SMART AGRICULTURE THROUGH IOT SOLUTIONS

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Abstract: The integration of Internet of Things technologies into agriculture has opened new avenues for enhancing productivity and resource efficiency. This paper presents a smart agriculture system designed for real-time environmental monitoring and automated irrigation management. The proposed system utilizes a Raspberry Pi as the central processing unit, interfaced with a DHT11 sensor to measure ambient temperature and humidity, and a soil moisture sensor connected through the MCP3208 for accurate soil moisture detection. Based on the acquired sensor data, the system implements an automated control mechanism involving two motors. The primary motor is activated when soil moisture levels fall below a predefined threshold, ensuring timely irrigation. Conversely, a secondary motor operates when moisture levels exceed the set limit, enabling effective drainage and preventing waterlogging. The collected data is transmitted to the cloud-based platform ThingSpeak, allowing farmers to remotely monitor field conditions and analyze trends in real time. The proposed solution significantly reduces manual intervention, optimizes water usage, and supports sustainable agricultural practices. Experimental results demonstrate that the system improves irrigation efficiency and crop productivity while conserving resources. This research highlights the potential of IoT-enabled smart farming systems in addressing modern agricultural challenges and promoting precision agriculture.

KEYWORDS: - RASPBERRY PI 3, SOIL MOISTURE SENSOR, DHT11 SENSOR, MINI PUMP MOTOR, L298N MOTOR DRIVER MODULE, MCP3208

I. INTRODUCTION

Agriculture plays a vital role in sustaining economies and ensuring food security worldwide. However, conventional farming practices often rely heavily on manual labor and lack precise resource management, leading to inefficiencies such as over-irrigation, water wastage, and inconsistent crop yields. With the growing global population and increasing demand for food, there is a pressing need to adopt advanced technologies that can enhance productivity while promoting sustainable resource utilization.

Recent advancements in Internet of Things have introduced innovative solutions to modernize agricultural practices. IoT enables the integration of sensors, communication technologies, and automated systems to collect and analyze real-time data from the field. This data-driven approach allows farmers to monitor environmental conditions continuously and make informed decisions, ultimately improving crop management and reducing dependency on manual intervention.

In this research, a smart agriculture system is proposed using a Raspberry Pi as the central controller. The system is equipped with a DHT11 sensor to monitor atmospheric conditions and a soil moisture sensor interfaced through the MCP3208 to measure soil moisture levels accurately. Based on these sensor readings, the system automatically controls irrigation through motorized mechanisms, ensuring optimal water usage. Additionally, real-time data is transmitted to the cloud platform ThingSpeak, enabling remote monitoring and analysis.

The primary objective of this study is to develop an efficient, cost-effective, and automated farming solution that minimizes human effort, conserves water, and enhances crop productivity. By leveraging IoT technologies, the proposed system contributes to the advancement of precision agriculture and supports sustainable farming practices in modern agricultural environments.

II. LITERATURE SURVEY

The application of Internet of Things in agriculture has enabled the development of smart farming systems that improve efficiency and productivity. Early studies focused on using sensors to monitor key parameters such as temperature, humidity, and soil moisture, allowing real-time data collection and reducing manual effort.

Recent research highlights the integration of IoT with cloud platforms and data analytics, enabling farmers to make informed decisions based on real-time insights. Automated irrigation systems have been widely studied, where water supply is controlled based on soil moisture levels, leading to efficient water management and reduced wastage.

Advanced approaches combine IoT with technologies like artificial intelligence and wireless communication systems to support predictive analysis, crop monitoring, and improved yield. However, challenges such as high implementation cost, data reliability, and limited connectivity in rural areas still affect large-scale adoption.

Overall, the literature shows that IoT-based smart agriculture systems significantly enhance resource utilization, reduce human intervention, and promote sustainable farming practices.

III. RELATED WORK

Recent developments in Internet of Things-based smart agriculture systems have focused on real-time monitoring and automated irrigation control using sensor-driven approaches. Many studies have utilized environmental sensors such as the DHT11 sensor and soil moisture sensors to continuously collect field data, enabling accurate assessment of crop conditions. These sensors are typically integrated with microcontrollers or single-board computers like the Raspberry Pi for processing and decision-making.

Several research works have implemented threshold-based irrigation systems, where water pumps are activated when soil moisture drops below a predefined level. Such systems improve water efficiency by avoiding over-irrigation. However, most existing models focus on single-pump control, limiting their ability to manage excess water conditions effectively. The use of analog-to-digital converters like the MCP3208 has also been explored to enhance the accuracy of sensor data acquisition.

