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IOT MONITORING WATER NEEDS IN RICE FIELDS

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Abstract

Water management is a very important role in the success of increasing rice production in fields. This study took a case study on irrigated rice fields. In an effort to improve the quality and efficiency of water management in rice fields, a good monitoring system is also needed. Generally, monitoring has been done manually so far, the interaction between farmers and irrigation officers is still using the telephone, which costs a lot of money. With the IoT (Internet of Things) technology, it can be applied to a monitoring system for managing water needs in rice fields using mobile-based AHP, which is a system that provides notifications in the form of information on water levels and the best humidity values for rice plants in rice fields in real-time and is able to deliver reports via internet transmission media. This study aims to obtain the value of report delivery speed through monitoring applications and to be able to detect water levels and soil moisture in paddy fields using the Analytical Hierarchy Process (AHP) method and sensor accuracy so that the results are as expected. The research data has been obtained by looking at the suitability of soil moisture information in the application with the ETP302 measuring instrument with an accuracy value of 86.12% and the water level in applications with an actual water level of 66.35%. In testing the speed of sending reports an average value of 1.67 s. In the best soil moisture detection test using the AHP method, the suitability value is up to 91.7% and the water level reaches 93.4%. The sensor can also be turned off or on through the monitoring application.

Keywords: ***Monitoring systems, water management in fields, IoT (Internet of Things), humidity sensors, ultrasonic sensors, Analytical Hierarchy Process (AHP), mobile applications.***

1. INTRODUCTION

The percentage of water use efficiency in irrigated paddy fields is still relatively low. Efficiency levels in primary and secondary channels are estimated at 70-87%, tertiary channels between 77-81% and when combined with losses at the plot level, the overall water use efficiency is 40- 60%.[1]. Water use efficiency in paddy fields is needed so that water can be distributed evenly. The problem that is still faced is the inability of farmers to check and control the irrigation system, especially in irrigated rice fields, so they are unable to know the water needs of rice fields. Water management plays a very important role and is one of the keys to a successful harvest and increased rice production in paddy fields. For this reason, a system is needed that can facilitate monitoring activities carried out by farmers and irrigation officers. This research is related to previous researchers about "Irrigation System in Multi-storey Rice Fields Using Wireless Sensor Network". In this research, a circuit is made using Arduino Uno, servo, ultrasonic sensor, bluetoooth module and NRF24L01 module to design a water detection system in rice fields and a sluice gate opening and closing system using WSN (Wireless Sensor Network) which can be monitored and controlled through a mobile application. Ultrasonic sensor is used to detect water level and servo to open and close the sluice gate. For communication between nodes, NRF24L01 module is used and for communication to the mobile application, Bluetooth module is used. The programming language used is C language which is used to programme the Arduino Uno. The results of the comparison of water level measurements using ultrasonic sensors and manual measurements have the same error of 5 mm and obtained the results of 15 experiments in one time processing from land 1 to land 3 is 524.66 ms and from land 2 to land 3 is 405.33 ms.[2]

This research is related to previous researchers about "Protoriping Water Level Monitoring System and Sluice Control on ATMEGA16 Microcontroller-Based Irrigation Network Using Short Message Service (SMS)". In this research, an automatic system is made that checks the water level on farmland using SMS as control and media to receive monitoring results. The circuit used uses Atmega16 microcontroller, potentiometer, ULN2003 driver, DC motor, LCD and WAVECOM M13026B SMS modem. The user will send a message in the form of a code to the SMS Modem and the ATMEGA16 Microcontroller will execute a command to check the water level using a potentiometer or move the DC motor to open / close the floodgates.[3] This research is related to previous researchers about "Application of Internet of Things (IoT) on Irrigation Monitoring System (Smart Irrigation)". In this research, a system was created to monitor water levels, water discharge, temperature, and weather. The system can also control the dam door opening and closing system automatically accompanied by a notification either through the website or SMS if at any time the water overflows.

The Smart Irrigation device consists of 4 sensors connected to the Wemos D1 mini microcontroller including, a waterflow sensor that functions as a sensor to calculate the water discharge flowing in the irrigation system, the second temperature sensor that functions to detect the ambient temperature, the third rain sensor that functions as a weather detector, then the water level sensor to detect the water level of the irrigation channel system. Then the Smart Irrigation device is embedded with a servo and gsm module as a means of controlling the irrigation system, the servo functions to open or close the dam door. The sensors installed in the irrigation system are connected to the internet network. Data from sensors will be sent via the internet network in real-time. Users can perform controling and monitoring activities by opening the website address that has been created to display data from sensors in the Smart Irrigation system. To access the server/website on the Smart Irrigation system, users can use a personal computer/laptop or by using a smartphone.[4]. This research is related to previous researchers about "Design of Solar-Based Rice Field Pipe Irrigation Automation System". In this research, an automatic control system is made by utilising digital technology, microcontrollers and sensor networks. The Arduino Uno ATMega328P microcontroller is used as an automatic control system to drive the Valworx 561086 electric water tap actuation system based on soil moisture and water level in paddy fields detected by sensors. The value of the water level in the paddy field is set between 0 cm and 5 cm as the lower and upper setpoints for reference in driving the Valworx 561086 electric water tap actuation system.

