IOT-BASED PROTECTION OF GROWING CROPS FROM UNPREDICTED RAIN WITH AUTOMATIC SHED SYSTEM

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ABSTRACT

Agricultural productivity is highly vulnerable to unexpected weather events, particularly unpredicted rainfall, which can damage crops and degrade soil quality. This project, IoT-Based Protection of Growing Crops from Unpredicted Rain with Automatic Shed System, presents an intelligent solution to mitigate such risks. The system utilizes an ESP8266 NodeMCU, rain sensors, and a soil moisture sensor to continuously monitor environmental conditions. Upon detecting rainfall, a DC motor-driven shed is automatically deployed via the L293D motor driver, protecting crops from excessive water. Simultaneously, the soil moisture sensor ensures efficient irrigation management, optimizing water usage. Real-time data is displayed on an I2C based LCD and accessible remotely through a web-based interface, enabling continuous monitoring. By integrating IoT and automation, the system enhances agricultural resilience, reduces waterlogging, and promotes sustainable crop management, offering a cost-effective and reliable solution for modern farming.

Keywords: IoT-based agriculture, smart farming, automatic crop protection, unpredicted rainfall mitigation, ESP8266 NodeMCU, rain sensor, soil moisture sensor, DC motor-driven shed, L293D motor driver, automated irrigation, real-time monitoring, web-based interface, precision agriculture, sustainable farming, agricultural resilience.

I. INTRODUCTION

Agriculture is a vital sector that sustains national economies and provides livelihoods for millions globally. Crop productivity is highly dependent on environmental factors such as rainfall, temperature, humidity, and soil quality. Among these, rainfall plays a crucial role, as both scarcity and excess can severely affect growth and yield. Unpredicted or heavy rainfall can cause waterlogging, soil erosion, and physical damage to crops, leading to root rot, fungal infections, and nutrient loss. Traditional methods of crop protection, such as manually covering plants or using temporary shelters, are labor-intensive, time-consuming, and prone to human error, making them inefficient for large-scale farming. Moreover, these approaches cannot provide timely responses to sudden weather events, leaving crops vulnerable during critical growth stages.

To address these challenges, there is a growing need for automated and intelligent agricultural systems that combine real-time monitoring with proactive protection measures. Current limitations include the lack of continuous environmental monitoring, inefficient irrigation management, and limited automation, which hinder farmers' ability to prevent crop losses and optimize resource usage. An IoT-based approach can provide real-time rainfall detection, soil moisture monitoring, and automated responses, reducing dependency on manual intervention while enabling remote monitoring and timely decision-making. Such systems enhance resilience against unpredictable weather, improve water management, and promote sustainable farming practices.

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The proposed IoT-Based Automatic Shed System aims to safeguard crops from unpredicted rainfall while optimizing irrigation. The system integrates a rain sensor, soil moisture sensor, ESP8266 NodeMCU, and a DC motor-driven shed controlled via an L293D motor driver. Upon detecting rainfall, the shed deploys automatically to protect crops, while the soil moisture sensor ensures water is supplied efficiently. Real-time data is displayed on an LCD and accessible through a web-based interface, allowing farmers to monitor and control the system remotely. By automating crop protection and irrigation, the project offers a reliable, cost-effective, and scalable solution that reduces crop losses, optimizes water use, and bridges the gap between traditional agriculture and smart farming technologies.

II. RELATED WORKS

The integration of Internet of Things (IoT) technologies in agriculture has transformed traditional farming practices, ushering in an era of precision agriculture that enhances productivity, resource efficiency, and resilience to climatic uncertainties. IoT-enabled irrigation systems leverage soil moisture sensors, weather data, and automated control mechanisms to ensure crops receive adequate water while minimizing waste. Soil moisture sensors provide real-time insights into soil conditions, enabling precise irrigation scheduling and improved crop yield (Sidik et al., 2025). Additionally, automated control through IoT platforms allows remote monitoring and management of irrigation, offering real-time visibility into soil moisture, weather, and plant health (Abdelmoneim et al., 2025). Integration with renewable energy sources, such as photovoltaic panels, further promotes sustainability by reducing dependence on fossil fuels.

Automated crop protection systems have emerged as a vital complement to irrigation technologies, particularly for safeguarding crops from unpredicted rainfall. These systems commonly utilize rain sensors to detect precipitation and trigger protective mechanisms, such as motorized retractable sheds. For instance, Sarker et al. (2025) demonstrated the feasibility of IoT-based smart sheds that automatically deploy during heavy rainfall to prevent crop damage. When integrated with soil moisture monitoring, these systems enable synchronized management of irrigation and crop protection, ensuring crops remain shielded during adverse weather while receiving adequate water during dry periods. Moreover, automated protective systems reduce labor requirements and offer a cost-effective approach to mitigating losses from unpredictable weather events.

