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IOT-BASED SMART FARMING IMPLEMENTATION USING THE MQTT PROTOCOL

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Abstract: This research aims to implement smart farming solutions utilizing the MQTT protocol within the framework of the Internet of Things (IoT). The use of IoT technology is expected to increase agricultural productivity and efficiency through better monitoring and control of crop conditions. Analysis, system design, tool development, and functionality testing are the methods used in this research. The results show that the developed system is capable of real-time monitoring of environmental parameters such as soil moisture, temperature, and lighting. This system can provide notifications to users through the red node dashboard regarding plant conditions and maintenance needs such as watering using integrated sensors and MQTT-based communication. This system can also use soil moisture sensor data as an indicator to manually control the water pump actuator at the water source by the user according to the soil moisture status. This research concludes that the implementation of IoT-based smart farming with MQTT protocol can improve efficiency in agricultural management, provide accurate and real-time information for better decision-making, and support the sustainability of agricultural production in the digital era.

Keywords: smart farming, Internet of Things (IoT), MQTT, crop monitoring, MQTT protokol.

INTRODUCTION

In recent decades, the agricultural industry in Indonesia has faced various challenges such as climate change, increasing the world's population, and the need to increase agricultural productivity in a sustainable way, hence the need for a more efficient tool design, hygienic in the process and with records or evidence. To address these issues, Internet of Things (IoT) technology has become one of the promising solutions. Concept (Charging et al., n.d.) smart farming, i.e. smart agriculture, involves the use of digital technology to increase efficiency and productivity in the agricultural sector.

The implementation of IoT in agriculture enables real-time data collection and analysis, helping farmers make more timely decisions. One of the communication protocols that is often used in IoT applications is Message Queueing Telemetry Transport (MQTT). The protocol is specifically designed for lightweight and efficient communication between IoT devices. MQTT is perfect for smart farming applications where many sensors and other devices are connected simultaneously, as it allows devices to interact with low bandwidth and low latency.

This study aims to investigate the application of smart farming based on the Internet of Things through the MQTT protocol. The main focus of this study is to analyze how the application of this technology can improve operational efficiency, reduce production costs, and improve overall crop yields.

Based on the background that has been written before, the researcher makes a problem formulation:

1. How to obtain data on a value from temperature, temperature, soil moisture and light from sunlight which is then used as one of the input variables to measure and monitor the soil and the situation in the agricultural environment in its realization IoT-free Smart Farming.
2. How to control the water supply, temperature, and light from the sun.

The purpose of this study is to obtain data from a different sensor input value that is detected.

In this study, the researcher limited the data from a detected sensor input value which became a benchmark for monitoring water needs in agriculture in real time that can be accessed anywhere.

By using soil moisture sensors that function to obtain data on soil moisture values installed in each garden and temperature and light support sensors with statistical methods to calculate and connect two variables. (Chan et al., 2023)

RESEARCH METHODS

1. ESP32

The ESP32 is a microcontroller developed by Espressif Systems, designed for Internet of Things (IoT) applications. The

ESP32 has the ability to connect devices via Wi-Fi and Bluetooth at the same time.

The research was conducted using a descriptive method to describe and explain the phenomena that occur in the environment in the agricultural sector. The ESP32 will process both analog and digital data from the sensor as input through analog or digital pins and to interface or connect two different devices, in this case integrated with the MQTT broker. Sensor data will be output through a serial monitor according to the baud rade, this data is then sent to the MQTT broker connected to the red node.