Cloud-based platforms such as ThingSpeak are widely adopted in related studies for storing, visualizing, and remotely accessing agricultural data. These platforms allow farmers to monitor environmental conditions through mobile devices, improving decision-making and reducing the need for physical presence in the field. In addition, motor drivers like the L298N motor driver are commonly used to control irrigation pumps in automated systems. While prior research demonstrates the effectiveness of automated irrigation, limited work has addressed dual-pump mechanisms for both irrigation and drainage. The proposed system extends existing approaches by introducing a dual-pump control strategy based on multiple moisture thresholds, along with real-time cloud monitoring and user-friendly feedback mechanisms such as mobile visualization and voice-based updates.

Overall, the reviewed works confirm that IoT-based automation significantly enhances water management and reduces manual effort, but there remains scope for more intelligent and adaptive systems that handle both water deficiency and excess conditions efficiently.

IV. BLOCK DIAGRAM EXPLANATION

The Soil Moisture Sensor and DHT11 Sensor continuously monitor essential environmental parameters in the agricultural field, including soil moisture, temperature, and humidity. These sensors play a crucial role in providing real-time data about the condition of the soil and surrounding atmosphere. The collected analog and digital signals are transmitted to a Raspberry Pi, which acts as the central processing unit of the system. Since the Raspberry Pi cannot directly read analog signals, the MCP3208 Analog-to-Digital Converter is used to convert the soil moisture sensor output into digital data for accurate processing.

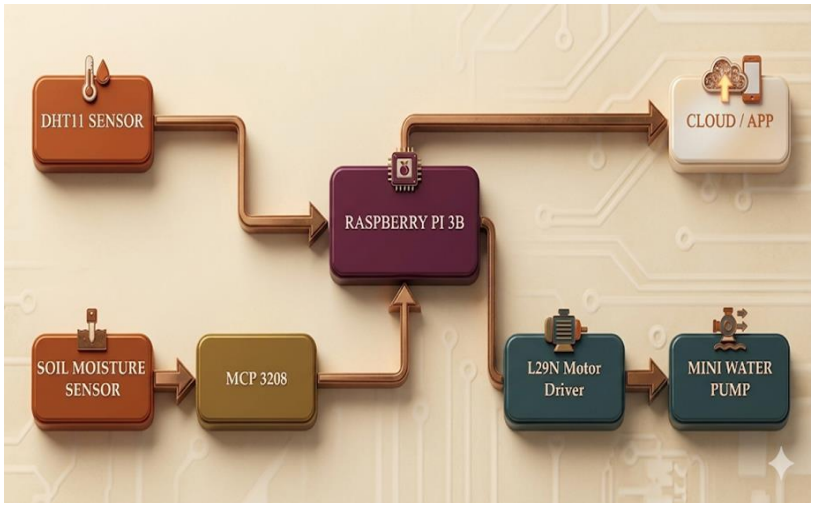

FIG-1: BLOCK DIAGRAM

Once the data is received, the Raspberry Pi analyzes the soil moisture level by comparing it with predefined threshold values programmed into the system. If the soil moisture level falls below 30%, it indicates that the soil is too dry and requires immediate irrigation. In this condition, Pump 1 is automatically activated through the L298N motor driver, which controls the direction and operation of the pump motor. This ensures that water is supplied efficiently to the field, preventing crop stress and maintaining healthy growth.

When the soil moisture level is between 30% and 60%, the system identifies this range as an optimal condition for plant growth. In this balanced state, both pumps remain turned off, conserving water and energy while avoiding unnecessary irrigation. On the other hand, if the soil moisture level exceeds 60%, it suggests that the soil is over-saturated, which could lead to root damage or waterlogging. To address this, Pump 2 is activated via the L298N motor driver to drain excess water or redistribute it to other areas, thereby maintaining proper soil conditions.

In addition to automatic control, the system integrates cloud-based monitoring using the ThingSpeak platform. Every set of sensor readings is continuously uploaded to the cloud, where the data is stored securely and displayed in graphical formats for easy understanding. Farmers can access this information remotely through a mobile application, enabling them to monitor field conditions from anywhere at any time. To further enhance usability, the system can provide voice-based updates or alerts, making it easier for farmers to understand the status without needing to interpret complex data.

This entire setup forms a continuous feedback loop, where real-time sensing, intelligent decision-making, and automated actuation work together seamlessly. The system reduces manual effort and ensures efficient water use by supplying the right amount of water based on real-time conditions. It prevents both under- and over-irrigation, helping conserve water, save energy, and improve crop yield, making farming more sustainable and efficient.

