Water pump optimization in an Internet of Things-based soil moisture monitoring system

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ABSTRACT

Internet of Things (IoT) technology in agriculture is increasingly growing, especially in the automation of irrigation systems. This study aims to design and implement an IoT-based soil moisture monitoring system equipped with a water pump operation optimization algorithm to improve water use efficiency. This system is integrated with a NodeMCU ESP 8266 connected to the Blynk application and Google Spreadsheet to transmit data in real-time via smartphone devices. A combination of soil moisture sensors and water flow sensors is integrated to detect intelligent controls designed to automatically regulate the time and duration of watering based on the specified humidity threshold and predicted environmental conditions. Test results show that this system is able to maintain soil moisture levels within optimal limits while reducing water consumption significantly compared to conventional irrigation systems. Thus, this system not only supports more efficient and sustainable agricultural practices but also provides a technological solution that can be adapted to various scales of agricultural land.

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1. INTRODUCTION

Global population growth and the increasing need for food resources demand more efficient and sustainable agricultural systems [1]. One of the main challenges in agriculture is water management, particularly in crop irrigation. Conventional irrigation is often inefficient because water is applied manually and without regard for actual soil moisture conditions [2],[3]. This can lead to water waste and disrupt plant growth. Along with the development of technology, Internet of Things (IoT) based approaches are starting to be widely applied in agricultural systems [4],[5]. IoT allows the integration of various sensors and actuators to collect data in real-time and control devices such as water pumps automatically [6]. In this context, optimizing the use of water pumps It is crucial for the irrigation system to run efficiently, save energy, and maintain soil moisture within the ideal range [7].

Optimal soil moisture is crucial for plant health. Generally, ideal soil moisture ranges from 30% to 60%, depending on the plant type and weather conditions [8]. If soil moisture is too low, plants can wilt. Conversely, excess water will reduce oxygen levels in the soil, disrupt root respiration, and cause the formation of toxic substances [9]. Continuous soil moisture monitoring is crucial to ensure soil conditions remain within ideal ranges. However, in practice, irrigation on agricultural land is generally still carried out manually without accurate moisture levels [10]. This can lead to inefficient nutrient absorption and suboptimal plant growth.

To overcome this problem, this study developed an IoT-based automatic irrigation system with real-time monitoring using the Blynk application and Google Spreadsheet. Blynk is used to monitor soil moisture, monitor water output from water pumps, and control devices remotely via smartphone [11]. Google

Spreadsheet is used as a medium for automatically recording moisture and water output monitoring data, which can be used for long-term analysis [12],[13]. This system allows users to intervene more quickly in soil conditions, as well as significantly reduce water consumption [14],[15]. Thus, this system can be an effective solution towards smart agriculture that is efficient, adaptive, and sustainable.

2. METHOD

With the use of block diagrams, it allows the evaluation process on the system can be done effectively. Where when reviewing the performance a system, process or activity that causes a decrease or encourages increase performance can identified in a way direct. Process This can done through review to input And output Which involved. Diagram block Water Pump Optimization in Soil Moisture Monitoring System based on Internet of Things is shown in Figure 1.

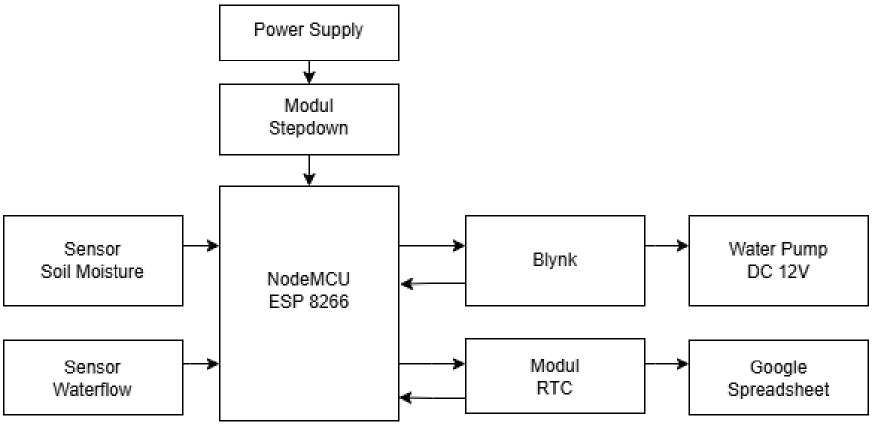


Figure 1. Block diagram

Water Pump Optimization in the Internet of Things -based Soil Moisture Monitoring System has a working principle with the Node MCU microcontroller. ESP 8266 as 'brain' Which arrange And operate program For manage input signals into output that will be displayed in the application Blynk and Google Sheets. Figure 2 shows the circuit scheme of proposed system.