2. Soil Moisture

Soil moisture sensor is an analog sensor of soil moisture that functions to measure the value of soil conditions. ESP32 is a microcontroller as a processor of the data transmitted from the soil moisture sensor and sends the data to the mqtt protocol of the localhost web page view server, which can make it easy for users to control with IoT devices. (Dwiyatno et al., 2022)

3. LDR

Sensor is a component that can convert physical quantity into electrical quantity. LDR sensor on the light intensity monitoring system is installed on the top side of the house as a monitoring that only captures natural light that enters the agricultural environment so that the measurement of the amount of light entering can be more easily processed to control plant growth. (Bazir et al., 2022). (Yusa et al., 2023)

4. DHT11

DHT11 is one of the sensors that can measure two environmental parameters at once, namely temperature and humidity. This sensor contains an NTC (Negative Temperature Coefficient) thermistor to measure temperature, a resistive type humidity sensor and an 8-bit microcontroller that processes the two sensors and sends the results to the output pin in a single-wire bidirectional format. (Satria, 2022)

5. Node-Red

Node-Red is a browser-based programming tool used to connect hardware, APIs, and online services. The environmental data read by the sensor every minute, is sent to Node-Red via a wireless network. Then the data is displayed with an interface in the form of a web application using the Node-RED dashboard UI by wireless. (Ambarwari et al., 2021)

6. Protocol MQTT

OSIA's standard messaging protocol for the Internet of Things (IoT) is designed to be simple and lightweight. It uses the publish/subscribe model, which is integrated and ideal for connecting remote devices that have limited memory and computing power, and uses minimal network bandwidth. MQTT server and Node-Red function to display the data monitoring results of sensor test components. On MQTT the server used is localhost 1880 which can be displayed with the MQTT broker application on the desktop. Figure 1 is an integrated image of the MQTT protocol. (Al Husaini et al., 2021)

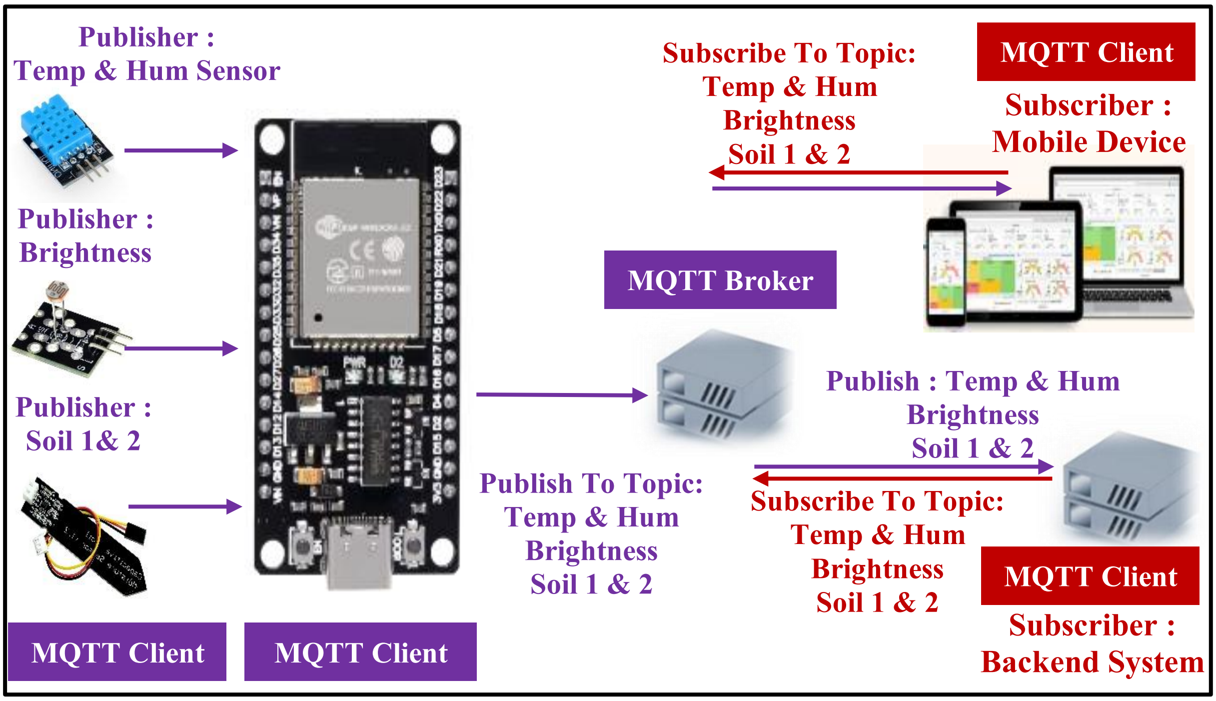


Figure 1. Modbus RTU/TCP Integration of MQTT Protocol and Node-Red Web Dashboard (Processed by researcher)