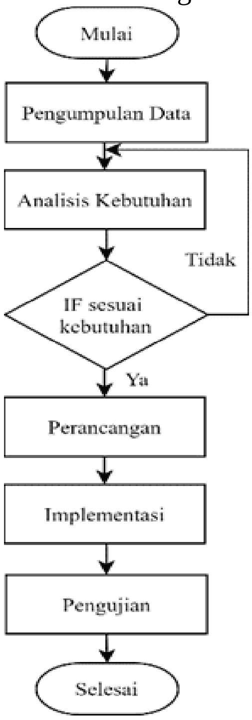
The microcontroller system limits the time duration for the opening and closing settings of the Valworx 561086 electric water tap to 300 seconds with a 90º rotation which can save battery power usage. The system is powered by solar energy consisting of solar panels, charger controller and battery, and can operate 24 hours without operator supervision. Operation trials in paddy fields were carried out by applying intermittent irrigation and irrigation water does not flow continuously. The experimental results show that the automatic irrigation control system can maintain the water level in the paddy field between the desired setpoint ranges.[5]. This research is related to previous researchers about "Remote Control of Rice Paddy Irrigation System Based on Internet Of Things (IoT)". In this research, a system for automatic irrigation control using Wemos D1 ESP8266 is made to be a tool made to help farmers make it easier to flow water to irrigate their rice fields remotely in real time. This tool aims to increase the effectiveness of farmers' work. Through this tool, it is also expected to simplify the work of farmers. The hardware used as a portal is using a servo motor to take water level data using an HC-SR04 ultrasonic sensor and as a control centre using a Wemos D1 ESP8266 microcontroller. In this irrigation portal control system, control is carried out using an android application that is connected to the controller node through the apy key from web hosting, then after the portal is open the water level data from the controller node is sent and displayed in the application. The process of controlling this system can be done anywhere anytime when connected to the internet in realtime. System testing uses prototype rice fields, testing parameters for the success of control functionality and connectivity. In testing using 3 different connectivity results in an average control delay with providers that have different speeds of 5.819 seconds, 3.545 seconds and 7.333 seconds after the control process from the application.[6]

In this research, a system is created that can monitor the condition of water distribution from irrigation and water availability in rice fields through mobile applications. This system will be supported by Internet of Things (IoT) technology as a vehicle that detects soil moisture and water level in rice fields. The system will determine the ideal soil moisture and water level based on the prioritisation of rice growth phases from agricultural experts using the AHP (Analytical Hierarchy Process) method, then display a notification to the user.

2. METHOD

2.1 Research Stages

The research stages used in this research are data collection, needs analysis, if in the needs analysis there is no change in needs, it will proceed to the design, implementation and testing stages. The flow chart of the research stages can be seen in Figure 1 below.



Flowchart of Research Stages

2.2 Data Collection

At this stage, data collection includes literature study and questionnaire techniques as follows:

1. Literature Study
   The literature study contains a series of search activities and assessment of relevant and trusted sources in the collection of material and becomes a reference in this writing. The literature we use is focused on monitoring systems, irrigation systems in rice fields, growth phases of rice plants, water needs in rice plants, AHP methods, android software hierarchies, mechanical and system designs on Wemos D1 microcontrollers, humidity sensors and ultrasonic sensors.
2. Questionnaire Technique
   In this technique, questions were asked to agricultural experts in the form of determining the scale of importance of soil moisture from each phase of rice plant growth. This technique is used as material for calculations using the Analitycal Hierarchy Process (AHP) method.

2.3 Needs Analysis

Needs analysis includes hardware and software. The specifications needed for making the system are as follows.

The hardware used in this research is as follows:

1. Laptop/Computer
2. Android Smartphone

3. Wemos D1 R2 ESP8266 Microcontroller
4. Moisture sensor (Soil Moisture)
5. Ultrasonic sensor

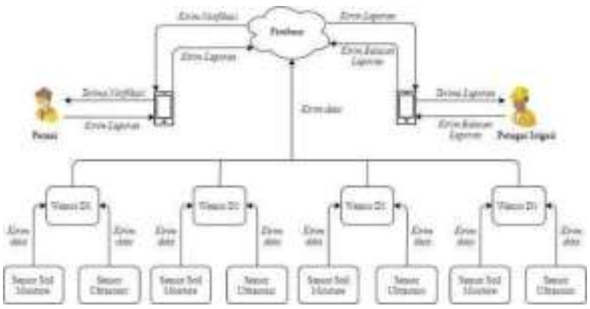
The software needed in this research is as follows:
1. Windows Operating System
2. Android Studio
3. Arduino IDE

2.4 Design

In the design of the "Monitoring System for Management of Rice Field Water Needs Using Mobile- Based AHP", hardware design, user interface design and hardware wiring diagrams are carried out.

1. Hardware Design

   Hardware design is the design of the tool's working system which can be seen in Figure 2 below.



Hardware design

Based on Figure 2, the hardware design starts by programming four Wemos D1 microcontrollers to be able to detect soil moisture and water level using moisture sensors and ultrasonic sensors. The sensor circuit will be positioned at four points on the rice field. Wemos D1 will send real-time data to firebase via the internet. After installing the application, the user will get information on water level and soil moisture from firebase. Users can send reports through the monitoring application to irrigation officers and receive notifications.

2. User Interface Design

a. Display of Login Page and Main Menu

   The login view is a page for users to enter the system. The main menu display will display information on soil moisture and water level values along with averages and AHP classification values from four sets of sensors connected to the real-time database on firebase. There will be four on/off control buttons. The design of the login page and main menu can be seen in Figure 3 below.

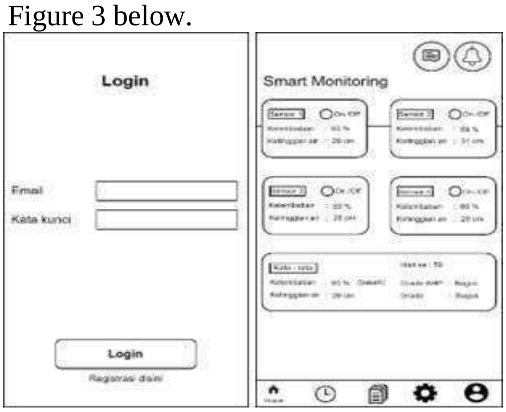
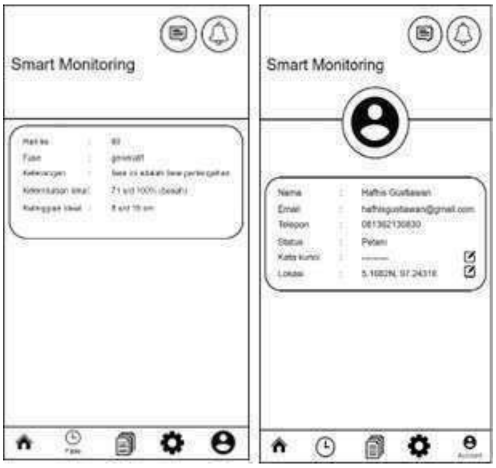


