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# Design and Build of IoT Based Flood Prone Monitoring System at Semani's Pump House Drainage System

**'Aisyah [a,1], Aji Ery Burhandenny [a,2,*], Happy Nugroho [a,3], Didit Suprihanto [a,4]**
[a] *Universitas Mulawarman, Sambaliung, Samarinda 75242, Indonesia*
[1] *petikaisyah@gmail.com;* [2]*a.burhandenny@ft.unmul.ac.id;* [3] *happynugroho@ft.unmul.ac.id;* [4]*didit.suprihanto@ft.unmul.ac.id*
** Corresponding author*

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**Abstract**

Floods are a common disaster in watersheds, and flood control is difficult. However, losses can be reduced by quickly disseminating alert status information. This paper proposes a prototype of a monitoring system that can determine the status of flood alerts in real time and quickly disseminating to the community, allowing people to be better prepared for flood disasters. The system was developed using the R&D method and consists of hardware and software development. The hardware comprises several sensor modules to read the discharge, temperature, humidity, and water level and to transmit the readings to the software. The software is divided into two applications: a website application and a Telegram application. The public can find the flood alert status history data from the website and obtain flood alert status warning messages and the latest alert status from Telegram. The results of the tests indicated that the sensors were very accurate, with a MAPE value of less than 10%. The software test also showed that the input and output were according to design. The proposed system can potentially reduce flood losses by providing early warning information to the community. The system is also scalable and adaptable to other watersheds.

**Keywords:** Flood; IoT; NodeMCU ESP 32; Telegram; Website.

## Introduction

A flood disaster is when water rises to the mainland; interferes with community activities and traffic; damages facilities and infrastructure, and property losses; and can cause casualties [1-7]. Damage and disaster losses have increased in recent decades [7-13]. Compared to other natural disasters, floods are the most frequent disasters [14]. The World Meteorological Organization places the flood disaster as the third largest disaster in the world [15]. In developing countries, floods are caused by several factors, one of which is climate change and tides, and often occur in coastal areas and watersheds [16]. Indonesia has about 600 rivers with a high potential to experience floods from 5,590 rivers [17].

The Karang Mumus River is a source of water for most of the people of Samarinda City. However, due to industrialization and inappropriate development policies led to overcrowding of houses in the watershed, causing the watershed to decrease function [18]. Karang Mumus River's watershed is experiencing heavy pollution due to the accumulation of garbage and household waste [19]. This damage caused silting of the river [20]. Based on a reply letter from the department of public works and spatial planning, Samarinda explained that the pump house drainage system on gelatik road cannot function optimally because the Karang Mumus River still needs to be thoroughly paved. This will certainly endanger the people of the gelatik road area. Losses due to floods can be reduced [21] by disseminating the latest alert status information quickly. Rapid dissemination of information will be more helpful when using the internet of things-based monitoring system [3], [22-24].

The Internet of Things is a technology that can be used by connecting several electronic devices to the Internet that can be accessed by everyone connected to the Internet [25-32]. IoT technology can provide benefits in terms of monitoring [33-38], tracking [39-43], or control in real time [44-49]. Research on monitoring systems using the Internet of Things has been extensively carried out in various fields such as fisheries [50-54], health [55-61] and smart homes [62-65]. Research on monitoring systems has been done before, such as using Arduino UNO, but the sensor reader results are only displayed on the LCD [66], [67]. Flood disaster monitoring system using SMS messaging [68-73]. In addition, monitoring systems that utilize IoT technology with the use of ESP8266 chips have also been widely done, although the WIFI speed of ESP8266 is not as good as ESP32 [67], [74-82]. The flood disaster monitoring system with the dissemination of information through the WhatsApp application is also widely done, but because the WhatsApp application does not have a built-in bot. Hence, it must rent bots from third parties [83].

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So that the monitoring system of flood-prone points of the drainage system pump house using microcontroller NodeMCU ESP32 because it has better specifications than NodeMCU ESP8266. In addition, the delivery of alert status messages using the telegram bot's application due to its speed and security of messages features [84].

This paper makes the following contributions: it presents a prototype of a low-cost and low-power sensor IoT-based flood monitoring and early warning system for the Semani Pump House Drainage System in Samarinda City, Indonesia. Thus, provide an evaluation of the performance of the prototype system in the field that can be beneficial to be easily adapted to other flood-prone areas.

