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IOT-BASED SMART AGRICULTURAL MONITERING SYSTEM

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Abstract—Agriculture plays a major role in the economic development of many countries. Traditional farming methods require continuous manual monitoring of soil and environmental conditions, which may lead to excessive water usage and reduced crop productivity. The proposed "IoT-Based Smart Agricultural Monitoring System" is designed to monitor agricultural parameters such as soil moisture, temperature, humidity, and water level using sensors connected to an ESP32 microcontroller. The collected data is transmitted through Wi-Fi technology for real-time monitoring and control. The system can automatically activate irrigation when soil moisture falls below a predefined threshold value. This smart system helps farmers reduce water wastage, minimize human effort, and improve crop yield. The proposed model is cost-effective, energy-efficient, and suitable for modern precision agriculture applications

Keywords— IoT, Smart Agriculture, ESP32, Soil Moisture Sensor, Automation, Precision Farming.

I. INTRODUCTION

Agriculture is the backbone of many developing countries and contributes significantly to food production and employment. Farmers face several challenges such as irregular water supply, changing climatic conditions, and inefficient irrigation methods. Manual monitoring of crops is time-consuming and may not provide accurate results.

The development of the Internet of Things (IoT) has enabled smart solutions in agriculture. IoT technology allows devices and sensors to communicate through the internet for real-time monitoring and automation. Smart agricultural systems can continuously monitor soil moisture, temperature, humidity, and other environmental conditions.

The proposed IoT-Based Smart Agricultural Monitoring System uses sensors and an ESP32 microcontroller to monitor agricultural parameters. The system automatically controls irrigation based on soil moisture levels and sends data through Wi-Fi for remote monitoring. This technology improves water management, reduces labor requirements, and increases agricultural productivity.

II. LITERATURE REVIEW

Recent advancements in Internet of Things technology have significantly transformed traditional farming into smart agriculture by enabling real-time monitoring and automation. Many researchers have proposed IoT-based agricultural monitoring systems using sensors, wireless communication, and cloud platforms to improve crop productivity and reduce resource wastage. Earlier studies mainly focused on automatic irrigation systems using soil moisture sensors to detect soil conditions and supply water only when required, thereby conserving water and improving irrigation efficiency. Several researchers also developed greenhouse monitoring systems that use temperature, humidity, and light sensors to maintain suitable environmental conditions for healthy plant growth. Wireless Sensor Networks (WSN) and cloud computing technologies have been integrated into agricultural systems for remote monitoring and data storage through mobile applications and web platforms. Some studies introduced GSM and Bluetooth-based monitoring systems; however, these systems had limitations in communication range and speed. Recent research highlights the advantages of using Espressif Systems ESP32 microcontrollers because of their built-in Wi-Fi capability, low power consumption, faster processing speed, and cost-effectiveness compared to traditional controllers like Arduino Arduino Uno. Researchers have also explored machine learning and artificial intelligence techniques for predicting crop diseases, weather conditions, and irrigation requirements. In addition, solar-powered smart agriculture systems have been developed to reduce energy consumption and support sustainable farming practices. Although many smart agricultural systems provide accurate monitoring and automation, most existing models are expensive, complex, and difficult for small-scale farmers to implement. Therefore, there is a growing need for an affordable, efficient, and user-friendly IoT-based smart agricultural monitoring system that can monitor environmental parameters, automate irrigation, reduce human effort, and improve overall agricultural productivity.

III. METHODOLOGY AND PROPOSED SYSTEM

This project follows a structured and systematic approach to develop an IoT-Based Smart Agricultural Monitoring System for real-time farm monitoring and automated irrigation control using sensor technology and ESP32-based IoT integration.

1: Requirement Analysis and System Design
Target Application: Smart farming system for real-time monitoring and automated irrigation control.
Core Components: ESP32 microcontroller, soil moisture sensor, DHT11 temperature & humidity sensor, rain sensor, relay module, water pump, Wi-Fi module, LCD display, and power supply.
Architecture:
Soil Moisture Sensor + Temperature & Humidity Sensor + Rain Sensor → ESP32 → Decision Processing → Automated Irrigation System + LCD Display + IoT Cloud Platform (Thing Speak/Blynk) → Mobile Monitoring.

