sensors, Microcontroller, Sustainable Agriculture, Smart Farming.

I. INTRODUCTION

Traditional farming methods often suffer from inconsistencies due to manual supervision and are vulnerable to external climate conditions, leading to resource waste and lower yields. This research introduces an Internet of Things (IoT)-based polyhouse system designed to automate the nurturing and monitoring of crops for enhanced agricultural efficiency. Our system addresses these challenges by creating a controlled environment where key parameters crucial for plant growth are automatically regulated. The proposed solution integrates various sensors to collect real-time data on environmental factors such as soil moisture, temperature, and humidity, which are then processed by a microcontroller and transmitted to a user-friendly dashboard. This approach minimizes the need for continuous human intervention, allowing farmers to oversee their crops remotely and respond to critical changes in a timely manner.

The system's core functionality is based on a seamless blend of hardware and software components. It utilizes cost-effective microcontrollers like Node MCU or ESP-32 for data processing and wireless communication. Sensors like the DHT11/DHT22 and soil moisture are employed to ensure accurate data acquisition, while actuators such as water pumps, fans, and exhaust systems are activated based on predetermined thresholds to maintain optimal growing conditions. The collected data is visualized on a remote monitoring dashboard, which provides farmers with real-time insights into their polyhouse environment. This design promotes a scalable and sustainable approach to farming, offering a significant step toward modernizing agricultural practices and ensuring crop security. The system's ability to optimize resource usage and improve crop quality is a major advantage over conventional methods, making it a viable solution for both small-scale and large-scale farming operations.

II. LITERATURE SURVEY

IoT-based greenhouse management systems help overcome the limitations of traditional farming. These systems use wireless sensor networks, data analytics, and automation to create a controlled environment.

Fares M. A. Taha et al. designed a remote greenhouse system using a Raspberry Pi and ESP8266 Wi-Fi module for real-time data transmission [1]. Mustafa Alper Akkaş et al. created a wireless sensor network with MicaZ motes to measure greenhouse parameters, providing a flexible and cost-effective solution [4]. Tung Cao Pham et al. proposed a low-cost mesh Wi-Fi network that sends sensor data to a cloud for a web-based dashboard [2].

M. Danita et al. developed an automated system with a Raspberry Pi 3 and ThingSpeak cloud to control environmental factors like moisture and temperature for maximum yield [10]. Deivaprasath A. et al. used an ESP-WROOM 32 with a PIR sensor and MQ gas sensor to provide safety alerts for rodents and air quality [7]. Aditya Vishwakarma et al. designed a low-cost system with Node MCU to monitor parameters and send data to a smartphone via a Telegram bot [8].

K. Sundaramoorthy et al. presented an automated system using Arduino and Raspberry Pi to monitor and control moisture and temperature via a webpage [11]. Rupali Satpute et al. also proposed a system with Arduino Uno and an ESP8266 to display real-time graphs on a custom webpage [14]. Badipati Chinna Babu et al. developed an IoT-based system for remote monitoring and control, leading to increased productivity and reduced costs [6].

Piyush Olambe et al. proposed a fully automated system with NodeMCU and the Blynk platform for remote monitoring and control [18]. Prof. Shital Raut et al. designed an Arduino-based system to monitor temperature and soil moisture, including a photoionization sensor for detecting harmful gases [5]. Pankaj Kale et al. highlighted that a polyhouse automation system with proper control of parameters can result in much higher yields [12].

Pradnya K. Patil et al. emphasized that an IoT-based polyhouse system can increase production and reduce labor costs [13]. Carlos González-Amarillo et al. designed a traceability system using Raspberry Pi and PID controllers to guarantee product quality from seedling to harvest [3]. Tinu Anand Singh et al. utilized the lightweight MQTT protocol on a Raspberry Pi for real-time alerts on gas leaks and environmental changes [9].

J. Seetaram et al. presented a system with an ESP-32 microcontroller and the Blynk app for remote and autonomous control of actuators [2]. V. Mamatha and J. C. Kavitha explored machine learning for hydroponics, using a KNN algorithm to predict crop growth with high accuracy [17]. A. Simo et al. developed a low-cost IoT device for small farmers to monitor environmental and electrical energy consumption [19].