Flood alert determination is obtained from analyzing information on water level observation stations. Based on information obtained from the Kalimantan IV Center and the Samarinda City Public Works and Spatial Planning Office, there is no data on the water level in Semani's Pump House Drainage System in the Gelatik Road area.

Due to the absence of secondary data, the determination of the flood alert of Semani's Pump House Drainage System relies on field observations. The alert Status in **Table 1** has been checked and approved by the Sub Coordinator of the Sub—the substance of Operation and Maintenance of Water Resources on Friday, August 26, 2022.

**Table 1.** Alert Status Flood Semani Drainage System Pump House

| **Alert Status** | **Pump House** | |
|---|---|---|
| | ***Water Height (cm)*** | ***Reporting interval (minutes)*** |
| Alert 1 | <100 | - |
| Alert 2 | 100-<130 | 360 |
| Alert 3 | 130-<150 | 180 |
| Alert 4 | ≥150 | 37,5 |

The alert status 4 has an elevation of less than 110 cm, indicating that the water level in Semani's site is in normal conditions. Alert status 3 suggests an early warning of a flood, such as a puddle, but still in safe criteria (not harmful). Alert status 2 notifies that the puddle has expanded and begun to endanger the surrounding population. And finally, alert status 1 declares that the water level in Semani's site is overflowing the long storage channel, thus beyond the control of Semani's Pump House Drainage System. The latest is considered a critical condition that needs serious attention.

## Method

The research method used is the Research and Development (R&D). It comprises seven stages: 1) Problem identification: The first stage is identifying and defining the problem the research study will address. This involves understanding the current state of knowledge on the topic and identifying gaps in the literature, as mentioned in the introduction section. 2) Literature review: The second stage is to conduct a literature review to identify and appraise the existing literature on the topic. The purpose of the literature review is to provide assistance in the first stage by delivering a comprehensive understanding of the current state of knowledge on the topic and to identify any gaps in the literature. 3) Prototype design: The third stage is to design a product or service prototype. This involves specifying the features and functionality of the product or service and the materials and components that will be used. 4) Hardware development: The fourth stage is to develop the hardware components of the product or service. This involves designing and fabricating the components and assembling them into the final product. 5) Software development: The fifth stage is to develop the software components of the product or service. This involves designing and programming the software and testing and debugging it. 6) Testing and evaluation: The sixth stage is to test and evaluate the product or service. This involves testing the product or service in a variety of environments and with a variety of users. 7) Deployment: The seventh stage is to deploy the final prototype. This involves making the prototype available to be tested in the field.

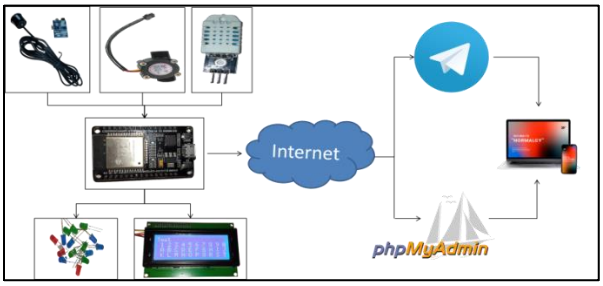



**Figure 1.** IoT-based flood point monitoring system Model

**Figure 1** shows the prototype design of flood prone monitoring Semani's Pump House Drainage System. It consists of two development stages including hardware and software. The hardware contains a collection of sensor modules and other components such as the NodeMCU ESP32 microcontroller, LCD, and LED. The sensors used in this monitoring system consist of 3 sensors, including AJ-SR04M ultrasonic sensor, YF-S201 water discharge sensor, and DHT22 temperature and humidity sensor. The software in this monitoring system is divided into two, including telegram bots and website.

**Figure 2** indicates the schematic diagram used in the proposed system. The NodeMCU ESP32 connected with the expansion base board to provide additional pin GND and output resources, namely 3.3 V and 5V. In this study, the expansion base board obtains input voltage using a 9V adapter. The AJ-SR04M waterproof ultrasonic sensor utilizes wave reflection to detect the water level in Semani's Pump House Drainage System. This sensor has a trigger pin and an echo pin. The trigger pin is an output pin that fires a signal pulse, while the echo pin is an input pin. The trigger pin is paired to digital pin 14 and the echo pin to digital pin 12 of NodeMCU ESP32. This sensor operates on a 5V voltage and 30mA current. The time of the reflected wave will be calculated to the water level. The AJ-SR04M sensor ranges from 20 cm to 500 cm with an accuracy of ±1 cm.

