

IoT Based Real Time Crop Irrigation And Energy Efficient System

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Abstract- Conventional irrigation methods often result in excessive water use, energy waste, and inadequate fertilizer management, despite the fact that agriculture is crucial to economic prosperity. To solve these problems, this study proposes an Internet of Things (IoT)-based real-time crop irrigation and energy-efficient system that integrates automatic water level monitoring, remote load control, and soil nutrient analysis. The proposed solution uses an ESP32 microcontroller to monitor the water tank's level and promptly alert the Smart Water mobile application when the tank fills up. Relay modules are used to control electrical loads, such as lightbulbs or irrigation pumps, to reduce power consumption and avoid overflow. Additionally, an NPK soil sensor interfaced via RS485 Modbus communication provides real-time potassium, phosphorus, and nitrogen measurements

Keywords: Internet of Things, Smart Irrigation, ESP32, Smart Water Monitoring Dashboard NPK Sensor, RS485 Modbus, Energy Efficiency, Precision Agriculture.

I. INTRODUCTION

Agriculture is one of the main sectors that supports the global economy and ensures food security for the growing population. Effective irrigation management is crucial for preserving soil health and boosting crop productivity. However, because of their strong reliance on human operation and rigid scheduling methods, traditional irrigation systems often lead to excessive water use, energy loss, and poor crop management. Farmers in many agricultural areas water crops based more on past performance than on the state of the environment, which can result in either too much or too little irrigation. The increasing need for sustainable agricultural practices has led to the inclusion of modern technology in resource waste. The Internet of Things (IoT) has evolved as a technology that enables real-time monitoring, automation, and remote administration of agricultural activities

To solve these problems, precision and sustainable farming are being supported by the integration of modern technologies into agriculture.

This proposed system uses soil moisture sensors to continually check the soil's water content. Water waste is decreased and efficiency is increased when irrigation pumps are automatically controlled to supply water only when required based on sensed data. techniques for communication like WiFi and GSM

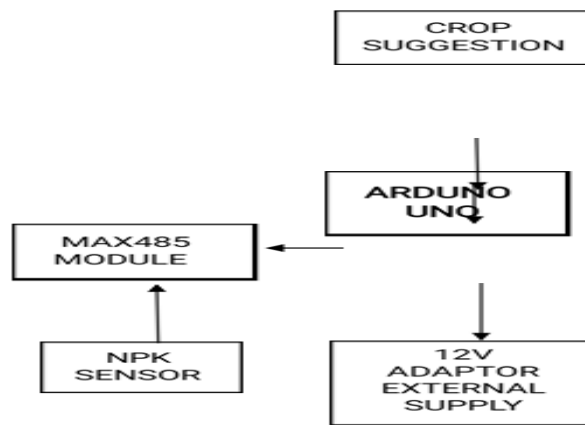
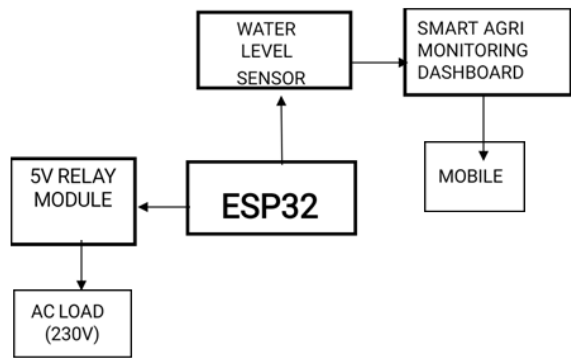
RELATED WORKS

Increasing agricultural output while protecting water resources is the primary goal of many studies on Internet of Things (IoT)-based smart irrigation systems. These research focus on combining state-of-the-art sensors, wireless communication, and cloud-based data processing to enable real-time monitoring and intelligent decision-making in irrigation operations.

