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Implementation Study Of Soil Moisture Yl-69 For Sensor-Based Soil Moisture Monitoring System For Irrigation Optimization

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Abstract — *Soil moisture is a critical parameter in plant growth and irrigation management. Conventional manual monitoring methods are constrained by their subjective nature and inability to provide real-time data. This study presents the design and implementation of an IoT-based soil moisture monitoring system using an ESP32 DEVKIT V1 microcontroller, an analog soil moisture sensor (YL-69/RX203), a 16x2 LCD I2C display, and the Blynk IoT platform. The system reads analog values from the sensor via the 12-bit ADC on GPIO 34, converts them into moisture percentages using a linear mapping function, and classifies soil conditions into three categories: Dry (< 30%), Moist (30-70%), and Wet (>= 70%). Measurement results are displayed locally on the LCD and transmitted to the Blynk dashboard every two seconds via a Wi-Fi connection. Functional testing demonstrates that the system successfully classifies and transmits real-time soil moisture data, confirming its feasibility as a decision-support tool for precision irrigation management.*

Keywords:
ESP32;
Soil moisture sensor;
IoT monitoring;
Blynk;
Precision irrigation;

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I. INTRODUCTION

Soil moisture is a fundamental parameter in agricultural systems because the water contained in the soil functions as a solvent for nutrients and supports plant physiological processes. Soil that is too dry can cause plants to experience water deficits, while soil that is too saturated can potentially disrupt the root system and trigger root diseases. Therefore, the availability of accurate and real-time soil moisture information is crucial for efficient irrigation management [1], [2].

Conventional practices of manual soil moisture monitoring have several fundamental limitations, including: subjective observation results, the inability to provide continuous data, and the need for physical presence on site. These limitations have driven the development of sensor-based monitoring systems capable of measuring soil moisture objectively and automatically [3].

The development of Internet of Things (IoT) technology opens up opportunities to integrate sensors, microcontrollers, and cloud platforms into an integrated monitoring system that can be accessed remotely. In the domain of precision agriculture, IoT is utilized to monitor various environmental parameters simultaneously. The Blynk platform has proven effective as an IoT monitoring interface because it can display sensor data in real time through a configurable dashboard on a smartphone [4], [5].

This study designs and implements an IoT-based soil moisture monitoring system using an ESP32 DEVKIT V1 microcontroller, a YL-69/RX203 analog soil moisture sensor, a 16x2 I2C local LCD display, and the Blynk platform as a remote monitoring medium. The system is not equipped with mechanical actuators such as relays or water pumps, so the implementation focuses entirely on the monitoring function. The system outputs information on soil moisture percentage and its condition classification (dry, moist, or wet), which can be used as a basis for manual irrigation decision-making.

The main objectives of this study are: (1) to design a soil moisture monitoring system based on an ESP32 and analog sensors; (2) to implement the conversion of ADC values to moisture percentage using a linear mapping function; (3) to validate real-time data transmission to the Blynk platform; and (4) to analyze the accuracy of soil condition classification based on predetermined thresholds.

II. METHODOLOGY

A. System Architecture and Overview

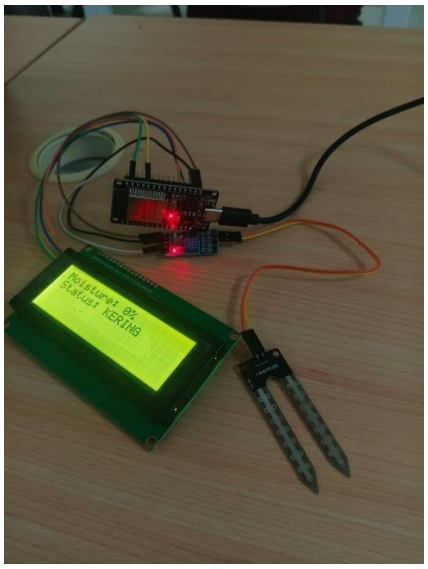
The designed soil moisture monitoring system consists of four main subsystems: (1) a data acquisition subsystem in the form of an analog soil moisture sensor; (2) a processing subsystem in the form of an ESP32 microcontroller; (3) a local output subsystem in the form of a 16x2 I2C LCD; and (4) a remote monitoring subsystem in the form of a Blynk platform. The data flow begins with the ESP32's 12-bit ADC reading the sensor's analog signal on GPIO pin 34. It is then processed into a moisture percentage value, and then sent simultaneously to the LCD and Blynk via Wi-Fi at two-second intervals.