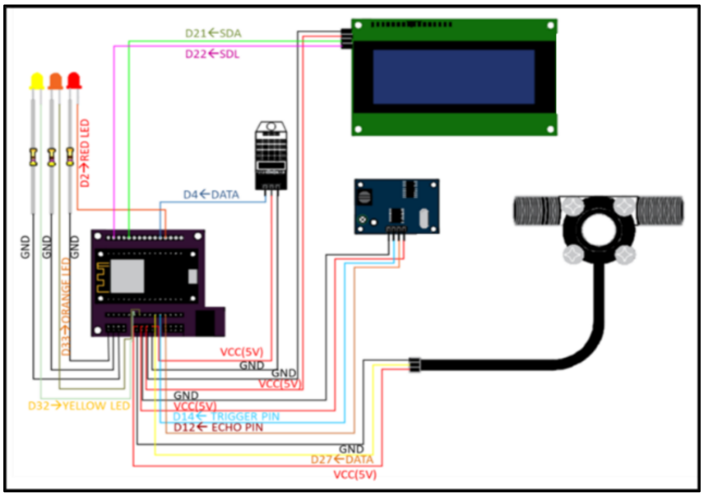
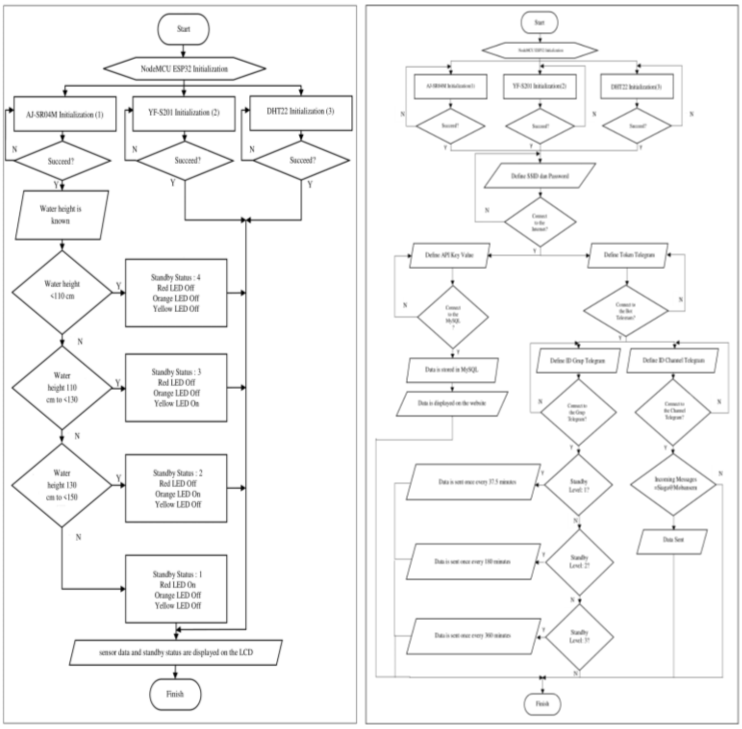



**Figure 2.** Hardware system circuit

The resulting water levels will be used in the monitoring system as a benchmark for flood alert status. **Figure 3** indicates that when the alert status is 4, the yellow, orange, and red LEDs do not light up, and the telegraph warning messages are not sent. When the alarm status 3 is detected, the yellow LED lit and a telegraph alert message is sent; the next alert will be sent every 4 hours. If it reaches alert status 2, the orange LED lights up and a telegraph alert message is sent; the next alarm will be sent once every 3 hours. Meanwhile, when alert 1 is detected, the red LED lights up and a warning message in telegram is sent, on the next alert, it will be sent once every 37.5 minutes.