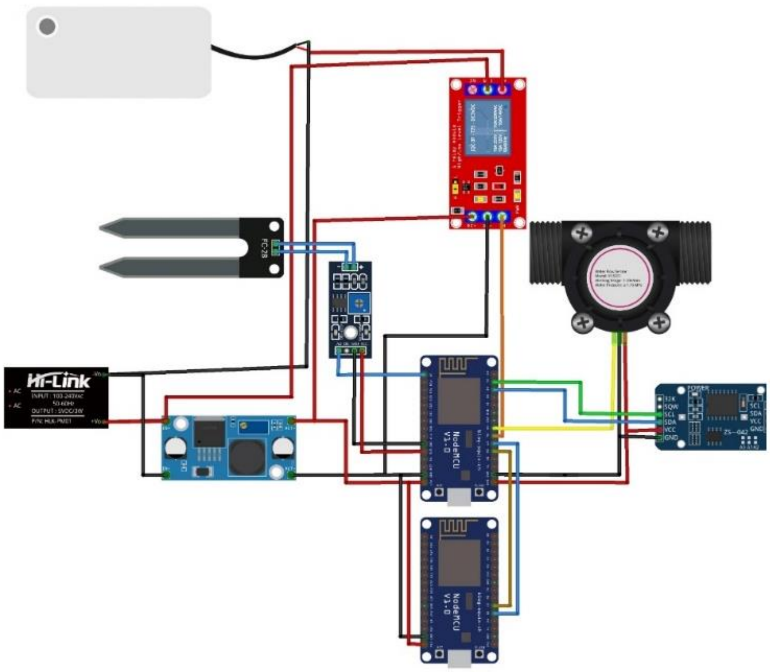


Figure 2. Circuit scheme of proposed system

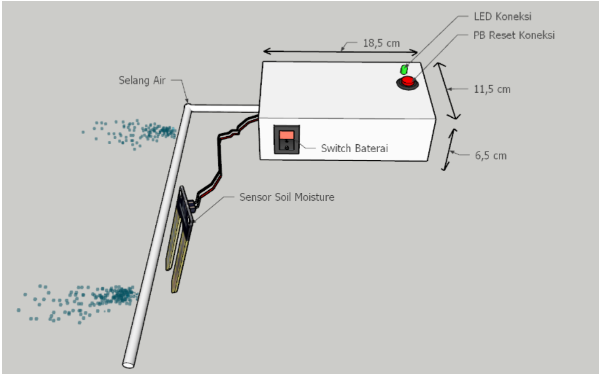


Figure 3. Mechanical design of the tool

The electronic assembly stage includes various processes consisting of combining each component with use cable connector. Figure 3 shows the mechanical design of the tool. This mechanical design must done after parts electronic finished assembled so that The overall tool assembly process can run effectively, before making a tool, the hardware shape of the tool to be made is first designed . The working principle of the "Water Pump Optimization in an Internet of Things -based Soil Moisture Monitoring System " tool This device can automatically control a 12V DC water pump using the Blnyk app on a smartphone. The water pump will turn on automatically when the soil moisture sensor detects 30% moisture and will turn off automatically when the soil moisture sensor detects 60%. When the water pump is running, the waterflow sensor will detect the amount of water flowing through the Blynk app. Data on humidity, water pump output , and time will then be summarized in a Google Sheet. After the device design process on the tool is complete, the next stage is namely creating an algorithm for system settings on a tool that has been created . Framework from idea the in the form of A flowcharts are useful for making it easier to create program. Figure 4 shows the flowchart of proposed system.