The proposed Internet of Things (IoT)-based smart irrigation system uses a network of sensors, such as temperature, humidity, and soil moisture sensors, to continually monitor the environmental conditions in agricultural areas. Soil moisture sensors are crucial among them as they gauge the soil's water content and establish if irrigation is required. Based on specified threshold levels, the system automatically activates or deactivates irrigation pumps, ensuring that crops receive the optimal

While these approaches improve water efficiency, many existing systems focus primarily on irrigation control and do not incorporate additional features such as nutrient analysis or crop recommendation. Integrating these capabilities can further enhance agricultural productivity and decision-making

BLOCK DIAGRAM DESCRIPTION



EXPLANATION

1. ESP32 Controller

The ESP32 microcontroller is the main IoT controller responsible for wireless connections and remote monitoring. It makes use of the Smart Agri Monitoring Dashboard IoT application and Wi-Fi to connect the system to the internet. Customers may now monitor and control irrigation systems from any place using a smartphone.

2. Water level Sensor

The water level sensor monitors the tank's water level. When the tank is full, the sensor alerts the ESP32 controller. The controller informs the Smart Agri Monitoring Dashboard application that the water tank is full after analyzing the data.

3. Smart Agri Monitoring Dashboard

Between the mobile device and the hardware, the Smart Agri Monitoring Dashboard serves as the cloud interface. Through the system, the user can operate devices and keep an eye on system status. The user can remotely

operate the irrigation system and receives a message when the tank is full.

4. Relay Module and AC Load

To control high-voltage devices like irrigation motors, pumps, and lightbulbs, the ESP32 is connected to a 5V 2channel relay module. When it detects a full tank or gets a signal from the mobile application, the controller modifies the relay to shut off the AC load (230V). This conserves electricity and prevents water from spilling.

5. NPK Soil Sensor

The NPK sensor measures three critical soil elements: nitrogen (N), phosphorus (P), and potassium (K). These minerals are necessary for both plant development and soil fertility. The sensor collects soil data in real time in the agricultural region.

6. MAX485 Module

The MAX485 module facilitates RS485 communication between the Arduino Uno and the NPK sensor. Since the NPK sensor communicates using the Modbus RS485 protocol, the MAX485 module converts RS485 signals into TTL signals that the Arduino can understand.

7. Arduino Uno

The Arduino Uno can receive soil nutrient data from the NPK sensor thanks to the MAX485 module. It evaluates the nutrient levels and suggests suitable crops or fertilizers based on the condition of the soil.

8. OLED Display

The OLED display shows the current NPK measurements and crop suggestions. This allows the farmer to examine soil nitrogen levels instantly and does away with the need for extra equipment.

9. Power Supply

A 12V external adapter powers the Arduino Uno and other connected gadgets. When there is a consistent power source, sensors and communication modules function reliably.

10. Crop Suggestion System

Based on the measured N, P, and K levels, the approach suggests suitable crops or fertilizer. This helps farmers increase crop yields and better manage soil fertility.

III. EXISTING SYSTEM

In traditional farming operations, irrigation is mostly carried out by hand or using set scheduling techniques. Farmers usually control irrigation pumps based on their experience rather than utilizing real-time field requirements. Such conventional irrigation systems do not regularly monitor soil moisture, water availability, and fertilizer levels. As a result, high water usage and poor irrigation management are common.

Many existing systems lack automation, which results in over-irrigation at some periods and insufficient watering during critical crop growth phases. Furthermore, if water tank levels are not checked, overflow issues might result in significant water waste. Constantly running irrigation motors also consume a lot of power, increasing farmers' overall costs. Some modern irrigation systems have implemented basic IoT-based monitoring through the use of mobile applications and soil moisture sensors. However, most of these systems primarily focus on water control and lack integrated features like crop recommendation and nutrient monitoring.

Examples of soil fertility variables that are frequently tested manually in laboratories include nitrogen (N), phosphorus (P), and potassium (K). Making judgments in real time is not appropriate for this procedure, which takes time.

IV. PROPOSED SYSTEM

To address the shortcomings of conventional irrigation techniques, this study proposes an Internet of Things (IoT)-based real-time crop irrigation and energy-efficient system that provides automatic water level monitoring, remote management of electrical loads, and soil nutrient analysis for precision farming.