Figure 3. Display of Login Page and Main Menu

b. Phase and Account Menu Display

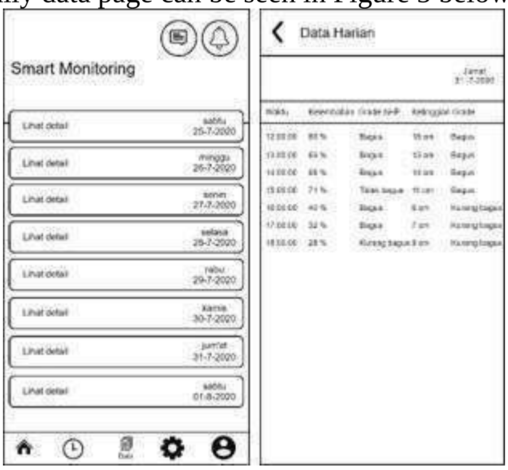
The phase view is a page that will display the results of the current phase detection. The account menu display is a page that will display information from logged-in users. The design of the phase and account menus can be seen in Figure 4 below.



Phase Menu Display

c. Data Menu Display

The data menu display is a page that will display a list of daily wemos d1 detections. The design of the daily data page can be seen in Figure 5 below.



d. Rule Menu Display

The rule menu display is a page that contains the classification of soil moisture using AHP and water levels which can be seen in Figure 6 below.

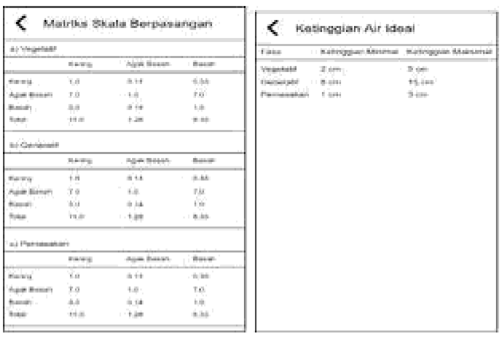


Figure 6. Display of Rule Menu

e. Reporting and Notification Page Display

This display is a page that will be used by users to report to users from the irrigation officer side or vice versa and view notifications. The design of this page can be seen in Figure 7 below.

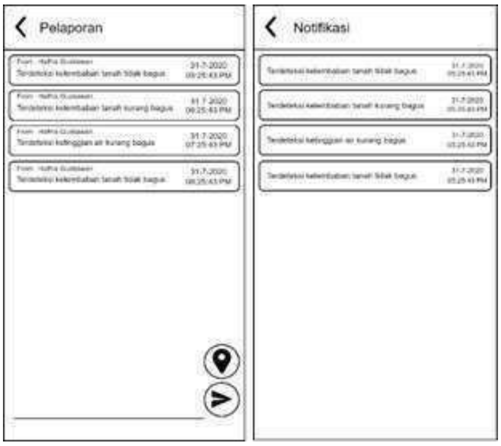


Figure 7. Display of Reporting and Notification Page

3. Hardware Wiring Diagram

Hardware wiring diagram will explain the design of the cable path between Wemos D1 with soil moisture sensor and ultrasonic sensor.

a. Soil Moisture Sensor Wiring Diagram

This wiring diagram uses a soil moisture sensor to detect soil moisture. Pin A0 serves as input, pin D5 as Charge or +5V current and Gnd as Ground. Wiring sensors can be seen in Figure 8 below.

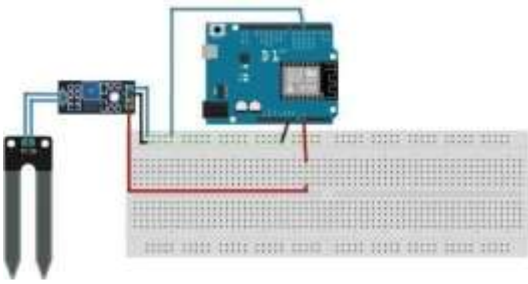


Figure 8. Wiring Diagram of Soil Moisture Sensor

b. Wiring Diagram of Ultrasonic Sensor

This wiring diagram uses an ultrasonic sensor to detect the water level. Pin D6 serves as a transmitter voltage source to send sound signals from the ultrasonic sensor. Pin D7 functions as a data receiver from the receiver. Vcc as Charge or +5V current and Gnd as Ground. Wiring sensors can be seen in Figure 9 below.

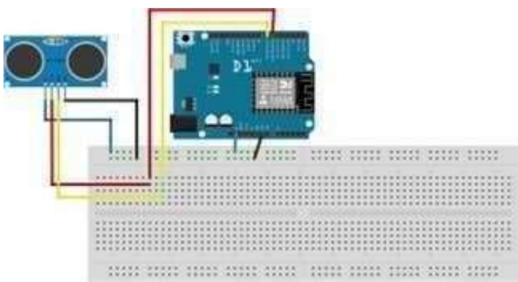
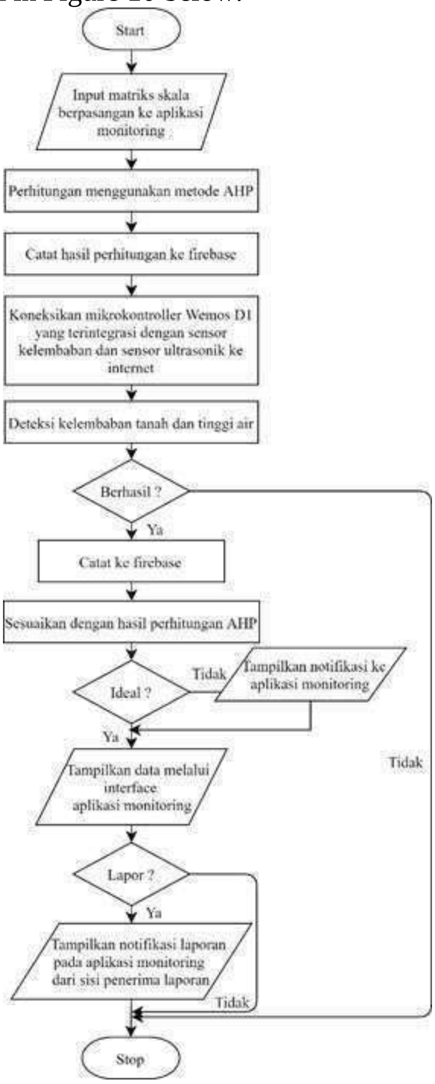


Figure 9 Wiring Diagram of Ultrasonic Sensor

2.5 Implementation

At this stage the author begins to discuss the schematic of the tool and the algorithm of the system built with the description of the flow chart.