RESEARCH RESULTS

1. Network Smart Farming With MQTT Protocol

Figure 2 is a picture of the network Smart Farming With MQTT Protocol in this study. Project Smart Farming The research made in this study uses a soil moisture sensor to measure soil moisture, an LDR sensor to detect light intensity, and a DHT11 sensor to measure air temperature and humidity. The actuator used is 5V DC relay as a switch, 5V DC water pump as a water supplier to meet the water needs of plants, LED as an indicator.

In this study, it was carried out to obtain data or quantitative results from sensor values when detecting objects that are used as one of the variables used in smart farming projects.

ESP32 as a data processor from an input/user that is used to connect other electronic devices to carry out operations and obtain analog and digital signals from sensors, sensors also have several types such as heat sensors, sound sensors,

sensors also have several types such as light sensors, proximity sensors, temperature sensors and many other sensors and then with the serial rate monitor is used to record data that will be analyzed then the data will be sent to the Node-Red dashboard with the MQTT protocol which acts as a subscriber and publisher according to Figure 1. (Prayogo et al., n.d.)

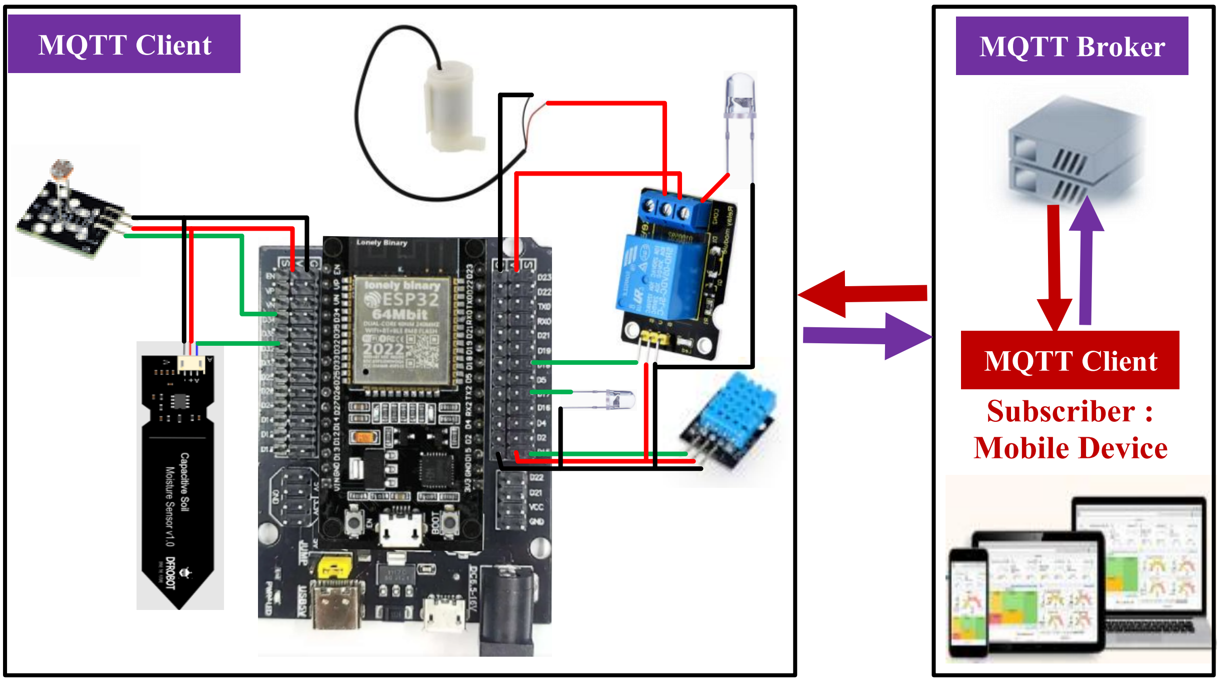


Figure 2. Smart Farming Network
(Processed by researcher)