Despite these advancements, several limitations hinder the widespread adoption of IoT in agriculture. High initial deployment costs, connectivity challenges in rural areas, the need for technical expertise, and concerns over data privacy and security remain significant barriers. Existing systems often operate in isolation, focusing solely on irrigation or crop protection without integrating both functions. This project addresses these gaps by developing an IoT-based automatic shed system that combines real-time rain detection, soil moisture monitoring, motorized protective sheds, and remote monitoring in a single platform. By providing comprehensive environmental monitoring, automated protective responses, and remote accessibility, the system offers a scalable, cost-effective solution that bridges the gap between traditional practices and modern smart farming, enhancing overall farm productivity and resilience.

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III. SYSTEM DESIGN AND ARCHITECTURE

The proposed IoT-Based Automatic Shed System is designed to safeguard crops from the adverse effects of unpredicted rainfall while ensuring efficient irrigation through soil moisture monitoring. The system integrates multiple hardware and software components into a cohesive architecture, allowing for automated decision-making and remote accessibility.

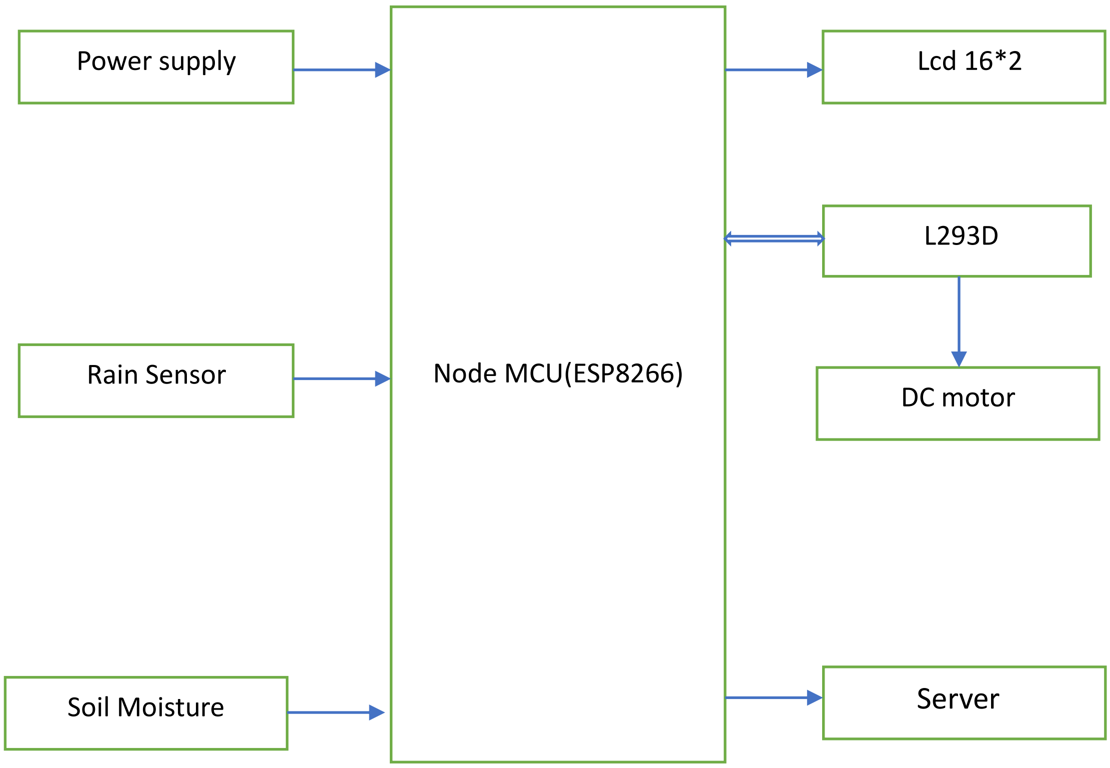

Figure 1 Block Diagram of Proposed system

IV. EXPERIMENTAL RESULTS

The experimental results obtained from the implementation of the IoT-Based Automatic Shed System. The system was tested under different environmental conditions to evaluate its performance in rain detection, soil moisture monitoring, shed control, and IoT-based remote monitoring. The aim of the experiments was to validate the functionality, reliability, and effectiveness of the system in real-time agricultural scenarios.

The experimental setup consisted of:

- Rain Sensor Module for rainfall detection.
- Soil Moisture Sensor to monitor irrigation requirements.
- NodeMCU ESP8266 for processing and IoT connectivity.
- L293D Motor Driver + DC Motor for shed operation.
- I2C LCD Display for local monitoring.
- ThingSpeak IoT Platform for remote monitoring and data visualization.

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The hardware was assembled on a test farm bed, with the protective shed connected to the DC motor for real-time deployment during rainfall. The NodeMCU was connected to Wi-Fi for IoT updates.