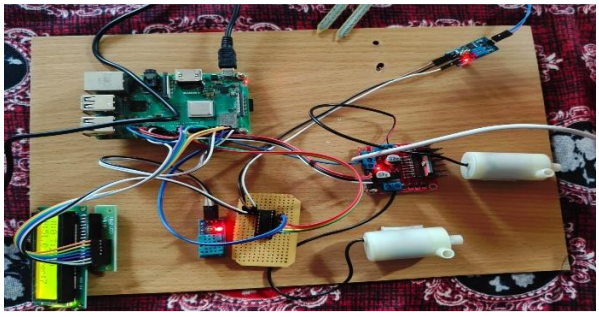

FIG -2:CIRCUIT ARRANGEMENT

V. RESULTS AND DISCUSSION

The result of this project is the successful development of an IoT-based smart irrigation system that automatically monitors soil moisture, temperature, and humidity, and controls water flow accordingly. The system effectively maintains optimal soil conditions by activating pumps based on moisture levels, reducing manual labor and human error.

It ensures efficient water utilization, prevents over- and under-irrigation, and supports healthier crop growth. Additionally, real-time data monitoring through the cloud enables farmers to track field conditions remotely, making the system reliable, time-saving, and highly beneficial for modern agriculture.

5.1 OUTPUT IN THINGSPEAK

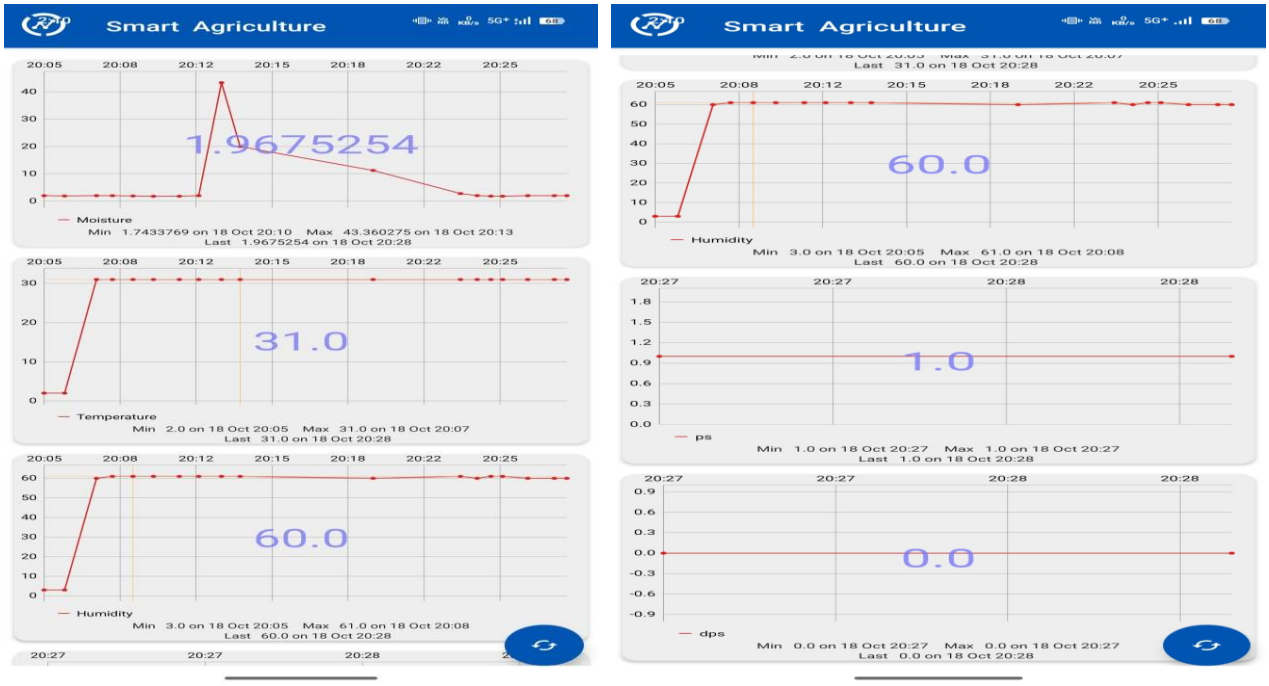

FIG-3: SMART AGRICULTURE SENSOR DATA DASHBOARD

5.2 FEATURES OF APP

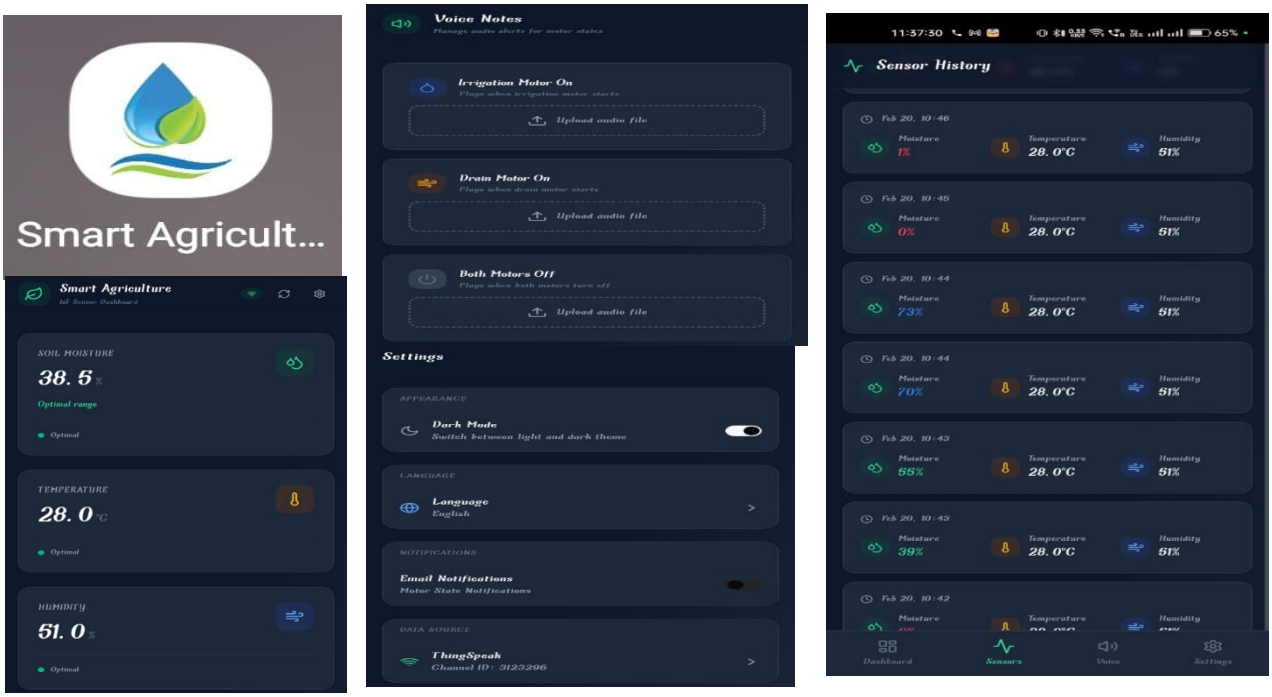

FIG-4: SMART AGRICULTURE MOBILE APP DASBOARD

Our Smart Agriculture app provides real-time monitoring of pH, temperature (28°C), and humidity (90%) across plant zones, with voice alerts and messages in preferred languages like Telugu. It tracks sensor history trends and displays irrigation/drain motor status (ON/OFF) for automated watering or drainage based on moisture levels. The intuitive dashboard supports hands-free operation, ensuring proactive crop management.

VI. APPLICATIONS

1. Used for automatic irrigation in farms and gardens.
2. Helps in saving water by supplying it only when the soil is dry.
3. Useful for monitoring soil and weather conditions in real time.
4. Can be used in greenhouses and nurseries for automatic watering.
5. Supports smart farming by sending data to the cloud for remote access.
6. Helps farmers increase crop yield and reduce manual effort.

VII. CONCLUSION

This paper presented an intelligent smart farming system that integrates IoT-enabled sensor networks with real-time data processing for precision agriculture. The system continuously monitors critical environmental parameters such as soil moisture, water level, and rainfall, and performs automated irrigation control based on predefined threshold conditions. By leveraging IoT technology, it provides real-time data collection, cloud-based monitoring, and remote control capabilities, enhancing accessibility and decision-making for farmers.

Experimental results demonstrate that the system effectively maintains optimal soil moisture levels, reduces water wastage by approximately 20 to 30 percent, and enables timely irrigation responses. The IoT-based architecture also improves system scalability, efficiency, and reliability, making it suitable for modern smart farming applications.

Overall, the proposed system offers a cost-effective and efficient solution for automated agricultural monitoring and irrigation management, contributing to improved crop productivity and sustainable resource utilization.

VIII. REFERENCES

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