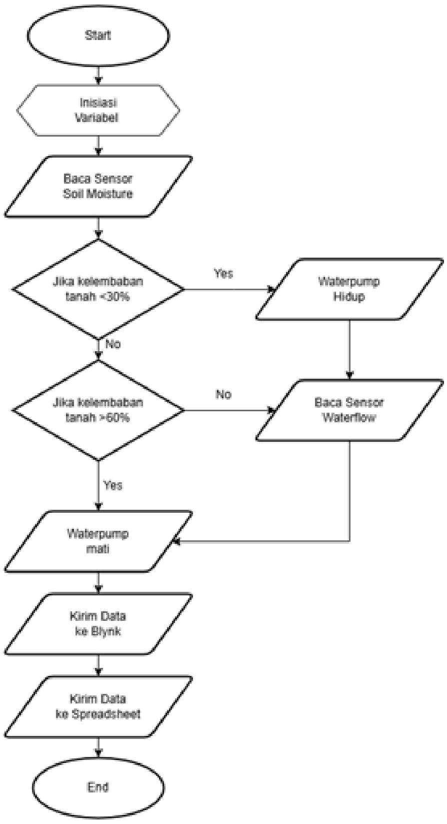
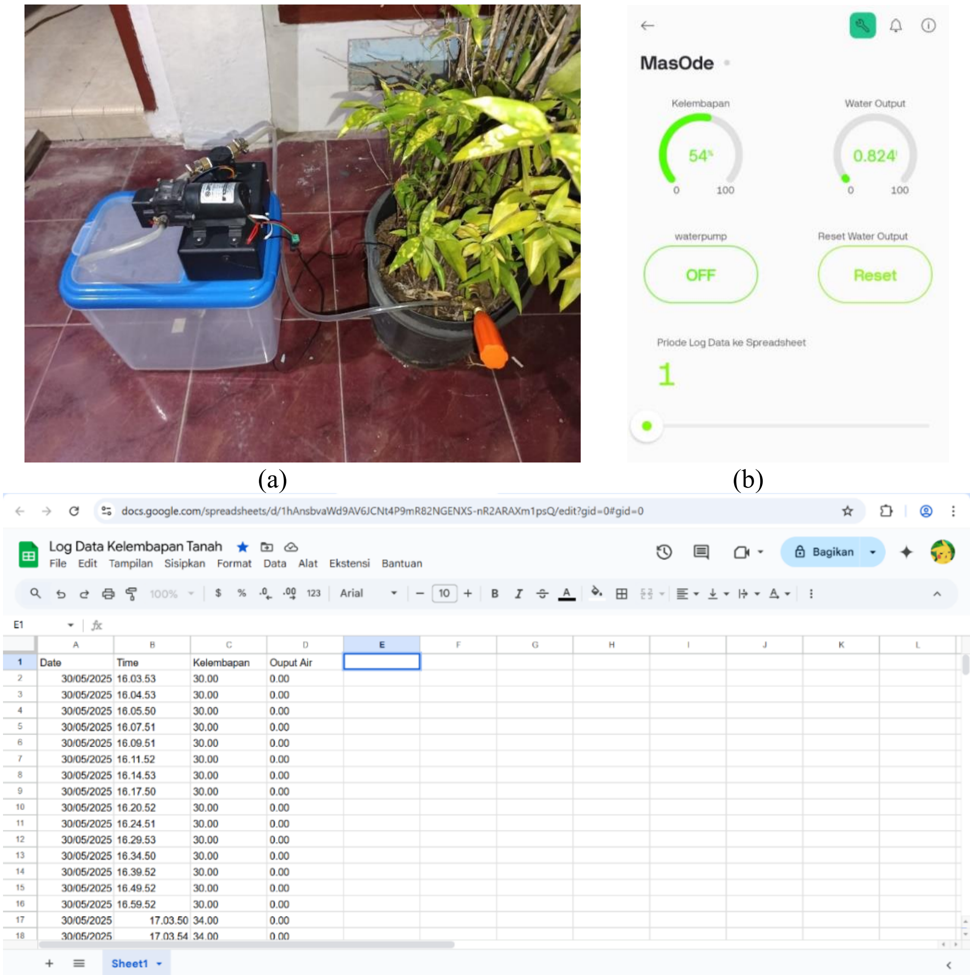


Figure 4. Flowchart of proposed system

3. RESULTS AND DISCUSSION

The purpose of testing and measuring the equipment is to ensure that all components are functioning properly and that the equipment is functioning as intended. Hardware testing was conducted to determine how the hardware circuit for obtaining control and monitoring data for humidity and water flow monitoring through the Blynk and Google Spreadsheet applications on the water pump optimization tool in the internet of things- based soil moisture monitoring system was successfully run. Tool in the Internet of Things -based Soil Moisture Monitoring System is made with a clear box design filled with water which is used for spraying water pump water with x6 boxes containing the tool's electronic circuit.



Date	Time	Kelembapan	Ouput Air
30/05/2025	16.03.53	30.00	0.00
30/05/2025	16.04.53	30.00	0.00
30/05/2025	16.05.50	30.00	0.00
30/05/2025	16.07.51	30.00	0.00
30/05/2025	16.09.51	30.00	0.00
30/05/2025	16.11.52	30.00	0.00
30/05/2025	16.14.53	30.00	0.00
30/05/2025	16.17.50	30.00	0.00
30/05/2025	16.20.52	30.00	0.00
30/05/2025	16.24.51	30.00	0.00
30/05/2025	16.29.53	30.00	0.00
30/05/2025	16.34.50	30.00	0.00
30/05/2025	16.39.52	30.00	0.00
30/05/2025	16.49.52	30.00	0.00
30/05/2025	16.59.52	30.00	0.00
30/05/2025	17.03.50	34.00	0.00
30/05/2025	17.03.54	34.00	0.00

(c)

Figure 5. (a) Photo of the entire tool (b) Blynk view of the tool, (c) Spreadsheet data view of the tool

4. CONCLUSION

Based on the design and testing results of the "Water Pump Optimization in an Internet of Things-Based Soil Moisture Monitoring System," it can be concluded that the designed system has functioned well according to specifications. All system components, including the soil moisture sensor, microcontroller, water pump, and application integration, are able to work synergistically and responsively. The soil moisture sensor demonstrated accurate performance in detecting moisture levels, which is crucial for maintaining soil conditions within the ideal range. In addition, the Blynk application proved effective in monitoring soil moisture status and water output, controlling water pumps remotely, resetting water output readings , and flexibly setting monitoring times. System integration with Google Spreadsheet also worked well, enabling automatic and real-time data recording for more comprehensive historical monitoring. Thus, this system provides an efficient and adaptive solution in data-driven irrigation management, and has the potential to support the implementation of water-efficient and sustainable smart agriculture.

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