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Design and Implementation of IOT Based Smart Agriculture Monitoring, Automated Irrigation and Crop Condition Assessment System

[1]Nayan Amol Jagtap, [2]Gauri Siddeshwar Devkate, [3]Sakshi Balasaheb Choudhari, [4]Vijay Somanath Mane, [5]Prof. S. R. Sayyad

[1234]Student, Dept. of Electronics and Telecommunication Engineering, MAEER's MIT College of Railway Engineering and Research, Barshi, Solapur, Maharashtra, India
[5]Professor, Dept. of Electronics and Telecommunication Engineering, MAEER's MIT College of Railway Engineering and Research, Barshi, Solapur, Maharashtra, India

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Abstract - *Agriculture is one of the most important sectors in India. Traditional farming methods require continuous human effort and proper monitoring of crops, soil moisture, temperature, and environmental conditions. To overcome these challenges, this research paper presents an 10T-based Smart Agriculture Monitoring and Automated Irrigation System with Crop Condition Assessment. The proposed system uses an ESP32 microcontroller along with sensors such as a soil moisture sensor, DHTII temperature and humidity sensor, rain sensor, and LDR sensor to monitor agricultural field conditions in real time. Based on the collected sensor data, the system automatically controls the water pump to provide the required amount of water to crops. It also includes an automatic fertilizer control mechanism, shade net operation using servo motors, ESP32-CAM based pest detection, a web-based monitoring dashboard, and a buzzer alert for low water levels.*

Key Words: IOT, Smart Agriculture, ESP32, Automated Irrigation, Soil Moisture Sensor, Crop Monitoring, Smart Farming.

1. INTRODUCTION

Agriculture plays an important role in the economic development of India. A large part of the Indian population depends on agriculture for their livelihood. However, traditional farming methods require more human effort, time, and proper management of water and other resources. Farmers often face problems due to irregular irrigation, changing weather conditions, and lack of proper crop monitoring.

With the development of Internet of Things (IOT) technology, smart agriculture has become an effective solution for improving farming practices. IOT allows different sensors and electronic devices to collect and share real-time information about agricultural field conditions. The proposed Smart Agriculture Monitoring System uses an ESP32 microcontroller to monitor soil moisture, temperature, humidity, and light intensity. Based on sensor readings, the system automatically controls irrigation and helps maintain suitable conditions for crop growth. The system also includes automatic fertilizer control, shade net operation, low-water level alerts, and a web-based monitoring dashboard to assist farmers in making better decisions.

A web-based dashboard is developed to display real-time sensor information and system status. The system also provides rule based crop condition suggestions based on environmental parameters. This helps farmers monitor field conditions and take appropriate decisions. The proposed system aims to reduce water wastage, minimize manual work, improve irrigation efficiency, and support smart and sustainable agriculture through IOT technology.

1.1 Literature Review

Several researchers have developed different techniques to improve agricultural activities using modern technologies. Traditional irrigation systems mainly depend on manual observation and fixed watering schedules. These methods may result in excessive water consumption and improper irrigation. Studies have shown that Internet of Things (IOT) technology can improve agricultural monitoring by collecting real-time data from different sensors [1], [2].

Soil moisture sensors are used to identify the water level in the soil, while temperature and humidity sensors help monitor environmental conditions Microcontrollers such as Arduino and ESP32 are widely used in smart agriculture applications because they can process sensor data and control electronic devices [3], [61. Automated irrigation systems use this information to operate water pumps according to soil moisture conditions. Some existing systems also provide mobile applications and web dashboards for remote monitoring. However, many systems focus mainly on irrigation and do not include automatic fertilizer control, shade net operation, low-water alerts, and rule-based crop condition suggestions.

2. PROPOSED SYSTEM ARCHITECTURE

The proposed system is an 10T-based smart agriculture monitoring and automated irrigation system designed to improve agricultural efficiency. It uses an ESP32 microcontroller as the main processing unit to collect data from different sensors installed in the agricultural field. The system monitors soil moisture, temperature, humidity, rain, and light intensity using suitable sensors. Based on the soil moisture level, the water pump is automatically switched ON or OFF to maintain the required soil condition. An automatic fertilizer control mechanism is also included to support agricultural operations.