Table 1. system hardware component specifications

No.	Component	Function
1	ESP32 DEVKIT V1 (CP2102)	Main microcontroller; processes ADC data, controls the LCD, and sends data to Blynk via Wi-Fi.
2	Sensor Soil Moisture YL-69 / RX203	Detects soil moisture content; generates an analog signal on GPIO pin 34 (12-bit ADC).
3	LCD I2C 16x2 (alamat 0x27)	Displays soil moisture percentage and status locally.
4	Jumper Cable	Connect all components in the circuit.
5	USB Cable	Powers the ESP32 during programming and testing.

B. Wiring Design

The analog soil moisture sensor is connected to a 3.3 V source from the ESP32 to ensure the analog output remains within the ADC's safe range. The sensor's analog output (AOUT) pin is connected directly to the ESP32's GPIO pin 34. The 16x2 I2C LCD utilizes the ESP32's built-in I2C communication path, with the SDA pin on GPIO 21 and the SCL pin on GPIO 22. All components share a common ground path for a stable voltage reference.



Picture 1. Prototype of a series of soil moisture monitoring systems that have been assembled.

C. Software Design

The software was developed using Arduino IDE 2.3.8 with the following core libraries: WiFi.h and WiFiClient.h for network connection, BlynkSimpleEsp32.h for Blynk platform integration, Wire.h for I2C communication, and LiquidCrystal_I2C.h for LCD control. The system's core function, sendSensorData(), is executed every two seconds using the Blynk timer mechanism (BlynkTimer).

The ADC value is converted to humidity percentage using the Arduino native linear mapping function, map(sensorValue, 4095, 1500, 0, 100). A value of 4095 represents very dry soil conditions (high resistance), while a value of 1500 represents wet soil conditions (low resistance), obtained through empirical calibration. The converted value is then constrained to a range of 0-100 using the constrain() function to prevent values from exceeding the percentage limits.

Table 2. Classification of Soil Conditions Based on Moisture Value

Moisture Range	Soil Status	Description
< 30%	(Dry)	Dry Low moisture content; soil requires attention.
30% - < 70%	(Moist)	Moist Optimal soil conditions for most plants.
>= 70%	(Wet)	High moisture content; potential for excess water at the roots.

D. System Flowchart

The overall system workflow is depicted in the following flowchart. After component initialization, the system enters a main loop that reads sensor values, performs conversion and classification, displays the results on the LCD, sends the data to Blynk, and then waits for two seconds before the next cycle begins.



Picture 2. flowchart of soil moisture monitoring system

III. RESULTS AND DISCUSSION

A. Prototype Implementation

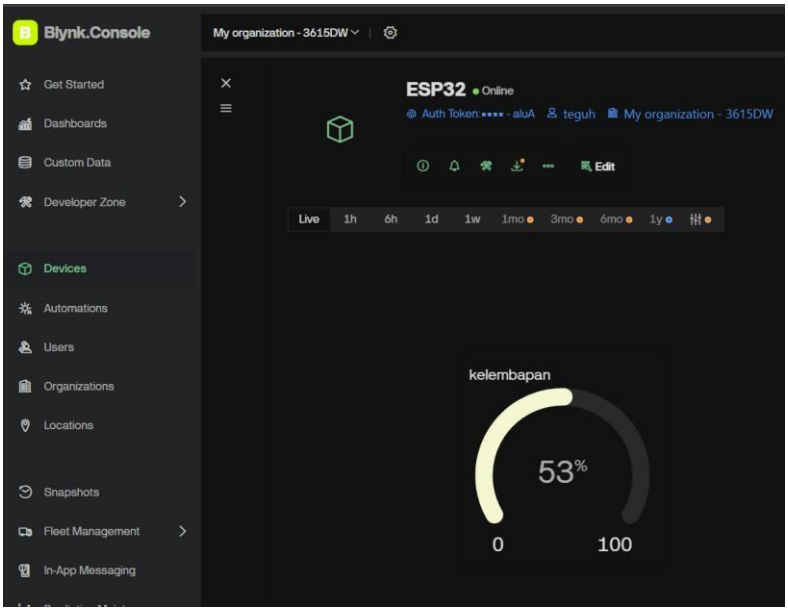
The system prototype was successfully assembled and operational. All components were properly connected, and the system was able to initialize a Wi-Fi connection to the UNG-WIFI network and connect to the Blynk server. The 16x2 I2C LCD with address 0x27 successfully displayed moisture values and soil status locally with each reading cycle.