1. System Implementation Design
   This design can be seen in Figure 10 below.



System Implementation Design

Based on Figure 10, the system implementation starts by inputting a paired scale matrix and the system will perform calculations and save the results to firebase firestore. After the user connects the Wemos D1 to the internet, the Wemos D1 along with the moisture sensor and ultrasonic sensor will detect soil moisture and water level in the rice field. The data will be stored in the firebase real-time database, and adjusted to the results of calculations using AHP. If the detected soil moisture value is not ideal, the system will notify the user. Otherwise, the monitoring application will read data from the firebase real-time database and then display it through the monitoring application interface. Users can send reports through the monitoring application from the reporting side (farmers) to the report recipient (irrigation officers) or vice versa based on the detected data. Notification of incoming reports will appear from the monitoring application on the receiving side of the report and lead directly to the monitoring application report delivery system

2. AHP Method

The stages of research using the AHP method can be seen in Figure 11 below.

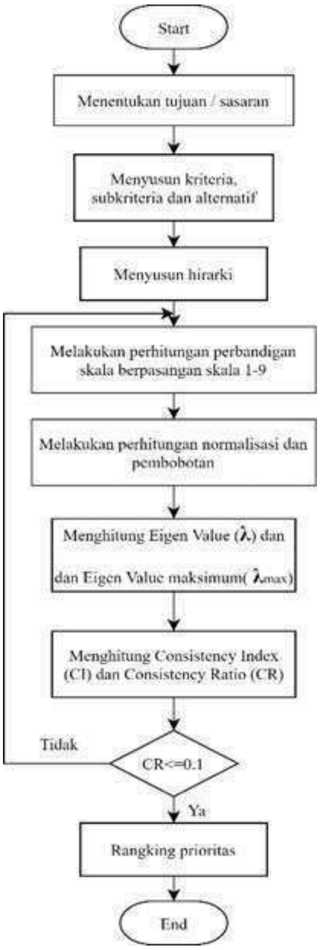


Figure 11: Standardised AHP Method Formation

Based on Figure 11, the initial stage of the AHP method is to determine the goals or objectives of the research. From these goals, a hierarchical structure will be arranged with the topmost order being goals, then followed by criteria or sub-criteria and alternatives. Each criterion or sub-criteria will be calculated on a 1-9 priority scale comparison. Then, calculations are carried out based on predetermined formulas. And in the final stage, the priority ranking is determined based on the highest score.

2.6 Testing

The testing stages are as follows:

1. Tested the accuracy of the humidity and water level data detected in the paddy field.
2. Testing the speed of data transmission in the
3. monitoring application during the reporting process.
4. Test the ability of the system to detect the best moisture value and water level in paddy fields based on the AHP method.

3. RESULTS AND DISCUSSION

A. Device Suite Implementation

The installation of the device circuit is done to find out whether the system has a circuit error or not, the circuit display can be seen in Figure 12 below