2. Aliran Flows at Node-Red Dashboard

Figure 3 is a desian image flow at Node-Red Dashboard from the project Smart Farming in this study. Flow at Node-Red as a visual representation of the process that functions as a subscriber/publisher of an application that is designed using a collection of nodes that are interconnected

Connected. Each node has a specific function, such as receiving inputs, processing data, or output and storage/processing flows are stored in JSON format, making them easy to import or export and share with other users. The nodes used in the Node-Red Dashboard flow are as follows:

1. MQTT in is a network nodes that function to receive messages from brokers. MQTT is based on a predetermined topic with a unique topic.

2. MQTT out is a network nodes that functions to send messages to MQTT brokers

with topics that have been determined in this study to activate water pump actuators and LEDs.

3. Debugs are common nodes that function to display messages or data from other nodes in the Flow in real-time, as in this study, data from soil moisture, LDR, and DHT11 sensors.

4. Function functions to write custom JavaScript code to process message objects in node flows, manipulate complex data and integrate with external APIs.

5. Gauges are dashboard nodes, one of the basic components in making dashboards to visually show numerical values and there are options for gauge, donut, compass and level types.

6. Charts are dashboard nodes, one of the basic components in creating dashboards to display data in the form of graphics such as lines, bars, pie, polars, and radar.

7. Buttons are dashboard nodes that are used to capture user interaction and send messages to the flow, in this study it is used for water pump and LED control.