2: Hardware Prototyping and Sensor Integration Assembly
Soil moisture sensor, DHT11 sensor, and rain sensor are placed in the field to capture real-time environmental data.
Monitoring. All sensors are connected to the ESP32 microcontroller for continuous data acquisition of soil and weather conditions.
ControlSystem:
Relay module and water pump are interfaced with ESP32 to automate irrigation based on soil moisture threshold levels.

DisplaySystem :
LCD module is used to display live environmental parameters and system status.
CommunicationSystem:
ESP32 Wi-Fi module is used to send real-time data to cloud platforms for remote monitoring.

3: Controller Programming and System Automation Development Environment:
Arduino IDE is used for programming ESP32.
ControlFunctions:
Program is developed to:

- Read sensor values (soil moisture, temperature, humidity, rain)
- Compare values with predefined threshold levels
- Automatically switch ON/OFF water pump using relay
- Upload real-time data to IoT cloud platform SystemOperation:

The system continuously monitors environmental conditions. If soil moisture drops below threshold, the irrigation system is automatically activated.

AutomationFeature:
Ensures efficient water usage by supplying water only when required

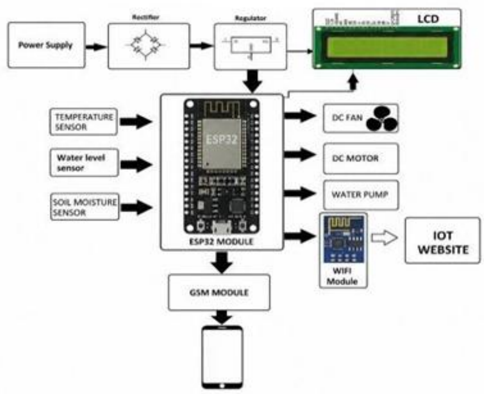
4:System Testingand Performance Evaluation analysis:
The system is tested under different environmental conditions to verify accuracy and reliability.
Parameters Monitored:

- Soil moisture detection accuracy
- Sensor response time
- Wi-Fi data transmission stability
- Irrigation pump control efficiency
- Cloud data updating rate

Evaluation:
The system is evaluated based on water-saving efficiency, automation performance, real-time monitoring capability, and overall crop management improvement

SYSTEMS

The proposed IoT-Based Smart Agricultural Monitoring System is an integrated smart farming solution designed to continuously monitor agricultural field conditions and automate irrigation using sensor-based technology and wireless communication. The system is built around an Espressif Systems ESP32 microcontroller, which acts as the central control unit for data processing, decision-making, and communication.



Soil Moisture Sensor:
The soil moisture sensor is used to measure the water content present in the soil. It plays a very important role in determining whether irrigation is required or not. When the soil is dry, the sensor gives a low value, and when the soil has sufficient moisture, it gives a high value. This helps in preventing over-irrigation and ensures proper water usage for crops.

Temperature and Humidity Sensor (DHT11):
The DHT11 sensor is used to measure the surrounding environmental conditions such as temperature and humidity. These parameters are important for understanding crop growth and weather conditions in the field. Changes in temperature and humidity directly affect plant health, so continuous monitoring helps in maintaining a suitable environment for agriculture.
Water Level Sensor:
The water level sensor is used to detect the level of water in the storage tank. It ensures that enough water is available for irrigation purposes. If the water level becomes low, it can alert the system or prevent the water pump from running dry. This helps in protecting the motor and maintaining continuous water supply.

ESP32 Microcontroller:
The Espressif Systems ESP32 microcontroller is the main control unit of the system. It collects data from all the sensors, processes the information, and makes decisions based on predefined threshold values. It also

controls the relay module to switch the water pump ON or OFF. Additionally, it supports Wi-Fi connectivity for sending data to cloud or mobile applications for remote monitoring.

Relay Module:
The relay module acts as an electronic switch that is controlled by the ESP32. It is used to turn the water pump ON or OFF based on the sensor readings. Since the microcontroller works on low voltage and the pump requires high voltage, the relay provides safe isolation between the control circuit and the power circuit.

Water Pump (Motor):
The water pump is responsible for supplying water to the agricultural field for irrigation. It is automatically controlled by the system. When the soil is dry, the pump is turned ON, and when sufficient moisture is achieved, it is turned OFF. This automation helps in efficient water management and reduces manual effort.