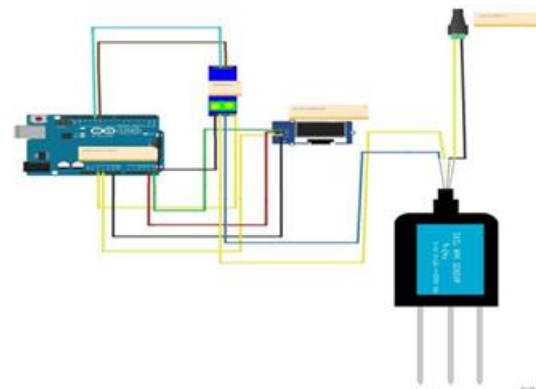
The first module's water level sensor monitors the storage tank's water level. When the tank fills full, the ESP32 microcontroller immediately alerts the farmer using the Smart Agri Monitoring Dashboard application. This real-time alert helps prevent water overflow and reduces unnecessary pump effort. By remotely managing electrical loads like lighting or irrigation pumps, relay modules improve energy efficiency.

The second module uses an NPK sensor to monitor the content of essential soil nutrients like potassium (K),

phosphorus (P), and nitrogen (N). The sensor's RS485 Modbus protocol interface with the Arduino Uno ensures dependable long-distance data delivery. After the nutritional levels are Analyzed, suggestions for crops and fertilizers are made. The real-time nutritional data may be extended to cloud-based monitoring in addition to being shown locally on an OLED panel.

The proposed system provides an efficient smart agriculture solution by reducing water waste, energy consumption, and crop yield through nutrient-based irrigation and fertilizer guidance.

V. CIRCUIT DIAGRAM



a) EXPLANATION

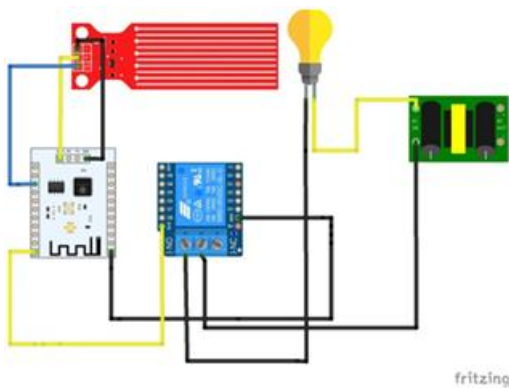
The core controller of the system is the Arduino Uno microcontroller board. As the main processing unit, it reads sensor data and controls the connected modules. An external 12 V power supply provides the electrical energy required for the system's components.

A soil nutrient sensor (NPK sensor) is used to monitor the levels of nitrogen (N), phosphorus (P), and potassium (K) in the soil. These elements are important indicators of soil fertility and agricultural growth conditions. The NPK sensor and the Arduino can communicate more easily thanks to a MAX485 TTL to RS485 Converter Module, which converts RS-485 communication signals from the sensor into TTL signals that the Arduino can process. This enables long-distance communication between the sensor and the controller.

An OLED Display Module is connected to the Arduino to display the measured soil properties in real time. The potassium, phosphorus, and nitrogen readings that the sensor picked up are shown. Farmers or consumers may now easily check the soil's nutritional condition directly on the gadget, doing away with the need for extra equipment.

The wiring diagram shows the connections between the Arduino, the MAX485 module, the OLED display, and the NPK sensor. The Arduino sends the findings to the OLED display for viewing after processing the nutritional data using the MAX485 module.

All things considered, this technology supports crop recommendation systems and intelligent irrigation decisions by helping to monitor soil nutrient levels in real-time. By analyzing soil nutrient data, farmers may maximize fertilizer usage, choose the best crops, and boost agricultural production while using less resources.



Node MCU (Controller Unit)

The system's primary controller is the Node MCU ESP32. It determines whether to turn the irrigation device on or off after processing the input data from the soil moisture sensor. The Node MCU can transmit data to cloud platforms for remote monitoring because it has built-in Wi-Fi.