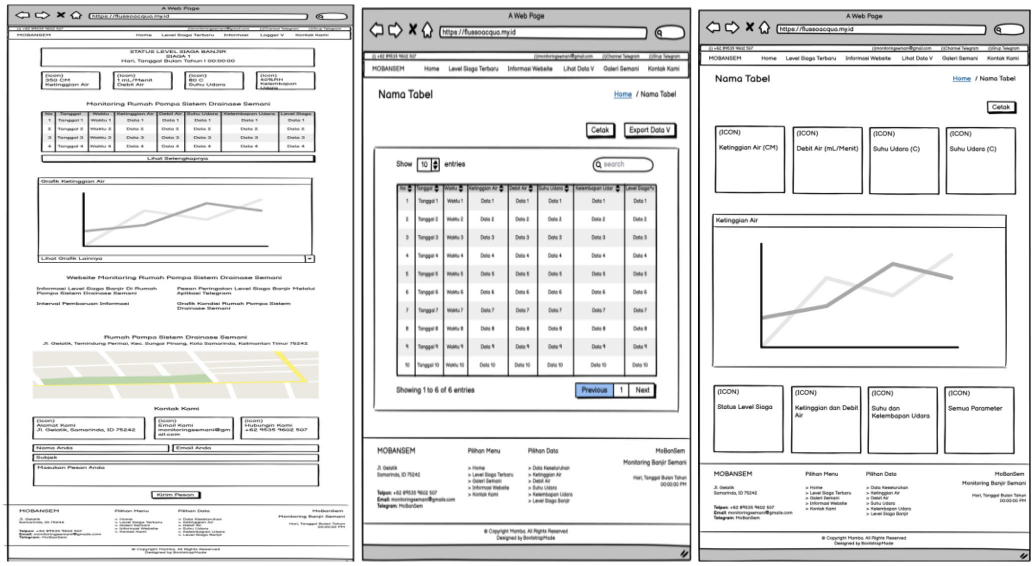



(a) (b)

**Figure 3.** Monitoring system flowchart (a) hardware and (b) software

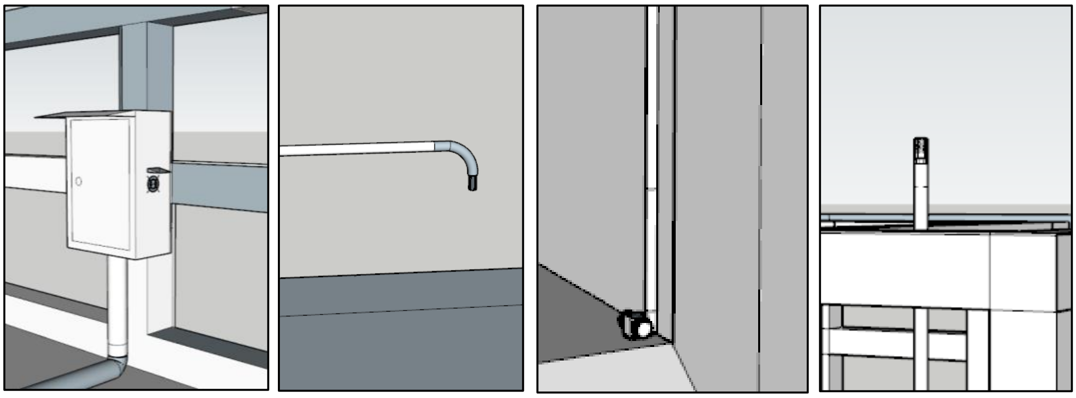
The YF-S201 Sensor has the function of reading the discharge or water flow velocity, the YF-S201 sensor has three pins consisting of power supply, ground and output signals paired to pin 27 on the NodeMCU ESP32. The YF-S201 sensor uses a hall sensor and magnetic rotor to read the discharge and uses a voltage of 5V and a current of 10mA. The YF-S201 sensor ranges from 1 to 30 mL/min with an accuracy of ±10%. While the DHT22 sensor has the function of reading temperature with a range of 40°C-80°C with an accuracy of ±0.5 C accuracy and can read humidity with a range of 0 to 100% RH with an accuracy of ±2% RH accuracy. The DHT22 Sensor has a humidity-sensing measurement component and a thermistor. The DHT22 Sensor also has 3, the same as the YF-S201 sensor. On the DHT22 sensor, the data pin is paired to pin 4 on the NodeMCU ESP32. The use of air temperature and humidity parameters compared to rainfall is due to the extreme climate change in Samarinda that causes some rain to occur unevenly. In addition, humidity and air temperature influence flood disasters [85].

The NodeMCU ESP32 sends the obtaines measurement data to display LCD while at the same time the reading results are also stored in the MySQL database on the webserver. This monitoring system provide useful dashboards to the website visitors. The Website in this study was named MOBANSEM which stands for Semani's Flood Monitoring. The website has three basic pages in MOBANSEM namely an index, a table page and a chart as seen in **Figure 4**.



(a) (b) (c)

**Figure 4.** MoBanSem website design (a) index page (b) table page (c) chart page



(a) (b) (c) (d)

**Figure 5.** Mechanical design (a) Box (b) AJ-SR04M Sensor (c) YF-S201 Sensor (d) DHT22 Sensor

## Results and Discussion

To determine the performance of the system it is necessary to test each part and the entire system.