Two servo motors are used to control the shade net according to environmental conditions. A buzzer provides an alert when the water level becomes low. A 16x2 12C LCD display and web-based dashboard are used to display sensor readings and system status. The system also provides rule-based crop condition suggestions using collected environmental data and ESP32-CAM based pest detection. This integrated approach helps farmers monitor agricultural conditions, reduce manual effort, save water, and improve farming management.

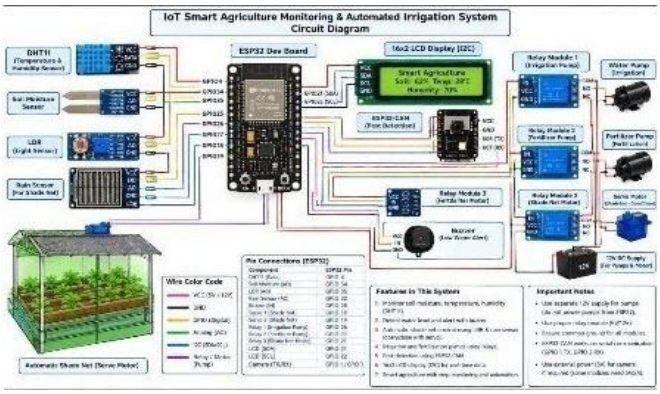

Fig -1: Block and Circuit Diagram of Proposed IOT Smart Agriculture System

Table -1: ESP32 Pin Configuration

Component	ESP32 Pin
DHTII (Data)	GPIO 4
Soil Moisture (AO)	GPIO 34
LDR (AO)	GPIO 35
Rain Sensor (AO)	GPIO 32
Buzzer (IN)	GPIO 25
Servo 1 & 2 (Shade Net)	GPIO 18, GPIO 19
Relay 1 (Irrigation Pump)	GPIO 26
Relay 2 (Fertilizer Pump)	GPIO 27
16x2 LCD (SDA / SCL)	GPIO 21 / GPIO 22
ESP32-CAM (TX / RX)	GPIO / GPIO 3

2.1 Methodology

The methodology of the proposed system involves sensing, processing, monitoring, and automatic control of agricultural parameters. The ESP32 microcontroller is used to collect data from different sensors and perform the required operations:

1) Data Collection: The soil moisture sensor measures the moisture level in the soil. The DHTII sensor measures temperature and humidity, while the LDR sensor detects light intensity and rain sensor detects rainfall.
2) Data Processing: The ESP32 processes the collected sensor readings and compares them with predefined threshold values.
3) Automated Irrigation: When soil moisture falls below 35%, the water pump is switched ON. When moisture reaches 50% or above, the pump is switched OFF.
4) Fertilizer Control: The system provides automatic fertilizer pump control based on the configured operation.
5) Shade Net Control: Servo motors operate the shade net according to the light, rain, and temperature conditions.
6) Alert System: A buzzer provides an alert when the water level becomes low.
7) Monitoring & Pest Detection: An LCD display and web dashboard show real-time sensor readings and system status. Rule-based crop suggestions are provided, and ESP32-CAM captures images of crops to identify possible pest attacks.

3. RESULTS AND DISCUSSION

The proposed loT-based smart agriculture system was tested to verify its monitoring and automation functions. The ESP32 successfully collected data from the soil moisture, temperature, humidity, and light sensors. During testing, when the soil moisture level decreased below 35%, the irrigation pump was automatically switched ON. When the soil moisture reached 50% or above, the pump was switched OFF. This operation helped maintain the required soil moisture level. The fertilizer pump control, servo motor operation, LCD display, buzzer alert, and web-based monitoring dashboard were also included in the system testing.