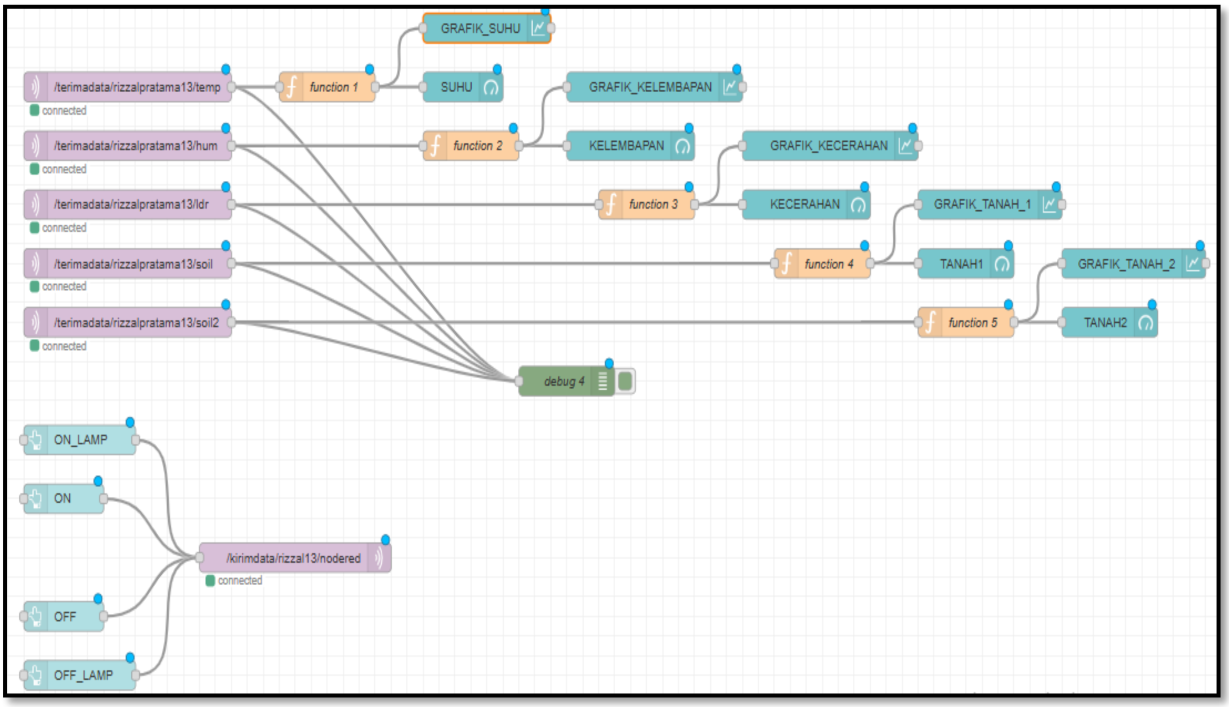


Figure 3. Design of flows on Node-Red Dashboard

3. Chart Results from Sensor Soil Moisture, LDR, dan DHT11

Signal graph detected by Sensor Solil Moisture, Sensor LDR, dan The DHT11 sensor is then processed by the ESP32 microcontroller and displayed via the serialprint function. The sound sensor signal graphic data can be seen as shown in Figure 4. to Figure 9.

In this study, data was taken in real time on the Node-Red user interface dashboard with different data. Data from the Node-Red and MQTT dashboards that are then stored on the Laragon Server and internet network are very important for communication between microcontroller devices with the MQTT protocol.

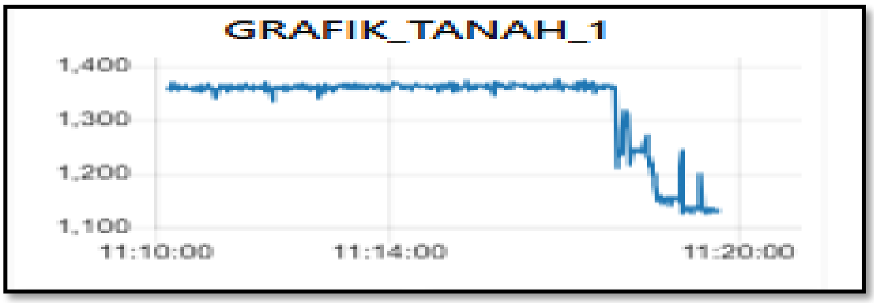


Figure 4. Soil Moisture Sensor Signal Graph 1 with Detection Value 1135

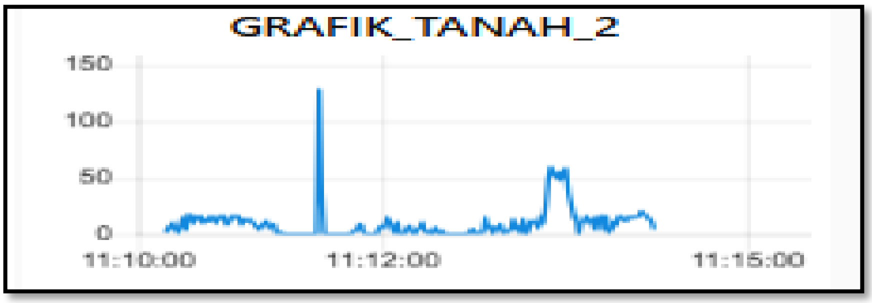


Figure 5. Soil Moisture Sensor Signal Graph 2 with Detection Value of 9

Figure 6. LDR Sensor Signal Graph with Detection Value of 1018 High Light Intensity

Figure 7. LDR Sensor Signal Graph with Detection Value of 4095 Low Light Intensity

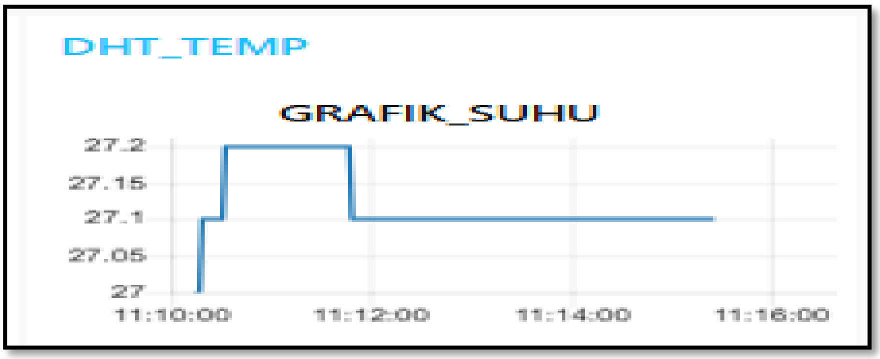


Figure 8. DHT 11 Sensor Signal Graph with Temperature Detection Value 27.10 Celsius