Water level Sensor

The water level sensor is immersed in the water to measure the water level. It has three pins: • VCC, which is connected to the power supply of the Node MCU GND stands for grounded. • Signal (S): connected to an analog pin on a Node MCU

Relay Module

The 5V two-channel relay module functions as a switch. The relay module receives a control signal from the Node MCU. The relay either connects or disconnects the power supply to the load (water pump or lamp) based on the signal.

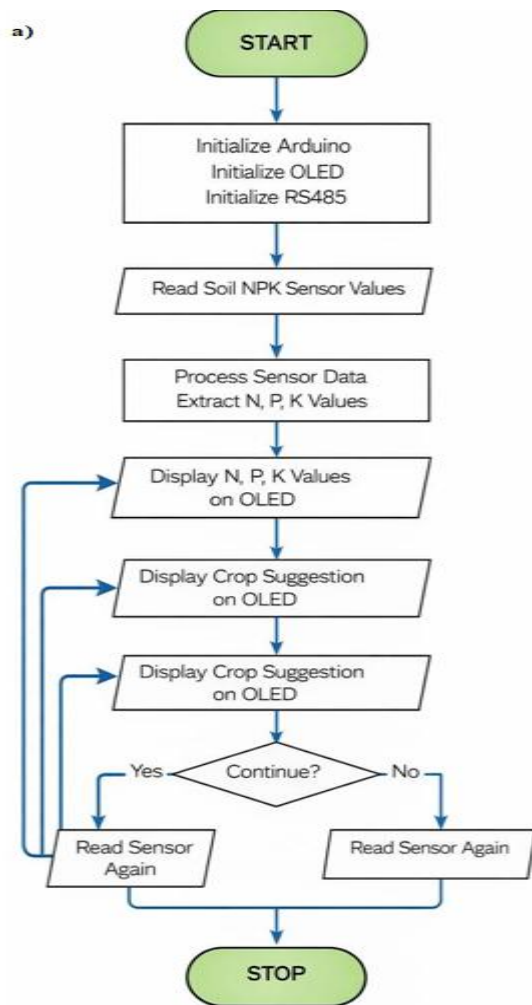
Power Source

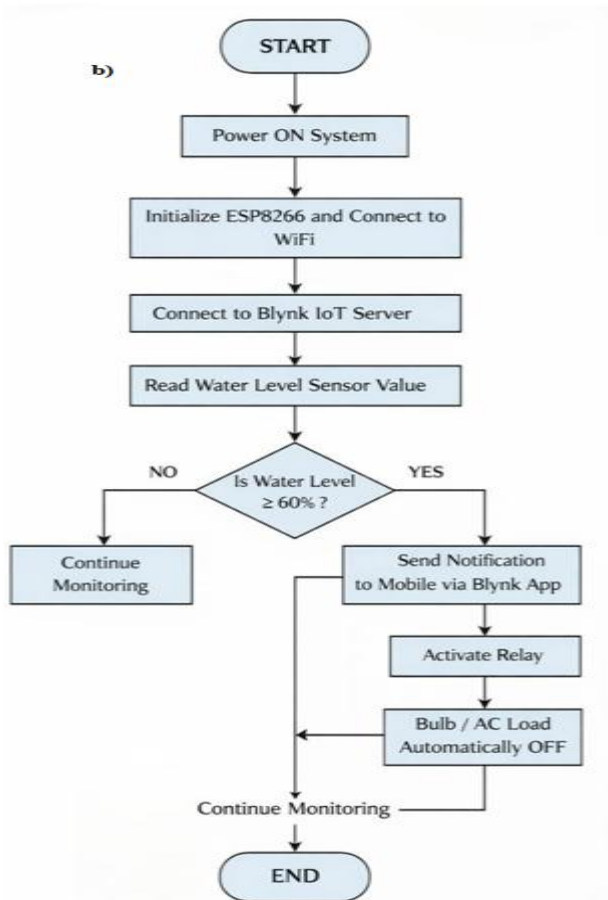
The AC mains voltage is converted into the DC voltage required for the circuit by the AC-DC Power Supply Module. This supply powers the load and other parts of the system.