### *A. NodeMCU ESP32 Testing*

Testing NodeMCU ESP32 is divided into two parts, the first test is testing the input voltage using a multimeter. In this test, the desired voltage of 9V while the rated voltage of 9.33 V. The input voltage can already be used to supply the circuit used in the flood-prone point monitoring system in Semani's Pump House Drainage System. Testing the second test was conducted to determine whether NodeMCU ESP32 could connect to the internet, websites, MySQL, Telegram channels, and Telegram groups using the pre-defined parameters. Based on **Table 2**, it can be seen that the NodeMCU ESP32 black box test was successful.

**Table 2.** NodeMCU ESP32 Test Result

| Test Item | NodeMCU ESP32 Testing | | |
|---|---|---|---|
| | ***Output Designed*** | ***Output Testing*** | ***Conclusion*** |
| WiFi | NodeMCU ESP32 Connect to WiFi | Works well according to designe | Success |
| Website | NodeMCU ESP32 Connect to website | Works well according to designe | Success |
| MySQL | NodeMCU ESP32 Connect to MySQL | Works well according to designe | Success |
| Channel | NodeMCU ESP32 Connect to channel Telegram | Works well according to designe | Success |
| Group | NodeMCU ESP32 Connect to group Telegram | Works well according to designe | Success |

### *B. Sensors Accuracy Testing*

Sensor testing is performed to determine the sensor's accuracy in detecting objects. This test is split into two parts: determining the value of error per test sampling and determining the value of Mean Absolute Percentage Error (MAPE). Determine the value of error per test data retrieval depending on the level of accuracy in the first test. This test uses a 10% error level or a 90% confidence level.

The hypothesis proposed are:

Ho: The difference from the sensor read value to the master read value exceeds the accuracy level.

Ha: The difference from the sensor read value to the master read value does not exceed the accuracy level.

**Table 3.** Sensors Test Result

| Sensor | Testing | | |
|---|---|---|---|
| | ***Accuracy*** | ***Amount of Sample*** | ***The Maximum Value Above Accuracy*** |
| AJ-SR04M | ±1 cm | 31 | 3 |
| YF-S201 | ±5% | 35 | 4 |
| DHT22 (temperature) | ±0,5°C | 45 | 5 |
| DHT22 (humidity) | ±2%RH | 45 | 5 |

**Table 3** shows all sensors meet the first testing criteria. Based on the hypothesis used, Ha is accepted and Ho is rejected with the conclusion that the difference from the sensor reading value to the master reading value does not exceed the accuracy level. According to the hypothesis used, Ha is accepted and Ho is rejected with the conclusion that the difference from the sensor reading value to the master reading value does not exceed the accuracy level.

In the second test to determine the value of MAPE can use Equation 1, the closer to 0, the value of MAPE will be better or more accurate[86].

$$MAPE(\%) = \frac{\sum\left(\frac{|A_t - F_t|}{A_t}\right) \times 100}{n} \qquad (1)$$

Where,
MAPE : Mean Absolute Percentage Error
n : Amount of data
$A_t$ : Actual value of request to t
$F_t$ : Result of alleged involvement.

**Table 4.** Sensors Test Result (MAPE)

| Sensor | Testing | | |
|---|---|---|---|
| | ***Amount of sample*** | ***∑PE*** | ***MAPE*** |
| AJ-SR04M | 31 | 26,899 | 0,868 |
| YF-S201 | 35 | 69,669 | 1,991 |
| DHT22 (temperature) | 45 | 20,461 | 0,455 |
| DHT22 (humidity) | 45 | 7,672 | 0,170 |

Table 4 indicated that all sensors have a MAPE value < 10% therefore fall into the category of highly accurate.

### C. LCD and I2C Testing

The purpose of testing the display results on the LCD 204 and I2C is to determine whether the LCD screen can display sensor readings and other data such as time, date, and alert status. According to Table 5, the LCD can properly display results in accordance with the specified data.