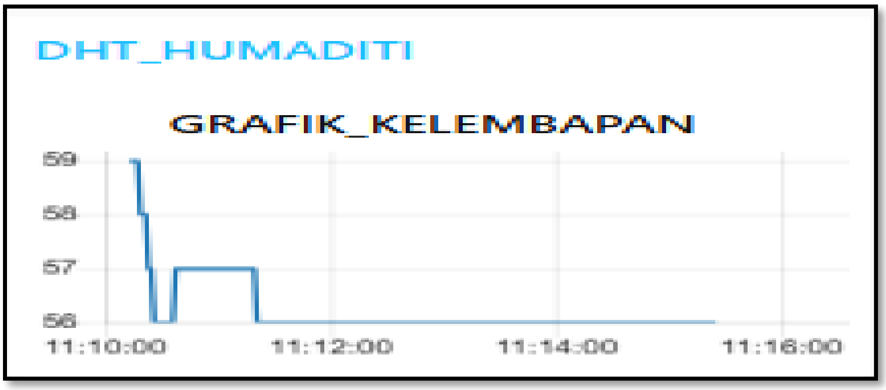
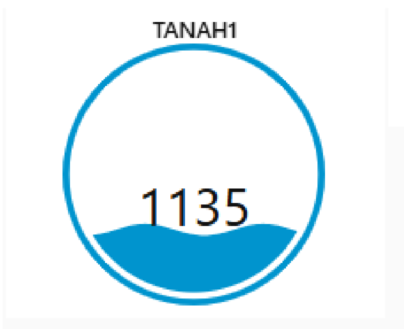


Figure 9. DHT 11 Sensor Signal Graph with 56% Humidity Detection Value

4. Output Results from Sensor with Node-Red Gauge Function

The following is a picture of the output of the Soil Mosurire Sensor, LDR Sensor and DHT11 Sensor on the Node-Red Gauge function in this study can be seen in figures 9 to 12.



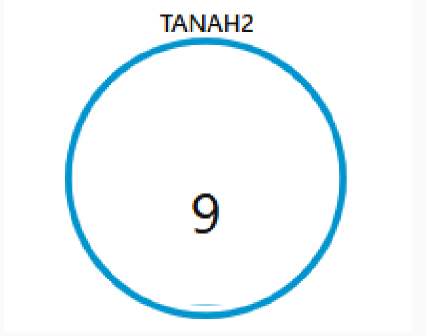


Figure 9. Data Sensor Soil Moisture

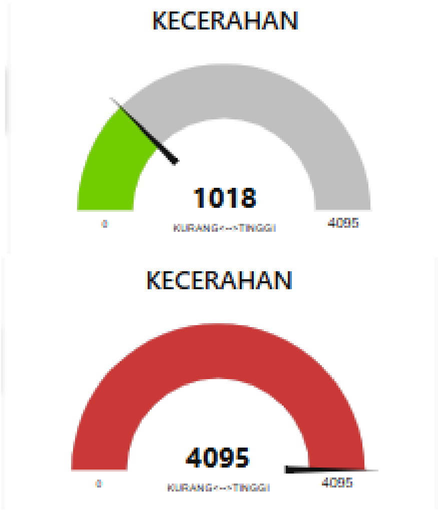


Figure 10. Data Sensor LDR

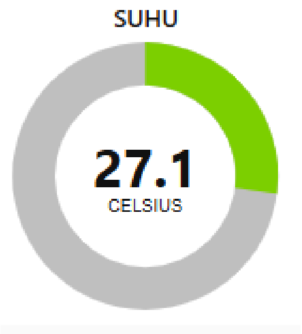


Figure 11. Data Sensor DHT11 Temp

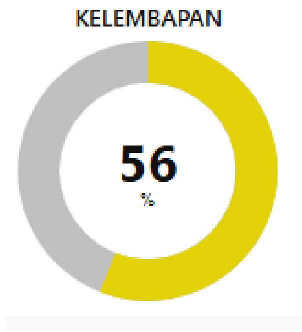


Figure 12. Data Sensor DHT 11 Humidity

From the results of the image above, there is a difference between each Sensor data value as follows:

1. Soil Mositure sensor which is affected by soil moisture texture.
2. LDR sensor that is affected by light intensity.
3. DHT 11 sensor which is affected by the air temperature in the surrounding environment.