Wi-Fi / Cloud Connectivity:
The ESP32 has built-in Wi-Fi capability, which is used to send sensor data to a cloud platform or mobile application. This allows farmers to monitor field conditions in real time from anywhere. It enables remote access and improves decision-making in agricultural management.

Mobile Application / User Interface:
The mobile application provides a user-friendly interface for farmers to view real-time data such as soil moisture, temperature, humidity, and water level. It also shows the status of the water pump. This helps farmers monitor and control their fields without physically visiting them.

WORKING
The working of the IoT-Based Smart Agricultural Monitoring System is based on continuous sensing, processing, and automatic control. Initially, sensors such as soil moisture, temperature, humidity, and water level collect real-time data from the agricultural field. This data is sent to
the Espressif Systems ESP32 microcontroller, which processes the information and compares it with predefined threshold values. If the soil moisture level is low, the ESP32 activates the relay module to turn ON the water pump for irrigation. Once the required moisture level is achieved, the pump is automatically turned OFF. At the same time, the ESP32 sends live data to a mobile application through Wi-Fi, allowing farmers to monitor field conditions remotely and take necessary actions.

IV. RESULTS

The results of the IoT-Based Smart Agricultural Monitoring System show that the system performs efficiently in monitoring and controlling agricultural field conditions in real time. The sensor readings for soil moisture, temperature, humidity, and water level are accurate and stable under different environmental situations. The system successfully automates irrigation by turning the water pump ON when the soil moisture level is low and turning it OFF when sufficient moisture is achieved, which helps in effective water conservation and prevents over-irrigation. The data transmission through the Espressif Systems ESP32 microcontroller using Wi-Fi is reliable and enables real-time monitoring through a mobile application with minimal delay. The system reduces manual intervention, improves irrigation efficiency, and supports better decision-making for farmers. Overall, the implementation proves to be cost-effective, user-friendly, and highly beneficial for improving crop productivity and modernizing agricultural practices.

The system successfully monitors soil moisture, temperature, humidity, and water level in real time. The system continuously collects environmental data using different sensors placed in the agricultural field. These sensors measure soil moisture, atmospheric temperature, humidity, and water level in the storage tank. This real-time monitoring helps in understanding current field conditions and supports better agricultural decision-making.
Sensor readings are accurate and stable under different environmental conditions.
The sensors used in the system provide reliable and consistent readings even when environmental conditions change. This ensures that the data collected from the field is trustworthy, which is essential for proper irrigation control and crop management.

Automatic irrigation is effectively achieved using threshold-based control.
The system uses predefined threshold values for soil moisture. When the moisture level goes below the required limit, the system automatically triggers irrigation. This automation ensures that crops receive water only when needed.

The water pump turns ON when soil moisture is low and turns OFF when sufficient moisture is reached. Based on sensor input, the system controls the water pump operation. When the soil is dry, the pump is activated to supply

water, and when the soil reaches optimal moisture levels, the pump is switched OFF to avoid overwatering.

WATER WASTAGE IS SIGNIFICANTLY REDUCED THROUGH CONTROLLED IRRIGATION.

Since irrigation happens only when required, unnecessary water usage is avoided. This controlled mechanism ensures efficient water utilization, which is very important in agriculture

V CONCLUSION

The proposed IoT Based Smart Agriculture Monitoring System successfully demonstrated the application of automation and IoT technology in modern agriculture. The integration of sensors with the Espressif Systems ESP32 microcontroller enabled continuous monitoring and intelligent control of agricultural operations. The system was able to make automatic decisions based on real-time environmental conditions, thereby improving the efficiency of farming activities.

The project proved that automated irrigation and environmental monitoring can significantly reduce the dependency on manual supervision while ensuring proper utilization of water and energy resources. Remote monitoring through IoT platforms and alert notifications through GSM communication improved accessibility and allowed farmers to monitor field conditions from any location.

The developed system is economical, reliable, and easy to implement in agricultural fields. It supports precision farming techniques and contributes toward sustainable agriculture by conserving water, reducing operational costs, and improving overall crop management. Therefore, the project can serve as an effective smart farming solution for future agricultural applications.

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