**Table 5.** LCD and I2C Test Result (MAPE)

| Sensor | Testing | |
|---|---|---|
| | *Input Testing* | *LCD Result* |
| Time and date | LCD can display time & date | Display time & date |
| Alert status | LCD can display alert status | Display alert status |
| Water height | LCD can display water height | Display water height |
| Flow water | LCD can display flow water | Display flow water |
| Temperature | LCD can display temperature | Display temperature |
| Humidity | LCD can display humidity | Display humidity |

### D. LED Testing

LED testing aims to determine whether the LED is active when the flood alert status enters a certain alert status. If alert 4, the LED will not turn on, but if alert 3, the yellow LED will light up. If it rises to alert 2, the orange LED will light up, and if on alert 1 then the red LED will light up. Based on Table 6 can be seen that all the LEDs act correctly based on the given alert status.

**Table 6.** LED Test Result

| Alert Status | Testing | | |
|---|---|---|---|
| | *Yellow LED* | *Orange LED* | *Red LED* |
| Alert 4 | OFF | OFF | OFF |
| Alert 3 | OFF | OFF | OFF |
| Alert 2 | OFF | OFF | OFF |
| Alert 1 | ON | ON | ON |

### E. Grup Telegram Testing

The Telegram group serves to accommodate users for the latest sensor readings through the Telegram application. For example, users can type and send "Siaga@MobansemBot" in the message prompt and then the MOBANSEM will send the latest data obtained real-time from the node. Table 7 shows that Telegram Bot perform correctly accordance with the design.

**Table 7.** NodeMCU ESP32 Test Result

| Input Testing | NodeMCU ESP32 Testing | | |
|---|---|---|---|
| | *Output Designed* | *Output Testing* | *Conclusion* |
| Level | MoBanSem responded with a briefing message | Works well according to designe | Success |
| Test | MoBanSem responded with a briefing message | Works well according to designe | Success |
| Siaga | MoBanSem responded with the latest data | Works well according to designe | Success |

### F. Channel Telegram Testing

Telegram channel serves to send a warning message when the flood alert status reaches alert 3, alert 2, and alert 1. Message delivery starts from alert 3 because at this time there has been a puddle in the location around Semani's Pump House Drainage System. Table 8 shows that the channel Telegram receives message successfully accordance with the alert status.

**Table 8.** NodeMCU ESP32 Test Result

| Input Testing | NodeMCU ESP32 Testing | | |
|---|---|---|---|
| | *Output Designed* | *Output Testing* | *Conclusion* |
| Alert 4 | MoBanSem does not send messages | Works well according to designe | Success |

| Input Testing | NodeMCU ESP32 Testing | | |
|---|---|---|---|
| | ***Output Designed*** | ***Output Testing*** | ***Conclusion*** |
| Alert 3 | MoBanSem sends an alert message containing the alert status, time, date and sensors reading results and the next message is sent once every 360 minutes. | Works well according to designe | Success |
| Alert 2 | MoBanSem sends an alert message containing the alert status, time, date and sensors reading results and the next message is sent once every 180 minutes. | Works well according to designe | Success |
| Alert 1 | MoBanSem sends an alert message containing the alert status, time, date and sensors reading results and the next message is sent once every 37,5 minutes. | Works well according to designe | Success |

### *G. Website Testing*

Testing on the website aims to determine whether the website is by the design so that it uses black box testing. Based on **Table 9** can be seen that the website black box testing successful.

**Table 9.** NodeMCU ESP32 Test Result

| Test Item | NodeMCU ESP32 Testing | | |
|---|---|---|---|
| | ***Output Designed*** | ***Output Testing*** | ***Conclusion*** |
| Header page | NodeMCU ESP32 Connect to WiFi | Works well according to designe | Success |
| Footer page | Display header | Works well according to designe | Success |
| Index page | Display footer | Works well according to designe | Success |
| Message features | Display the first 10 data in Tabular Form and the first 20 data in graph form | Works well according to designe | Success |
| Overall data page | Users can send messages and the message that the user sends goes to Mobansem email | Works well according to designe | Success |
| Water height page | Display the overall data in tabular Form | Works well according to designe | Success |
| Flow water page | Display the water height data in tabular Form | Works well according to designe | Success |
| Temperature page | Display the flow water data in tabular Form | Works well according to designe | Success |
| Humidity page | Display the temperature data in tabular Form | Works well according to designe | Success |
| Alert status page | Display the humidity data in tabular Form | Works well according to designe | Success |
| Graphs page | Display the alert status data in tabular Form | Works well according to designe | Success |

### *H. Implementation of Monitoring System Prototype*

**Figure 6** (a) illustrates the prototype of this monitoring system uses a panel box to protect main components from animal attacks or bad weather. All hardware components are placed on the box panel except the AJ-SR04M, YF-S201, and DHT22 sensors. The exhaust fan was also added to maintain the temperature inside the box panel. The internet network used in this system comes from the GSM modem, as shown in **Figure 6** (b).