Picture 3. LCD display when the sensor reads dry soil conditions

B. Functional Testing of Data Transmission to Blynk

Functional testing was conducted by placing the sensor in three different soil conditions: dry soil, moist soil, and wet soil. Moisture data was successfully transmitted to the Blynk platform and displayed via the Gauge widget on the dashboard. Figure 4 displays an overview of the Blynk dashboard with the ESP32 device in Online status, proving that the system's connectivity to the Blynk cloud is consistently maintained.



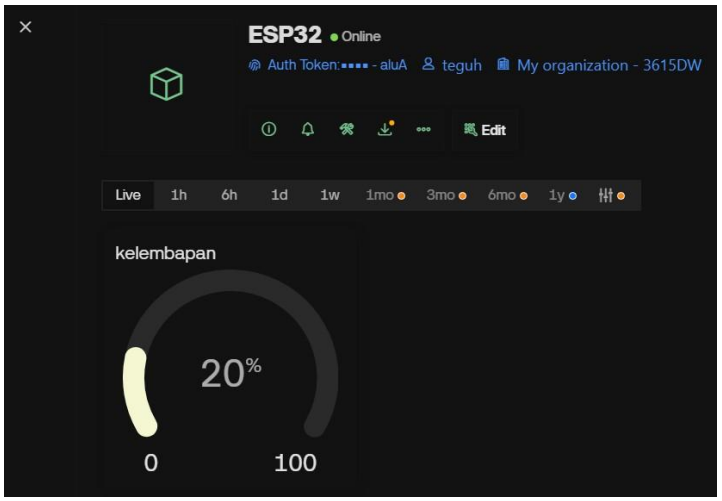
Picture 4. The Blynk dashboard display shows the soil moisture value on virtual pin V1.

Table 3. System Functional Test Results

No.	Test Condition	Blynk Humidity Value (%)	Display Status
1	Dry Soil	20%	DRY
2	Moist Soil	48%	MOIST
3	Wet Soil	72%	WET

C. Dry Conditions - Blynk (<30%)

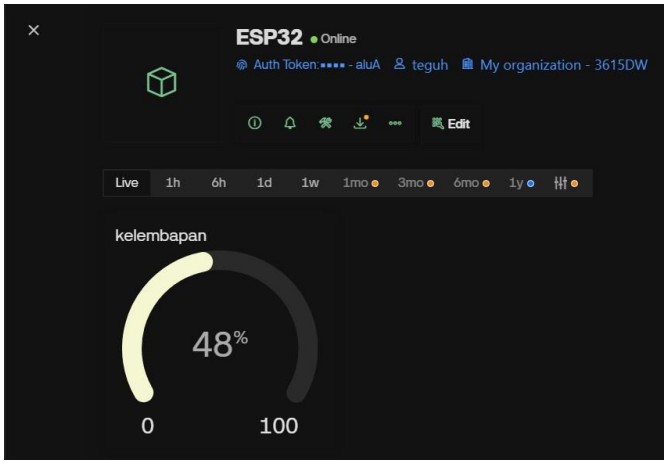
Under dry soil conditions, Blynk displays a moisture value of 20%, which is correctly categorized as DRY according to the established classification logic (<30%). The relatively high ADC value under these conditions results in a low percentage conversion, consistent with the calibration model used.



Picture 5. Blynk screenshot when the soil is in dry condition (< 30%), humidity value 20%.

