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OPTIMIZING WATER MANAGEMENT: IOT CROP MONITORING SYSTEM

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Abstract—**The agricultural sector is vital for sustaining human life, yet rural India faces challenges like water scarcity, soil fertility depletion, and unpredictable weather. The proposed system is developed using soil moisture, rain, temperature, humidity, and pH sensors with a NodeMCU ESP8266 microcontroller. The system optimizes crop irrigation and resource management through real-time data collection and the Blynk platform for remote monitoring. Despite benefits such as enhanced resource management and real-time crop health monitoring, challenges include environmental risks and maintenance in remote areas. The potential of the Internet of Things (IoT) in farming highlights the need for further research and implementation.**

Index Terms—**Agricultural sector, Crop monitoring system, Internet of Things, Microcontroller, Sensors.**

I. INTRODUCTION

Agriculture, which is the cornerstone of civilization, is essential for human survival by providing food, fibre, and raw materials. Many people in India make their living mostly from agriculture. Climate, soil fertility, water availability, population density, and technology all have a significant impact on the agricultural sector. Every element has an impact on farming; for instance, farmers face difficulties due to unpredictable weather, and agricultural yields are threatened by decreasing soil fertility and water quality. Because they are more affordable, traditional methods continue to be used in many parts of India even in the face of technological breakthroughs. This research is a technological revolution in agriculture, using cost-effective and efficient technology to increase agricultural productivity.

A. Objectives

The proposed work aims to achieve three main objectives. Firstly, it focuses on efficiently measuring water quality, particularly pH levels, to determine suitability for crop irrigation and enhance agricultural practices for improved yields and sustainable water management. Secondly, using the Blynk platform, the research will provide real-time notifications on crucial factors such as water quality, temperature, humidity, and soil moisture levels. Additionally, the research aims to deploy affordable IoT solutions to monitor and evaluate crop fertility, aiming to increase productivity cost-effectively.

II. RELATED WORKS

The related works section delves into several key papers addressing the multifaceted challenges faced by farmers in Karnataka, along with the strategies proposed to mitigate these issues and enhance agricultural sustainability.

Vijay Kumar Hemappa Manegar et al. investigate the numerous difficulties faced by farmers in Karnataka, emphasizing the urgency of addressing these challenges to improve agricultural conditions. Their thorough analysis highlights current efforts such as the creation of controlled marketplaces and remote storage facilities as potential solutions. The authors provide insightful explanations of both the challenges faced by farmers and the initiatives undertaken to address them, offering important new perspectives on the complex structure of agriculture in Karnataka [1].

A significant contribution to precision irrigation in agriculture comes from the development of an IoT smart water management platform. This platform focuses on developing seamless business models and architectural layers to optimize water usage in agriculture. By collecting data from sensors, analyzing it, and enabling real-time responses, the platform aims to enhance water distribution management and improve agricultural system efficiency [2]. The application of sensor networks and IoT technology in precision agriculture is explored in-depth in a study focusing on wireless sensor networks. This research examines the monitoring of temperature, and humidity, soil moisture, on small-scale farms using sensors, while also highlighting the obstacles involved in implementing such networks in agricultural settings [3].

Anupama et al. discuss a proposed system for smart farming utilizing IoT-based water management. This system in corporates various components connected to an Arduino UNO board and a Wi-Fi module to provide smart irrigation and farming solutions, particularly beneficial in areas with limited water resources [4].

The integration of IoT and machine learning in soil monitoring and testing for fertility level and crop prediction is explored in another paper. This research underscores the importance of enhancing crop yield through smart farming practices. The proposed system involves using sensors to measure soil nutrients, storing data in a database, and analyzing it using ML algorithms to classify soil types and predict suitable crops [5]. A study by Mohammed Ameenul Hasan et al. explores the importance of soil testing in agriculture and the role of IoT and sensors in developing a cost-effective Site Specific Nutrient Management system. This system aims to boost productivity, protect the environment, and reduce costs and energy consumption in farming practices [6].

Muthumanickam Dhanaraju et al. highlight the benefits of smart farming practices, particularly in water conservation in agriculture. Their study emphasizes the role of IoT-based technologies in implementing controlled and efficient irrigation systems. By leveraging IoT, farmers can optimize water usage, leading to significant savings and environmental benefits [7].

III. PROPOSED SYSTEM

Diagrammatic view of the experiment is as shown below in Figure 1. The proposed IoT-based crop monitoring system is

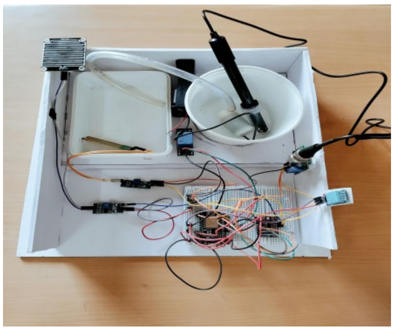

Fig. 1. Diagrammatic View of the Experiment

Designed to gather essential data such as soil moisture levels, rain occurrence, water pH value, temperature, and humidity. The system integrates several components with a NodeMCU ESP8266 microcontroller:

- **Soil Moisture Sensor:** Measures the soil's moisture level.
- **Rain Sensor:** Detects the occurrence of rain.
- **pH Meter:** Determines the pH content in the water used for irrigation.
- **DHT11 Temperature and Humidity Sensor:** Records temperature and humidity levels.
- **NodeMCU ESP8266 Microcontroller:** Coordinates data collection and processing.