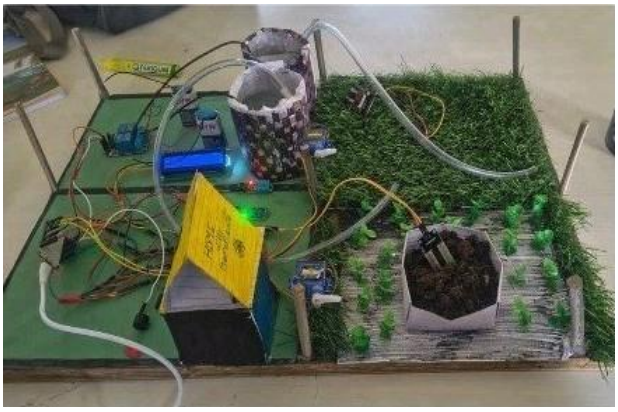

Fig -2: Hardware Setup of Proposed System

The dashboard displayed sensor readings and system status for monitoring purposes. The system demonstrated the ability to reduce manual intervention and support efficient water management. The rule-based crop condition suggestions provided basic guidance according to the monitored environmental parameters. The camera-based monitoring feature helps observe crop conditions and identify possible pest-related issues.

Fig -3: Web Dashboard Setup showing Live Readings

As shown in Fig. 3, the web-based dashboard displays real-time sensor readings (Temperature: 28.4^0 C, Humidity: 62%, Soil Moisture: 38%, Light Intensity: 720 lux) and allows users to monitor and control different operations easily. The low-water alert system provides notifications when the water level becomes insufficient. Overall, the developed system combines IOT technology, sensor monitoring, and automation to improve agricultural resource management.

4. CONCLUSIONS

The proposed loT-Based Smart Agriculture Monitoring and Automated Irrigation System provides an efficient solution for improving traditional agricultural practices through automation and real-time monitoring. The system uses ESP32, soil moisture sensor, DHTI 1 temperature and humidity sensor, and LDR sensor to monitor important environmental conditions. Based on the soil moisture level, the system automatically controls the water pump to provide sufficient water to crops and reduce unnecessary water consumption. The fertilizer pump and servo motors are also used to support automated agricultural operations. A web-based dashboard and camera-based monitoring feature allow users to monitor sensor readings, detect pests, and receive rule-based crop condition suggestions to promote sustainable agricultural practices.

5. FUTURE SCOPE

The proposed Smart Agriculture Monitoring and Automated Irrigation System can be further improved by integrating advanced technologies. Future enhancements include: (1) Integration of Machine Learning techniques for accurate crop condition and disease prediction, (2) Development of a mobile application for remote monitoring and control, (3) Cloud storage integration for maintaining historical agricultural records, (4) Advanced image processing for automated pest detection, (5) Weather forecasting data integration for proactive irrigation planning, and (6) Use of solar energy to provide an alternative off-grid power supply in agricultural fields.

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BIOGRAPHIES

Nayan Amol Jagtap, Student of Bachelor of Technology (B.Tech) in Electronics and Telecommunication Engineering at MAEER's MIT College of Railway Engineering and Research, Barshi, Solapur, Maharashtra, India.

Gauri Siddeshwar Devkate, Student of Bachelor of Technology (B. Tech) in Electronics and Telecommunication Engineering at MAEERs MIT College of Railway Engineering and Research, Barshi, Solapur, Maharashtra, India.

Sakshi Balasaheb Choudhari, Student of Bachelor of Technology (B.Tech) in Electronics and Telecommunication Engineering at MAEER's MIT College of Railway Engineering and Research, Barshi, Solapur, Maharashtra, India.

Vijay Somanath Mane, Student of Bachelor of Technology (B.Tech) in Electronics and Telecommunication Engineering at MAEER's MIT College of Railway Engineering and Research, Barshi, Solapur, Maharashtra, India.

Prof. S. R. Sayyad, Professor and Project Guide, Department of Electronics and Telecommunication Engineering at MAEERs MIT College of Railway Engineering and Research, Barshi, Solapur, Maharashtra, India.