Figure 12. Device circuit

B. User Interface Design

a. Display of Login Page and Main Menu

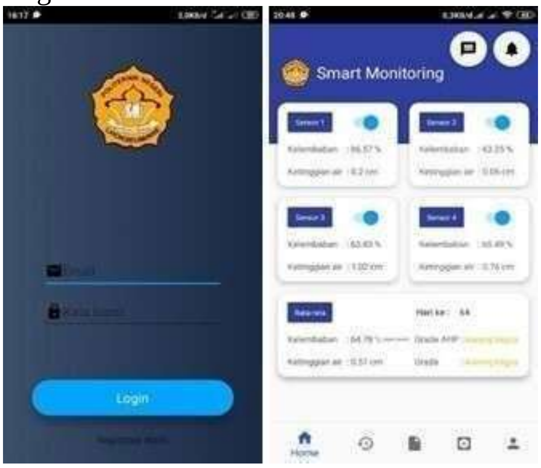


Figure 13. Display of Login Page and Main Menu

b. Phase and Account Menu Display

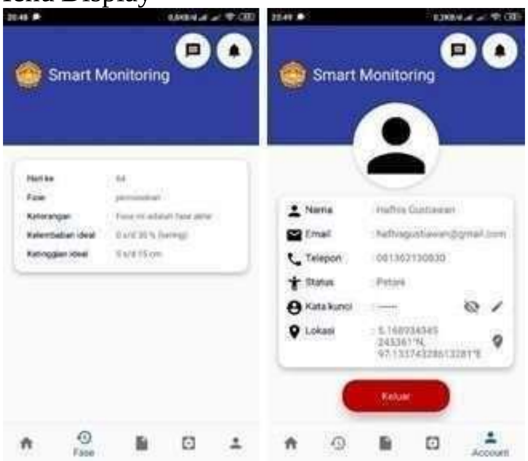


Figure 14. Phase Menu Display

c. Data Menu Display

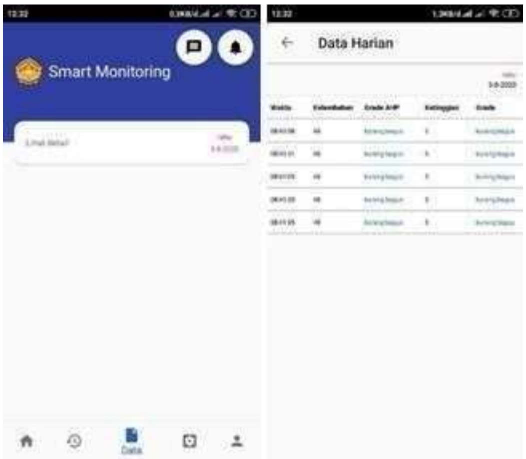


Figure 15. Data Menu Display

d. Rule Menu Display

Figure 16. Display of Rule Menu

e. Reporting and Notification Page Display

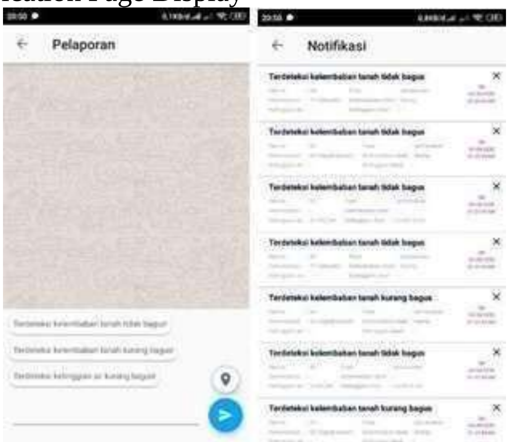


Figure 17. Display of Reporting and Notification Page

C. Testing

System testing is carried out to determine whether the system can function effectively and can produce outputs as expected. Testing begins with testing the components or sensors in the system separately and then testing as a whole.

D. Testing Soil Moisture Information on the Application

This test is conducted to determine the suitability of the data displayed in the application with the actual soil moisture based on the average error value of the soil moisture sensor. Testing soil moisture information is carried out on all four soil moisture sensors by calibrating data from the application with the measurement results of the ETP302 soil moisture / pH meter.

The parameters measured during the test have been engineered to shorten the time. To engineer the soil moisture, a sample of growing media that is given water is used, which is given water little by little. The test results of soil moisture information on the soil moisture sensor can be seen in table 1 below.

TABLE I
SOIL MOISTURE INFORMATION TESTING

Sensor	**Application (%RH)**	**ETP302 (%RH)**	***Error* (%RH)**	**Percentage *error***
1	21,41	20	1,41	7,05%
	22,97	20	2,97	14,85%
	22,97	20	2,97	14,85%
	23,07	20	3,07	15,35%
	23,26	20	3,26	16,3%
	23,07	20	3,07	15,35%
	23,17	20	3,17	15,85%
	23,26	20	3,26	16,3%
	24,05	20	4,05	20,25%
	23,95	20	3,95	19,75%
	47,1	40	7,1	17,75%
	46,3	40	6,3	15,75%
	46,1	40	6,1	15,25%
	46,14	40	6,14	15,35%
	44,13	40	4,13	10,325%
	49,14	40	9,14	22,85%
	45,62	40	5,62	14,05%
	46,1	40	6,1	15,25%
	47,3	40	7,3	18,25%
	46,13	40	6,13	15,325%
	79,3	70	9,3	13,286%
	77,14	70	7,14	10,2%
	77,1	70	7,1	10,143%
	75,13	70	5,13	7,329%
	74,9	70	4,9	7%
	77,3	70	7,3	10,429%
	76,1	70	6,1	8,714%
	76,94	70	6,94	9,914%
	76,1	70	6,1	8,714%
	75,9	70	5,9	8,429%
	23,07	20	3,07	15,35%
	22,87	20	2,87	14,35%
	22,48	20	2,48	12,4%
	22,39	20	2,39	11,95%
	22,39	20	2,39	11,95%
	22,39	20	2,39	11,95%
	22,29	20	2,29	11,45%
	22,29	20	2,29	11,45%
	22,19	20	2,19	10,95%

2	22,09	20	2,09	10,45%
	45,0	40	5,0	12,5%
	45,2	40	5,2	13%
	49,91	40	9,91	24,775%
	40,11	40	0,11	0,275%
	44,78	40	4,78	11,95%
	48,6	40	8,6	21,5%
	43,1	40	3,1	7,75%
	43,42	40	3,42	8,55%
	46,65	40	6,65	16,625%
	46,13	40	6,13	15,325%
	79,3	70	9,3	13,286%
	77,7	70	7,7	11%
	69,3	70	0,7	1%
	66,92	70	3,08	4,4%
	73,14	70	3,14	4,486%
	74,0	70	4,0	5,714%
	79,3	70	9,3	13,286%
	74,18	70	4,18	5,971%
	73,89	70	3,89	5,557%
	73,21	70	3,21	4,586%
3	21,99	20	1,99	9,95%
	22,19	20	2,19	10,95%
	22,29	20	2,29	11,45%
	22,19	20	2,19	10,95%
	22,29	20	2,29	11,45%
	21,9	20	1,9	9,5%
	21,9	20	1,9	9,5%
	21,9	20	1,9	9,5%
	26,88	20	6,88	34,4%
	22,19	20	2,19	10,95%
	47,11	40	7,11	17,775%
	47,72	40	7,72	19,3%
	43,33	40	3,33	8,325%
	48,8	40	8,8	22%
	45,34	40	5,34	13,35%
	46,62	40	6,62	16,55%
	49,32	40	9,32	23,3%
	50,3	40	10,3	25,75%
	51,11	40	11,11	27,775%
	49,5	40	9,5	23,75%
	71,8	70	1,8	2,571%
	79,1	70	9,1	13%
	79,3	70	9,3	13,286%
	74,18	70	4,18	5,971%
	71,23	70	1,23	1,757%
	82,67	70	2,67	3,814%
	73,0	70	3,0	4,286%
	81,2	70	1,2	1,714%
	81,7	70	1,7	2,429%
	80,2	70	0,2	0,286%
	27,27	20	7,27	36,35%