A. System Setup

The system setup consists of two main parts: an agricultural field represented in a tray and a water storage represented by a small tank.

- **Water Storage (Tank):**
  - **pH Sensor:** Placed within the water tank to monitor the water's pH levels.
  - **Water Pump:** Located inside the water tank, responsible for pumping water to the field when needed.

- **Agricultural Field (Tray):**
  - **Soil Moisture Sensor:** Embedded in the ground within the tray to monitor soil moisture levels.
  - **Rain Sensor:** Positioned near the field to detect rain occurrence.
  - **Temperature and Humidity Sensor (DHT11)**: Located near the field to record temperature and humidity levels.
  - **NodeMCU ESP8266 Microcontroller:** Placed nearby to collect and process data from all sensors.

IV. METHODOLOGY

The implementation process of the proposed IoT-based crop monitoring system involved several stages to ensure its efficiency. Initially, a thorough analysis of system requirements was conducted to determine the necessary hardware components. Following this, hardware components such as soil moisture sensors, rain sensor, DHT11 temperature and humidity sensor, pH sensor, NodeMCU ESP8266 microcontroller, CJMCU-4051 74HC4051 8 Channel Analog Multiplexer/De multiplexer Breakout Board, mini water pump with relay module, breadboard, and jumper wires were assembled and connected according to the system design.

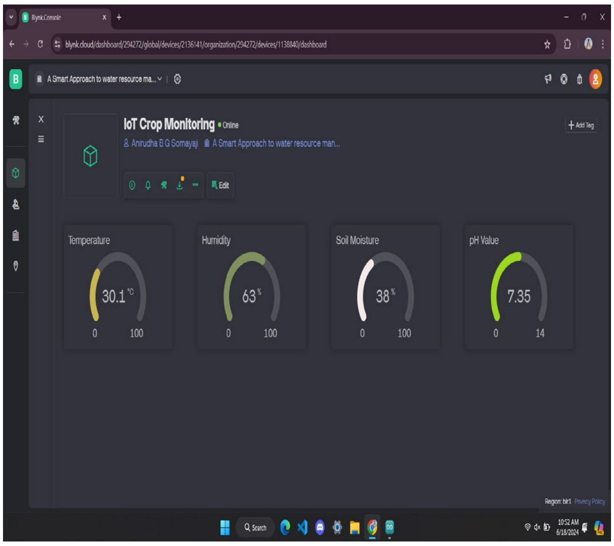

Fig. 2. Blynk Web Application

Next, communication was established between the Blynk platform. Using this platform, as shown in Figure 2, the system provides real-time data and notifications. The operation begins with the rain sensor detecting the presence of rain. If rain is detected, the system alerts the user about the rain; otherwise, it checks the soil moisture content. If the soil water content is below the user given threshold value, the system alerts the user and proceeds to check the pH content of the water. If the soil moisture content is above the threshold, no action is taken.

Next, the system measures the pH value of the water. If the pH is within the ideal range of 6.0 to 8.0, the water pump is activated to irrigate the plants. If the pH value is outside this range, the system alerts the user about the pH level in the water. This process helps farmers make informed decisions, enhancing crop yield and productivity.

V. RESULTS AND CONCLUSION

The implemented IoT-based crop monitoring system seamlessly integrated sensors, microcontrollers, and the Blynk platform to improve agricultural management and productivity significantly. It provided continuous monitoring of rain intensity to optimize irrigation practices, promoting water conservation and preventing overwatering. Effective monitoring of soil moisture levels triggered alerts when thresh olds were exceeded, allowing for proactive soil management strategies. Real-time pH monitoring of water quality ensured ideal conditions for crop irrigation, with prompt notifications enabling timely corrective measures. Table I summarizes the comprehensive outcomes achieved by the system.

TABLE I
SYSTEM MONITORING RESULTS

Important Parameters	Results		
	Criteria	Expected Result	Outcome
Rain Intensity	Below Threshold	Soil Moisture Content Analysis	Soil Moisture Content Analysis
	Above Threshold	Pump is off	Pump is off
Soil Moisture Content	Below Threshold	Alert the user, pH Content Analysis	Alert the user, pH Content Analysis
	Above Threshold	Pump is off	Pump is off
pH Content in Water	Above 8.0	Alert the user about alkalinity of water, pump stays off	Alert the user about alkalinity of water, pump stays off
	Below 6.0	Alert the user about acidity of water, pump stays off	Alert the user about acidity of water, pump stays off
	Between 6.0 - 8.0	Watering the plants	Watering the plants

Temperature and humidity, among other environmental parameters, were continuously monitored to supply essential data for making informed decisions in crop planning and resource allocation. The Blynk platform facilitated real-time notifications on water quality, soil moisture, and environmental conditions, enhancing remote monitoring capabilities and overall system usability.

The IoT-based system demonstrated reliable performance with accurate sensor readings and seamless data transmission. It effectively addressed key challenges faced by farmers in rural India, including optimizing irrigation, managing soil health, and adapting to climate variability. The research underscored the potential of IoT technologies to support sustainable agriculture practices, improve resource management, and foster economic resilience. Practical experience gained in sensor integration and data management highlighted the transformative impact of IoT in modernizing agricultural practices and promoting environmental sustainability.

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