Load (Lamp/Water Pump)

The lamp in the diagram represents the irrigation pump or motor. It is connected via the relay connections. When the relay is activated, the circuit shuts and the pump starts.

VI. FLOWCHART





VII. DATABASE FOR CROP SUGGESTIONS USING NPK VALUES

In a smart irrigation system or precision agriculture, this table can be used to suggest crops based on soil NPK sensor data.

Nitrogen (N) Level	Phosphorus (P) Level	Potassium (K) Level	Suggested Crops
Low (0–40)	Low (0–20)	Low (0–40)	Millets, Pulses (Green gram, Black gram)
Medium (40–80)	Medium (20–40)	Medium (40–80)	Wheat, Maize, Groundnut
High (80–120)	Medium (20–40)	Medium (40–80)	Rice, Sugarcane
Medium (40–80)	High (40–80)	Medium (40–80)	Cotton, Sunflower
Low (0–40)	Medium (20–40)	High (80–120)	Potato, Tomato
High (80–120)	High (40–80)	High (80–120)	Banana, Papaya, Vegetables

b) Using weather forecasts, crop planning and nutrient management for Tiruvarur District, Tamil Nadu (May–October 2026)

Weather Forecast Analysis

Month	Avg Temperature	Rainfall	Climate
May	32°C	52 mm	Summer
June	32°C	35 mm	Pre-Monsoon
July	31°C	54 mm	Early Monsoon
August	30°C	101 mm	Monsoon
September	30°C	102 mm	Active Monsoon
October	29°C	210 mm	Northeast Monsoon

c) Suggestions for Seasonal Crops

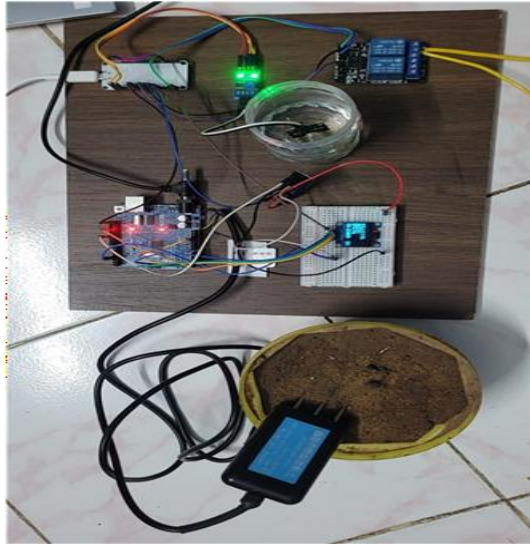
- Millets, okra, and green gram in the summer (May).
- Pre-monsoon June: groundnuts, sesame, and maize.
- Black gram, corn, cotton, and paddy during the monsoon season (July–September).
- Northeast Monsoon in October: tomatoes, chilies, and rice of the Samba variety

d) Control of Nutrients in Fertilizer

- It is recommended to apply urea on paddy (100–120 kg/ha), maize (120–150 kg/ha), groundnuts (25–30 kg/ha), and vegetables (60–80 kg/ha).
- Potassium should be applied to paddy (40–60 kg/ha), maize (40–50 kg/ha), ground nuts (30–40 kg/ha), and vegetables (50–70 kg/ha)

BEFORE



AFTER**VIII. RESULT ANALYSIS**

The experiment findings show that the device effectively monitors water levels and soil nutritional indicators in real time. Notifications are successfully delivered to the Smart Agri Monitoring Dashboard mobile application when the water tank fills up. The relay module reduces energy consumption by enabling remote control of irrigation pumps. The exact nitrogen, phosphorous, and potassium levels determined by the NPK sensor—which are utilized to choose crops—are shown on the OLED panel.

IX. ACKNOWLEDGMENT

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X. CONCLUSION

This study introduced an IoT-based, energy-efficient, real-time agricultural irrigation system for precision farming. The ESP32, Arduino Uno, and NPK sensors work together to provide automated irrigation monitoring and soil nutrition analysis. The method enhances fertilizer use, reduces water waste, and boosts agricultural productivity. The system may eventually include cloud data analytics and AI-based crop guidance algorithms.

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