Saumya Singh and Charen Vishwa created a model using machine learning algorithms like Linear Regression and Random Forest to predict environmental parameters with high accuracy [21]. Hiep Xuan Huynh et al. built a system for Brassica Juncea cultivation, with a web interface and mobile app for remote management [20]. Zaidon Faisal Shenan et al. proposed a system using fuzzy controllers to stabilize temperature and soil moisture within a single microcontroller [15].

Kunwar Akhand Pratap Singh et al. provide a comprehensive overview of greenhouse technology, emphasizing its role in year-round production and resource optimization [23]. Another paper by Mr. SM Shirsath et al. describes a similar system using an ESP8266 with various sensors for remote monitoring via a mobile app [22].

These studies collectively highlight the significant advancements in smart agriculture, with a shift from manual, labor-intensive practices to automated, sensor-based systems. Our proposed project idea builds upon this research by integrating various sensors and a microcontroller to create a real-time, user-friendly monitoring and control system, offering a scalable and sustainable solution for modern farming.

III. METHODOLOGY

The methodology focuses on designing an automated smart polyhouse system by identifying essential sensing needs, selecting suitable hardware, and defining the data flow between components. It outlines how environmental parameters are captured, processed, and used to trigger automated responses, while also enabling remote monitoring through cloud integration.

3.1 System Design

The methodology begins with designing the overall architecture of the smart polyhouse system. This involves integrating key components: a sensor system for input capture, a microcontroller for processing and automation, and a communication module for transmitting data wirelessly to a cloud platform. The system also incorporates actuators for automated responses, along with control switches for manual operation. The part of the design includes a display and a remote monitoring dashboard for the farmer to view real-time parameters and manage the system.

3.2 System Diagram Overview

The monitoring section focuses on data acquisition from the physical environment of the polyhouse. A comprehensive sensor system is strategically placed within the greenhouse to capture critical environmental data. This includes sensors for measuring moisture, pH, temperature, humidity, and water level. The collected data is then fed into a central microcontroller, which serves as the brain of the system, processing the inputs to determine the current conditions inside the polyhouse.

Once the microcontroller processes the sensor data, it initiates an automatic response to maintain optimal conditions. This involves a feedback loop where the microcontroller controls various actuators based on predefined rules or thresholds. For example, it can activate fans for ventilation, turn on water pumps for irrigation, or control lights to adjust for sunlight exposure. These actions are managed by control switches, ensuring the system can maintain a stable environment for the crops without continuous human intervention.

The system's data is transmitted wirelessly from the microcontroller to a cloud platform, which acts as the central hub for all information. From there, a remote monitoring dashboard is created for the farmer. This dashboard allows the farmer to view real-time parameters of the polyhouse from anywhere using a smartphone, laptop, or other internet-enabled device. This enables the farmer to monitor the system's status, check sensor readings, and even manually control certain aspects of the system remotely.