4	27,47	20	7,47	37,35%
	27,57	20	7,57	37,85%
	27,57	20	7,57	37,85%
	28,25	20	8,25	41,25%
	28,45	20	8,45	42,25%
	20,63	20	0,63	3,15%
	21,41	20	1,41	7,05%
	21,6	20	1,6	8%
	21,6	20	1,6	8%
	42,0	40	2,0	5%
	46,1	40	6,1	15,25%
	46,41	40	6,41	16,025%
	45,5	40	5,5	13,75%
	45,0	40	5,0	12,5%
	49,4	40	9,4	23,5%
	49,0	40	9,0	22,5%
	40,12	40	0,12	0,3%
	41,0	40	1,0	2,5%
	40,2	40	0,2	0,5%
	79,3	70	9,3	13,286%
	87,7	70	17,7	25,286%
	87,0	70	17,0	24,286%
	87,7	70	17,7	25,286%
	84,0	70	14,0	20%
	80,0	70	10,0	14,286%
	79,0	70	9,0	12,857%
	82,32	70	12,32	17,6%
	80,1	70	10,1	14,429%
	82,2	70	12,2	17,429%
Total				1665,25%

Based on table 1 by conducting 120 tests on each sensor, the average percentage of the overall error can be calculated with the calculation below.

$$\frac{Total\ error\ (\%)}{Total\ Pengujian} = \frac{1665{,}25\%}{120} = 13{,}877\%$$

So it can be taken that the percentage of soil moisture error displayed in the application is 13.877% and it can be concluded that the system can detect soil moisture well with an accuracy value of up to 86.123%.

E. Testing Water Level Information on Applications

This test is conducted to determine the suitability of information from ultrasonic sensors displayed by the application with the actual water level based on the average value of the sensor error. Testing of water level information is carried out on all four ultrasonic sensors. The parameters measured during the test have been engineered to shorten the time. To engineer the water level, examples of planting media are used which are given water starting from a water level of 0 cm, 1 cm to 4 cm. The results of testing the water level information on the ultrasonic sensor can be seen in table 2 below.

TABLE II
TESTING WATER LEVEL INFORMATION

Sensor	Water height (cm)	Application (cm)	*Error* (cm)	Percentage *error*
1	0	0,37	0,37	37%
	0	0,4	0,4	40%
	0	0,37	0,37	37%
	0	0,4	0,4	40%
	0	0,37	0,37	37%
	0	0,4	0,4	40%
	0	0,37	0,37	37%
	0	0,4	0,4	40%
	0	0,37	0,37	37%
	0	0,37	0,37	37%
	1	1,3	0,3	30%
	1	1,3	0,3	30%
	1	1,26	0,26	26%
	1	1,3	0,3	30%
	1	1,3	0,3	30%
	1	1,3	0,3	30%
	1	1,3	0,3	30%
	1	1,3	0,3	30%
	1	1,3	0,3	30%
	1	1,3	0,3	30%
	4	4,2	0,2	5%
	4	4,16	0,16	4%
	4	4,16	0,16	4%
	4	4,2	0,2	5%
	4	4,16	0,16	4%
	4	4,2	0,2	5%
	4	4,2	0,2	5%
	4	4,16	0,16	4%
	4	4,16	0,16	4%
	4	4,16	0,16	4%
2	0	0,49	0,49	49%
	0	0,49	0,49	49%
	0	0,45	0,45	45%
	0	0,45	0,45	45%
	0	0,45	0,45	45%
	0	0,45	0,45	45%
	0	0,49	0,49	49%
	0	0,45	0,45	45%
	0	0,51	0,51	51%
	0	0,45	0,45	45%
	1	1,4	0,4	40%
	1	1,4	0,4	40%
	1	1,4	0,4	40%
	1	1,4	0,4	40%

	1	1,4	0,4	40%
	1	1,38	0,38	38%
	1	1,4	0,4	40%
	1	1,36	0,36	36%
	1	1,4	0,4	40%
	1	1,36	0,36	36%
	4	4,25	0,25	6%
	4	4,29	0,29	7%
	4	4,25	0,25	6%
	4	4,29	0,29	7%
	4	4,25	0,25	6%
	4	4,25	0,25	6%
	4	4,29	0,29	7%
	4	4,25	0,25	6%
	4	4,29	0,29	7%
	4	4,25	0,25	6%
3	0	0,76	0,76	76%
	0	0,73	0,73	73%
	0	0,73	0,73	73%
	0	0,73	0,73	73%
	0	0,76	0,76	76%
	0	0,76	0,76	76%
	0	0,73	0,73	73%
	0	0,76	0,76	76%
	0	0,73	0,73	73%
	0	0,76	0,76	76%
	1	1,33	0,33	33%
	1	1,36	0,36	36%
	1	1,36	0,36	36%
	1	2,34	1,34	134%
	1	1,33	0,33	33%
	1	2,29	1,29	129%
	1	1,33	0,33	33%
	1	2,29	1,29	129%
	1	2,29	1,29	129%
	1	2,34	1,34	134%
	4	3,96	0,04	1%
	4	3,92	0,08	2%
	4	3,91	0,09	2%
	4	3,91	0,09	2%
	4	3,91	0,09	2%
	4	3,91	0,09	2%
	4	3,91	0,09	2%
	4	3,92	0,08	2%
	4	3,91	0,09	2%
	4	3,91	0,09	2%
	0	0,16	0,16	16%
	0	0,16	0,16	16%
	0	0,16	0,16	16%
	0	0,13	0,13	13%
	0	0,73	0,73	73%
	0	0,16	0,16	16%

4	0	0,18	0,18	18%
	0	0,16	0,16	16%
	0	0,16	0,16	16%
	0	0,18	0,18	18%
	1	1,36	0,36	36%
	1	1,36	0,36	36%
	1	1,35	0,35	35%
	1	1,36	0,36	36%
	1	1,36	0,36	36%
	1	1,36	0,36	36%
	1	1,36	0,36	36%
	1	1,36	0,36	36%
	1	1,36	0,36	36%
	1	1,36	0,36	36%
	4	4,89	0,89	22%
	4	4,89	0,89	22%
	4	4,89	0,89	22%
	4	4,89	0,89	22%
	4	4,85	0,85	21%
	4	4,89	0,89	22%
	4	4,89	0,89	22%
	4	4,89	0,89	22%
	4	4,89	0,89	22%
	4	4,89	0,89	22%
Total				1665,25%

Based on table 2 by doing 120 tests on each sensor, the average percentage of the overall error can be calculated with the calculation below.

$$\frac{Total\ error\ (\%)}{Total\ Pengujian} = \frac{722 + 925 + 1592 + 799}{120} = \frac{4038\%}{120} = 33{,}65\%$$

So it can be taken that the percentage of water level error displayed in the application is 33.65% and it can be concluded that the system can detect water levels well with an accuracy value of up to 66.35%

F. Testing Report Delivery Speed

This test is carried out to determine the average delivery speed of the application when sending reports. This test is done using the logcat window in android studio. Class log in java which is placed in the program section onClick the send button and onSuccess add data to firebase firestore which will bring up the log in the logcat window. Comparison of time logs that will be the benchmark in this test. Internet speed testing on android smartphones is done shortly before testing the speed of sending reports using the meteor application. The results of testing the speed of sending reports can be seen in table 3 below.