**Figure 7** (a) indicates the AJ-SR04M sensor placed vertically above the sluice gate of Semani's Pump House Drainage System at a height of 335 cm from the bottom of the sluice gate, while **Figure 7** (b) shows the YF-S201 sensor placed at the base of the sluice gate using a buffer of steel pipes to withstand heavy water flow. The **Figure 7** (c), the DHT22 sensor is placed above the sluice door at a height of 120 cm from the top of the sluice door. AJ-SR04M and DHT22 sensors use buffers from PVC pipes.

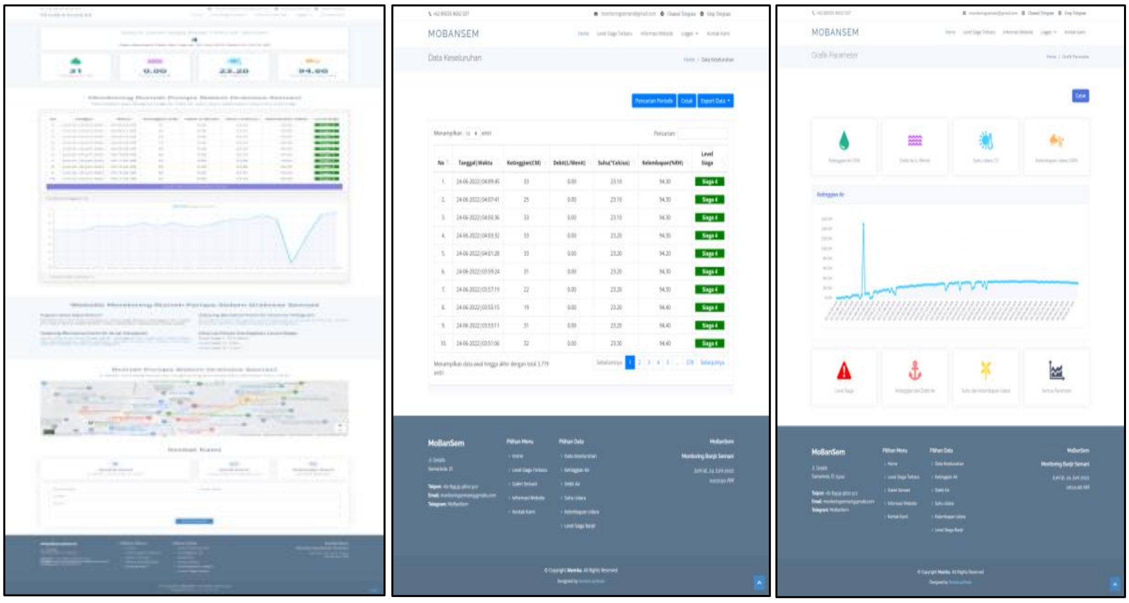
(a) (b)

**Figure 6**. Display panel box (a) outside view and (b) inside view

(a) (b) (c)

**Figure 7**. Sensor display on Semani Drainage System Pump House (a) AJ-SR04M, (b) YF-S201 (c) DHT22

**Figure 8** depicts the index and the logger parts of the MOBANSEM. The logger has seven pages: the overall data page with a table view, the water height page with a table view, the water flow page with a table view, the temperature page with a table view, the humidity page with a table view and a special graph page that displays on the today's data.




(a) (b) (c)

**Figure 8**. MOBANSEM website display (a) index page (b) table page (5) chart page

**Figure 9** illustrates the information displayed on the telegram channel and telegram group in accordance with the given alert status setting and the bot's prompt. These features were used since they are able to accommodate a huge number of audiences. The Telegram features used are channels because they can accommodate an unlimited audience and Telegram groups because they can accommodate 20,000 members.


(a) (b)

**Figure 9**. Display (a) Telegram Channel, (b) Telegram Group

### *I. Interpretation of Observational Data*

Table 10 shows the 10$^{th}$ first rows from 2766 observation data obtained within five consecutive days, started from July 21, 2022 to July 25, 2022 obtained. Based on the setting value, data was sent within 2 minutes interval. Data is sent to the website to be stored in MySQL and displayed on the website.