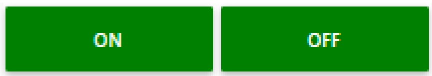


Figure 13. Green Button to turn on the Water Pump

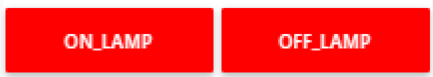


Figure 14. Green Button to turn on the Garden Lights

DISCUSSION

Based on the research of the project that has been made with the output data from the sensor that is visible and displayed on the Node-Red dashboard, with the chart function displaying graph data and the gauge function displaying the level data from each sensor. We can analyze that the output signal from the sensor component has different characteristics and functions.

In Figure 9, which is the result of data Tanah_1 signals from the soil moisture sensor 1, we can see that the signal is >1000 with the parameters of moist soil texture or sufficient water supply and the Tanah_2 data from the soil moisture sensor 2 we can see that the signal is <1000 with the parameters of dry soil texture or insufficient water supply.

In Figure 10, which is the result of signal brightness data from the LDR sensor, we can see that the 1st signal is <2000 with high/light intensity parameters and the 2nd signal is >2000 with low/low or dark light intensity parameters.

In Figure 11, which is the result of signal temperature/temperature data from the DHT 11 sensor, we can see that the signal is valued at 270 Celsius with temperature parameters in the Comfortable category.

In Figure 12, which is the result of the humidity data from the DHT 11 sensor, we can see that the signal is 56% with the air humidity parameter in the medium category and sufficient for plant growth.

In Figure 13 which is the navigation button to activate the relay which functions as a switch for the On/Off water pump as an actuator that supplies water.

In Figure 14, which is the navigation button to activate the LED which functions as a switch illumination for the On/Off water pump as an actuator that supplies water.

From these data, each has a safe and convenient value category parameter to monitor plant growth:

Table 1. Safe value parameters at Temperature, Light Intensity and Humidity

Parameter	Rentang Nilai Aman	Penjelasan
Intensitas Cahaya	50% - 100% (2.587 - 4.287 lux)	Intensitas cahaya optimal untuk fotosintesis dan pertumbuhan tanaman, tergantung jenis tanaman.
Suhu	22°C - 30°C	Suhu ini mendukung aktivitas metabolisme dan fotosintesis tanaman secara optimal.
Kelembaban Tanah	40% - 75% kapasitas lapang	Kelembaban tanah yang cukup menjaga kesehatan akar dan mendukung pertumbuhan tanaman.

COVER

By using the MQTT protocol, this system shows reliable data communication efficiency with low latency and high bandwidth efficiency, the creation of a smart farming project in this study implements an Internet of Things-based smart farming system. It uses an LDR sensor to monitor light intensity, a Soil Moisture sensor to detect soil moisture, and a DHT11 sensor to measure air temperature and humidity.

The test results show that the system is able to monitor the conditions of the agricultural environment in real-time with the Node-Red dashboard, the user interface operator can monitor changes in environmental parameters based on the soil humidity level and lighting control based on light intensity wherever it is, such as when the soil needs water supply, the operator can activate the water pump at a long distance with an internet or wireless connection.

, It is hoped that this research will be the basis for further development in the use of Internet of Things technology to improve agricultural productivity and sustainability.

The suggestion from the researcher is that the IP address used should use the user's IP address, because if you use the built-in localhost IP of the protocol, there is a possibility of clollision data or data collisions. To anticipate this, the researcher uses a unique topic to minimize the occurrence of collisions.

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