TABLE III
REPORT DELIVERY SPEED TEST

Testing	*Status*	*Internet* Speed	*Delay*(s)
1	Successful	Download: 2.8 mbps Upload : 10.8 mbps Ping : 54 ms	2s
2	Successful	Download: 4.8 mbps Upload: 11.3 mbps Ping: 66 ms	3s
3	Successful	Download: 2.0 mbps Upload: 16.2 mbps Ping: 116 ms	2s
4	Successful	Download: 2.4 mbps Upload: 12.6 mbps Ping: 92 ms	2s
5	Successful	Download: 3.0 mbps Upload: 5.8 mbps Ping: 50 ms	2s
6	Successful	Download: 1.2 mbps Upload: 7.2 mbps Ping: 109 ms	3s
7	Successful	Download: 874.0 kbps Upload: 20.1 mbps	2s
8	Successful	Download: 1.4 mbps Upload: 12.1 mbps Ping: 92 ms	2s
9	Successful	Download: 1.2 mbps Upload: 12.2 mbps Ping: 58 ms	2s
10	Successful	Download: 1.8 mbps Upload: 15.2 mbps Ping: 69 ms	1s
11	Successful	Download: 1.3 mbps Upload: 10.2 mbps Ping: 83 ms	2s

12	Successful	Download: 2.3 mbps Upload: 14.2 mbps Ping: 87 ms	2s
13	Successful	Download: 2.0 mbps Upload: 2.9 mbps Ping: 56 ms	1s
14	Successful	Download: 979.0 kbps Upload: 3.0 mbps Ping: 87 ms	2s
15	Successful	Download: 3.0 mbps Upload: 13.5 mbps Ping: 72 ms	1s
16	Successful	Download: 1.8 mbps Upload: 15.9 mbps Ping: 77 ms	2s
17	Successful	Download: 1.8 mbps Upload: 10.9 mbps Ping: 72 ms	1s
18	Successful	Download: 1.9 mbps Upload: 3.1 mbps Ping: 64 ms	1s
19	Successful	Download: 5.1 mbps Upload: 12.1 mbps Ping: 39 ms	1s
20	Successful	Download: 1.0 mbps Upload: 6.1 mbps Ping: 64 ms	2s
21	Successful	Download: 5.1 mbps Upload: 32.0 mbps Ping: 47 ms	1s
22	Successful	Download: 1.9 mbps Upload: 18.0	1s

		mbps Ping: 68 ms	
23	Successful	Download: 1.7 mbps Upload: 7.2 mbps Ping: 63 ms	1s
24	Successful	Download: 2.2 mbps Upload: 2.9 mbps Ping: 58 ms	2s
25	Successful	Download: 1.9 mbps Upload: 12.0 mbps Ping: 59 ms	2s
26	Successful	Download: 1.6 mbps Upload: 16.4 mbps Ping: 61 ms	2s
27	Successful	Download: 1.0 mbps Upload: 4.4 mbps Ping: 111 ms	2s
28	Successful	Download: 1.0 mbps Upload: 8.6 mbps Ping: 79 ms	1s
29	Successful	Download: 2.4 mbps Upload: 14.8 mbps Ping: 39 ms	1s
30	Successful	Download: 1.5 mbps Upload: 15.0 mbps Ping: 67 ms	1s
Total			50s

Based on table 3, the speed of sending reports can be calculated from the average delay using the calculation below.

$$\frac{Total\ Delay}{Jumlah\ Pengujian} = \frac{50\ s}{30} = 1{,}67\ s$$

From the results of the calculation of the delivery speed, it can be concluded that the speed of sending reports in the application reaches 1.67 s

G. Testing the Best Soil Moisture Detection in Rice Fields using AHP Method

Testing is done to find out whether the system can detect the best soil moisture based on the calculation results of the AHP method as expected. The results of the calculation of priority weights using the AHP method can be seen in table 4 below.

TABLE IV
RESULTS OF PRIORITY WEIGHT CALCULATION USING AHP METHOD

Phase	Soil Moisture	Condition	Notifications
Vegetative	Slightly Wet	Good	Does not appear
	Wet	Not so good	Appears
	Dry	Not good	Appears
Generative	Wet	Good	Does not appear
	Slightly Wet	Not so good	Appears
	Dry	Not good	Appears
Cooking	Dry	Good	Does not appear
	Slightly Wet	Not so good	Appears
	Wet	Not good	Appears

Based on table 4, it can be concluded that in the vegetative phase, the soil conditions are slightly wet in the first rank or grade, which is good, wet conditions in the grade are not good and then dry conditions are not good. In the generative phase, the wet soil conditions in the first rank or grade are good, the slightly wet conditions in the grade are not good and then the dry conditions are not good. In the ripening phase, dry soil conditions in the first rank or grade are good, slightly wet conditions in the grade are not good and then wet conditions in the grade are not good. The parameters measured during the test have been engineered to shorten the time. To engineer the soil moisture, a sample of the growing medium was used and water was applied little by little from dry to wet soil conditions. To engineer the phase, changing the start date on firebase is used. The results of the best soil moisture detection test using the AHP method can be seen in table 5 below.