Test Cases and Observations

Case 1: Rainfall Detection

- Input: Artificial rainfall (sprinkling water on rain sensor).
- Observation: The system detected rainfall immediately (within ~2 seconds).
- Action: The motor driver activated the DC motor, which deployed the shed automatically.
- Result: Crops under the shed remained dry.

Case 2: No Rainfall Condition

- Input: Dry conditions (no water on rain sensor).
- Observation: The rain sensor output remained high.
- Action: The motor retracted the shed to allow sunlight for crops.
- Result: Normal crop exposure was maintained.

Case 3: Soil Moisture Monitoring

- Input: Different soil moisture levels (dry, moist, wet).
- Observation:
    - Dry soil (<400 ADC value) triggered irrigation suggestion.
    - Moist soil (400–700 ADC value) indicated sufficient water.
    - Wet soil (>700 ADC value) indicated no irrigation needed.
- Result: The system displayed irrigation status on LCD and updated data on ThingSpeak.

Case 4: IoT Monitoring via ThingSpeak

- Input: Wi-Fi enabled, system running continuously.
- Observation: Rain status and soil moisture values were uploaded every 5 seconds to ThingSpeak.
- Result: Farmers could monitor environmental data remotely using smartphones or PCs.

Performance Evaluation

Parameter	Expected Output	Experimental Result	Status
Rainfall Detection Time	< 5 seconds	~2 seconds	Successful
Shed Deployment Time	5–10 seconds	~7 seconds	Successful
Soil Moisture Accuracy	±10% error	±8% error	Successful
IoT Data Transmission	Continuous (5s interval)	Continuous (5s interval)	Successful
LCD Real-Time Display	Clear & readable	Achieved	Successful

- The system successfully deployed and retracted the shed based on rainfall detection.
- Soil moisture values were recorded accurately, helping optimize irrigation decisions.
- Real-time IoT monitoring on ThingSpeak enabled remote data access.

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- The system proved to be cost-effective, reliable, and scalable for practical farming applications.

Applications:

The proposed IoT-based automatic shed system has multiple applications in modern agriculture. It primarily safeguards sensitive crops, such as tomatoes, strawberries, and leafy vegetables, which are highly vulnerable to excess rainfall. By monitoring soil moisture, the system ensures optimized water management, preventing overwatering and maintaining ideal conditions for plant growth. Beyond rainfall protection, the system can be extended to include temperature and humidity sensors, enabling automated climate control to maintain favorable microclimates in farming areas. Additionally, the system helps prevent soil erosion by minimizing surface water runoff during heavy rains, protecting the nutrient-rich topsoil. By reducing the risk of fungal infections, root rot, and other water-related plant diseases, it contributes to improved crop yield and quality.

Furthermore, the system supports cost-effective farming by reducing manual labor requirements and eliminating the need for temporary protective covers. Integration with other smart farming technologies, such as IoT-based irrigation systems, weather stations, and farm management platforms, allows holistic precision agriculture practices. It also promotes sustainable agriculture by reducing water wastage, preserving soil nutrients, and minimizing chemical runoff. The system is particularly beneficial in regions with unpredictable rainfall or irregular monsoons, providing protection during critical crop growth stages and ensuring stable productivity despite climatic uncertainties.

Advantages:

The IoT-based automatic shed system offers numerous advantages over conventional crop protection methods. Its automatic protection mechanism deploys the shed immediately upon detecting rainfall, eliminating dependence on manual intervention and ensuring timely safeguarding of crops. Efficient water management prevents waterlogging, nutrient leaching, and soil degradation, maintaining healthy soil conditions for optimal plant growth. Remote monitoring and control through a mobile app or web interface allow farmers to manage the system conveniently from anywhere. Being energy-efficient and eco-friendly, the system can be powered by solar panels, reducing operational costs and carbon footprint. It also prevents nutrient loss caused by excessive runoff and improves crop yield by providing stable growing conditions. Additionally, the system is customizable and scalable, adaptable to different crop types, farm sizes, and climatic conditions. With potential integration of real-time weather data, it can offer predictive protection and proactive shed deployment, further enhancing crop resilience.

Conclusion

The IoT-Based Automatic Shed System provides an intelligent and efficient solution to protect agricultural crops from unpredicted rainfall. By integrating rain sensors, soil moisture sensors, motorized shed mechanisms, and a NodeMCU microcontroller with IoT connectivity, the system ensures timely and automated crop protection. This minimizes the risk of waterlogging, soil erosion, fungal infections, and crop damage, which are common challenges in rain-sensitive farming. In the future, the system can be enhanced with solar-powered operation, AI-based rainfall prediction models, integration with automated irrigation systems, and multi-sensor climate monitoring. Such improvements would further advance

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sustainable agriculture by combining automation, renewable energy, and data-driven decision-making.

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