D. Moist Conditions - Blynk (30%-70%)

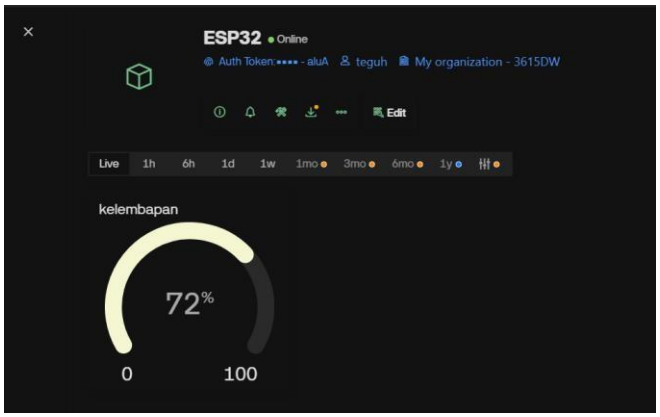
Under moist soil conditions, Blynk recorded a humidity value of 48%, which is classified as MOIST (range 30% - 70%). The Gauge indicator position is in the mid-renge, confirming that the transition between Dry adn Wet states is well detected.



Picture 6. Blynk screenshot when the soil is in a moist condition (30%-70%), humidity value 48%.

E. Wet Condition - Blynk (>= 70%)

In wet soil conditions, the moisture value transmitted to Blynk reached 72%, exceeding the 70% threshold, causing the system to automatically classify the soil condition as WET. Furthermore, Figure 7 shows a physical LCD display simultaneously displaying Moisture: 75% / Status: WET, confirming the consistency of the output between the local and remote displays.



Picture 7. Blynk screenshot when the soil is in wet condition (>= 70%), humidity value 72%.

F. Analysis and Discussion

Based on the functional test results, the monitoring system successfully performed the three main designed functions. First, the ADC value conversion using the map(sensorValue, 4095, 1500, 0, 100) function produced a percentage representation proportional to the soil moisture content. This function is linear and invertible, so any change in soil moisture content consistently results in an interpretable percentage change.

Second, the three-state classification mechanism (Dry/Moist/Wet) was proven to function according to the predetermined threshold logic. The three tested moisture values (20%, 48%, 72%) each fell within the correct category within the predetermined range, indicating that the conditional logic in the firmware was functioning correctly.

Third, data transmission via a Wi-Fi connection to the Blynk platform was successfully performed at two-second intervals using the WiFi.h and BlynkSimpleEsp32.h standard libraries. The ESP32 device was registered as Online on the Blynk console, and real-time sensor value changes were reflected in the Gauge widget on the dashboard. This confirmed the stability of the integration between the ESP32 firmware and the Blynk cloud platform during the testing period.

The system provides irrigation operators with relevant information to make watering decisions based on objective data, replacing subjective manual estimations. In the future, system accuracy can be improved through gravimetric calibration for various soil types and the addition of sensor redundancy.

IV. CONCLUSION

This research successfully designed and implemented an IoT-based soil moisture monitoring system using an ESP32 DEVKIT V1 microcontroller, a YL-69/RX203 analog soil moisture sensor, a 16x2 I2C LCD, and the Blynk platform. The main conclusions that can be drawn are as follows:

1. The system successfully reads the sensor's analog value through a 12-bit ADC on GPIO pin 34 of the ESP32 and converts it to a moisture percentage (0-100%) using the linear mapping function map(sensorValue, 4095, 1500, 0, 100).

2. The classification of three soil conditions (Dry <30%, Moist 30-70%, Wet >= 70%) functioned correctly, and the classification results were displayed consistently on the 16x2 I2C LCD.

3. Real-time data transmission to the Blynk platform via Wi-Fi using the WiFi.h and BlynkSimpleEsp32.h libraries was successful at two-second intervals, with the device's Online status confirmed in the Blynk console.

4. This system, although not yet equipped with automatic actuators, demonstrated its viability as a tool for precision irrigation decision-making based on objective, remotely accessible sensor data.

For further development, it is recommended to add gravimetric calibration for various soil types, implement historical data storage in Blynk, add automatic notifications for critical soil conditions, and integrate relay actuators for semi-automatic irrigation functions.

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