TABLE V
BEST SOIL MOISTURE DETECTION TEST

No.	**Phase**	**Average Soil Moisture (%RH)**	***Grade***	**Notifications**	**Results**
1	Vegetative	22,62	Not good	Appears	As per
2		24,28	Not good	Appears	As per
3		24,86	Not good	Appears	As per
4		20,21	Not good	Appears	As per
5		42,12	Good	Does not appear	As per
6		46,39	Good	Does not appear	As per
7		38,16	Good	Does not appear	As per
8		42,34	Good	Does not appear	As per
9		79,29	Not so good	Does not appear	Not suitable
10		72,22	Not so good	Appears	As per
11		72,67	Not so good	Appears	As per
12		74,41	Not so good	Does not appear	Not suitable
13	Generative	27,19	Not good	Appears	As per
14		24,43	Not good	Appears	As per
15		21,76	Not good	Appears	As per
16		23,32	Not good	Does not appear	Not suitable
17		40,19	Not so good	Appears	As per
18		47,45	Not so good	Appears	As per
19		49,44	Not so good	Appears	As per
20		47,34	Not so good	Appears	As per
21		71,14	Good	Does not appear	As per
22		74,43	Good	Does not appear	As per
23		77,18	Good	Does not appear	As per

24		71,56	Good	Does not appear	As per
25	Cooking	25,92	Good	Does not appear	As per
26		23,68	Good	Does not appear	As per
27		24,29	Good	Does not appear	As per
28		24,12	Good	Does not appear	As per
29		43,31	Not so good	Appears	As per
30		48,86	Not so good	Appears	As per
31		45,53	Not so good	Appears	As per
32		42,19	Not so good	Appears	As per
33		77,89	Not good	Appears	As per
34		75,27	Not good	Appears	As per
35		75,79	Not good	Appears	As per
36		73,16	Not good	Appears	As per

Based on table 5, by doing 36 tests, the percentage of conformity can be calculated with the calculation below.

$$\frac{Pengujian\ yang\ Sesuai}{Jumlah\ Pengujian} = \frac{33}{36} x\ 100\% = 91,7\%$$

From the calculation of the percentage of suitable tests, it can be concluded that the level of conformity reaches 91.7% and it can be concluded that the system can detect the best humidity based on the AHP method very well.

H. Testing the Best Water Level Detection based on Questionnaire

Testing is done to determine whether the system can detect the best height as expected. The table of the best water level based on the growth phase of rice according to experts can be seen in table 6 below.

TABLE VI
BEST WATER LEVEL BASED ON RICE GROWTH PHASE

Phase	**Water Level**	**Condition**	**Notifications**
Vegetative	0 - 5 cm	Good	Does not appear
	>5 cm	Not so good	Appears
Generative	5 - 8 cm	Good	Does not appear
	<5 or >8 cm	Not so good	Appears
Cooking	0 - 3 cm	Good	Does not appear
	>3 cm	Not so good	Appears

The best water level detection test was conducted based on the average value of the four ultrasonic sensors. There are two conditions of this test, namely good and less good. Good conditions are obtained when the water level value is within the range that can be seen in table 6. While poor conditions are obtained when the water level value is outside the range.
The parameters measured during the test have been engineered to shorten the time. To engineer the water level, a sample of growing media with water was used. To engineer the phase, the firebase start date was changed. The best water level detection test results can be seen in table 7 below.

TABLE VII
BEST WATER LEVEL DETECTION TEST

No.	Phase	Average Water Level (cm)	*Grade*	Notifications	Results
1	Vegetative	2.07 cm	Good	Does not appear	As per
2		2.17 cm	Good	Does not appear	As per
3		2.28 cm	Good	Does not appear	As per
4		2.14 cm	Good	Does not appear	As per
5		2.47 cm	Good	Does not appear	As per
6		6.0 cm	Not so good	Appears	As per
7		7.46 cm	Not so good	Does not appear	Not suitable
8		6.78 cm	Not so good	Appears	As per
9		6.43 cm	Not so good	Appears	As per
10		6.75 cm	Not so good	Appears	As per
11		6.55 cm	Good	Does not appear	As per
12		6.96 cm	Good	Does not appear	As per
13		6.83 cm	Good	Does not appear	As per

14	Generative	7.41 cm	Good	Does not appear	As per
15		6.61 cm	Good	Does not appear	As per
16		2.78 cm	Not so good	Appears	As per
17		2.96 cm	Not so good	Appears	As per
18		2.05 cm	Not so good	Appears	As per
19		2.69 cm	Not so good	Appears	As per
20		2.07 cm	Not so good	Appears	As per
21	Cooking	2.76 cm	Good	Does not appear	As per
22		2.41 cm	Good	Does not appear	As per
23		2.55 cm	Good	Does not appear	As per
24		2.49 cm	Good	Does not appear	As per
25		2.49 cm	Good	Does not appear	As per
26		6.89 cm	Not so good	Appears	As per
27		6.29 cm	Not so good	Appears	As per
28		6.6 cm	Not so good	Appears	As per
29		6.8 cm	Not so good	Appears	As per
30		6.63 cm	Not so good	Does not appear	Not suitable

Based on table 4.26 by doing 30 tests, the percentage of conformity can be calculated with the calculation below

$$\frac{Pengujian\ yang\ Sesuai}{Jumlah\ Pengujian} = \frac{28}{30}\ x\ 100\% = 93{,}4\%$$

From the calculation of the percentage of suitable tests, it can be concluded that the level of suitability reaches 93.4% and it can be concluded that the system can detect the best water level based on the questionnaire very well.

4. CLOSING

Conclusion

Based on all tests on the monitoring system that has been designed and implemented, the following conclusions can be drawn.

1. The monitoring performance system that has been implemented on the system can work as expected with the percentage of soil moisture sensor data accuracy up to 86.12% and ultrasonic sensor data accuracy up to 66.35%.
2. The speed of sending reports based on the tests that have been carried out reaches 1.67 s.

3. The best soil moisture detection system based on the growth phase using the AHP method can work according to calculations with a suitability level reaching 91.7%.
4. The best water level detection system based on expert questionnaires can work very well with a suitability level reaching 93.4%.

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