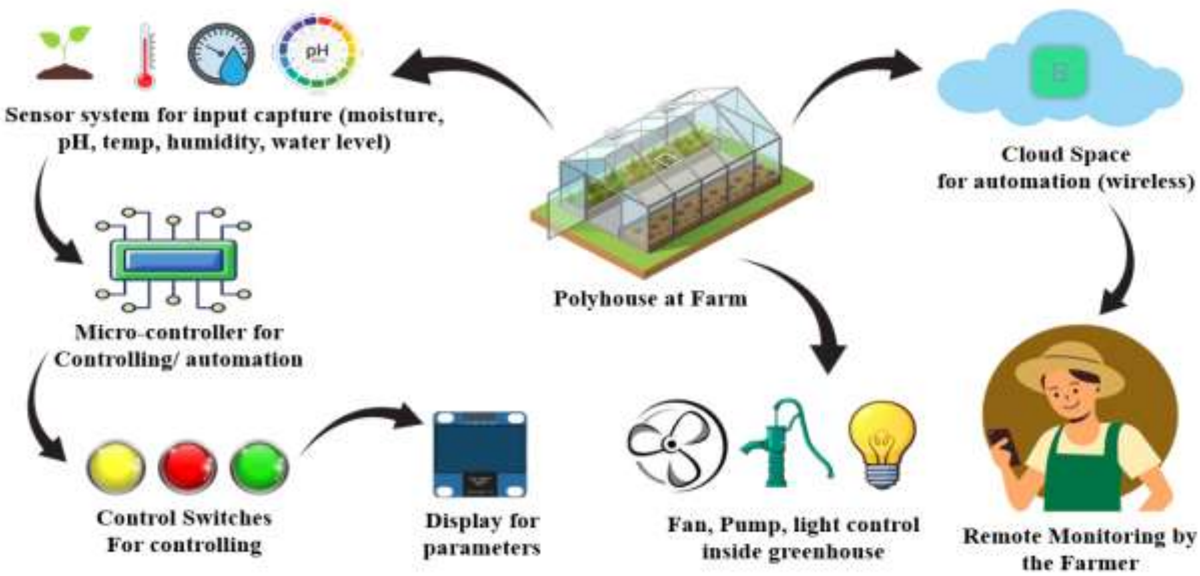

Fig.1 System Diagrams

IV. KEY FINDINGS

Lack of Real-time Monitoring and Automated Response: Many traditional greenhouse systems lack the ability for real-time monitoring of environmental conditions. This often leads to resource wastage due to manual supervision and no automated response to rapid climate changes inside the greenhouse. As a result, farmers are unable to make timely decisions, which can negatively impact crop health and yield.

High Labor Dependency: Traditional greenhouse systems are heavily reliant on human intervention for tasks such as watering, pest control, and environmental management. This high labor dependency increases operational costs and is prone to human error, which can affect the quality and quantity of crop production.

Limited Scalability and Portability: Some systems are designed for specific applications, such as seedling traceability, and may not cover all general greenhouse management needs. Additionally, a fixed setup and reliance on a single microcontroller can limit the system's scalability for larger or more remote greenhouses.

Complexity and Cost of Implementation: Integrating advanced technologies such as Fuzzy logic controllers, multiple sensors, and web servers can lead to a complex setup and high development costs. This complexity can also be a barrier for small-scale farmers who may lack the technical knowledge to install and maintain such systems.

V. DISCUSSION

Compact, Portable and Cost effective Automated Monitoring: Literature highlights the use of small, low-cost microcontrollers such as Node MCU, ESP-32 and Arduino for greenhouse monitoring. Building on this, the proposed system introduces a portable, kit-based greenhouse with automated roof control—an uncommon but valuable feature for responding to sudden changes in temperature and humidity. By using economical components like the ESP8266 and basic sensors, the solution remains affordable for small-scale farmers while offering greater value and automation compared to traditional setups.

Remote Monitoring of the Farm: A key finding across many studies is the ability to monitor and control the greenhouse from anywhere with an internet connection. This is achieved by transmitting sensor data wirelessly to a cloud platform, where it can be accessed via a web interface or a mobile application. Our project prioritizes this feature, enabling real-time remote monitoring and response for the farmer.

Effective Resource Usage: The papers consistently report that automated polyhouse systems lead to significant improvements in resource management, particularly for water and energy. By using sensors to trigger irrigation only when necessary, and controlling lighting and ventilation, these systems minimize waste. Our project is designed to facilitate this effective resource usage through protective farming practices.

Reduced Human Intervention: A core benefit of these systems is the reduction of human effort and labor dependency. Automated responses to environmental changes mean farmers do not need to be physically present at the farm to ensure optimal conditions. Our project's objective is to reduce human intervention and the effort required for regular supervision, allowing for automated and continuous operation.

VI. CONCLUSION

In conclusion, the reviewed literature highlights notable advancements in smart polyhouse monitoring systems, showcasing a shift from manual farming to automated, technology-driven solutions that improve efficiency, resource utilisation, and crop yield. By integrating sensors, microcontrollers, and wireless communication, existing systems address traditional challenges such as labour dependence, environmental variability, and resource wastage. However, the review also reveals constraints including technical complexity, high setup costs, and reliance on stable internet connectivity, limiting adoption by small-scale farmers. Building on these findings, our proposed system aims to offer a compact, portable, and cost-effective solution with an intuitive dashboard for remote monitoring and control, thereby reducing human intervention and enabling sustainable, accessible smart farming.

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