**Table 10.** NodeMCU ESP32 Test Result

| No | Date | Time | Height Water (cm) | Flow Water (mL/Minutes) | Temperature (°Celcius) | Humidity (%RH) | Alert Status |
|---|---|---|---|---|---|---|---|
| 1 | Thursday, 21 July 2022 | 12:00:46 AM | 37 | 0 | 23.8 | 93.9 | 4 |
| 2 | Thursday, 21 July 2022 | 12:02:49 AM | 38 | 0 | 23.8 | 93.9 | 4 |
| 3 | Thursday, 21 July 2022 | 12:04:53 AM | 38 | 0 | 23.8 | 94 | 4 |
| 4 | Thursday, 21 July 2022 | 12:06:57 AM | 39 | 0 | 23.8 | 94.1 | 4 |
| 5 | Thursday, 21 July 2022 | 12:09:00 AM | 38 | 0 | 23.8 | 94.1 | 4 |
| 6 | Thursday, 21 July 2022 | 12:11:04 AM | 39 | 0 | 23.8 | 94.2 | 4 |
| 7 | Thursday, 21 July 2022 | 12:13:07 AM | 39 | 0 | 23.8 | 94 | 4 |
| 8 | Thursday, 21 July 2022 | 12:15:11 AM | 39 | 0 | 23.8 | 94.1 | 4 |
| 9 | Thursday, 21 July 2022 | 12:17:14 AM | 39 | 0 | 23.8 | 93.6 | 4 |
| 10 | Thursday, 21 July 2022 | 12:19:18 AM | 39 | 0 | 23.7 | 93.4 | 4 |

Despite all the planning, there were just a few occasions of anomalies in the daily data collecting in this study. These anomalies were caused by a variety of factors that can be justified through data collection. The first anomaly is the unstable internet network on the GSM modem device in the microcontroller. The rising temperature in hot weather, along with long-term use (24 hours/day), causes the modem to stop working and will only turn back on when the modem state is normal. This event causes the sending of data from NodeMCU to the webserver to be interrupted.

Second, the DHT22 readings. The lowest temperature in the observational data is 22.5°C, while the highest is 40.80°C. Based on data from the Central Bureau of Statistics of East Kalimantan province (2021), from 2018 to 2020, the lowest temperature that has ever occurred in Samarinda city was 21.7°C, and the highest temperature was 37.20°C. The highest temperature in the results of the observation data has a range of 3.6°C above the highest temperature that has ever occurred in Samarinda city from 2018 to 2020, even so with the temperature of the previous observation data of 40.6°C which means it has a range of 0.2°C while for the temperature of the results of the observation data afterward of 40.4°C which means it has a range of 0.2°C. This is due to hot trapping in the DHT22 sensor case caused by the placement of the DHT sensor in the plastic sensor casing. The lowest humidity in the sensor readings is 38.4%, while the highest humidity is 94.6%. Based on the Central Bureau of Statistics of East Kalimantan province (2021), from 2019 to 2020, the lowest humidity in Samarinda city was 33%, and the highest humidity was 100%.

Third, the ultrasonic sensor readings. Based on the setting, when the water level reaches 150 cm, the water supposedly overflows the long storage channel. However, in the observation data on Thursday, July 21, 2022, at 16:23:36 PM, when the sensor read the water level reached 150 cm, the expected condition did not happen, while the previous and the afterward water level data were 0 cm. This anomaly is repeated 20 times in separate events. This is due to the occurrence of noise on the AJ-SR04M sensor, which may trigger several things, including small animal motion activity around the sensor reading distance. This is justified by the range value of the water level observation data before and after. Because there are so many data samples, using the error rate of 1% allows 27 data reading errors from 2766 data. According to this, the 20 anomalies data have deviations of 0.723% in water level. Therefore, the Flood Prone Monitoring System of Semani's Pump House Drainage System can be said to be feasible in performance. Apart from the anomalies, the highest peak in the observation data with a range value is not much different from the observation data of water level before and after.

Fourth, the YF-S201 readings. In the observation data, the water discharge is 0 mL/min. This occurs because, at the time of data collection, the Karang Mumus River did not experience the tide with the discharge of water that heavy enough so that it can be detected by the sensor YF-S201. The YF-S201 sensor in this study measures the discharge of water entering the sluice from the direction of the Karang Mumus River towards the residential areas.

## Conclusion

In the results of testing the prototype monitoring system flood prone point Semani's Pump House Drainage System based on the internet of things is known that the testing of sensors, software, and the entire system can work well. This is known from the results of hardware testing can run according to design and sensor testing has a different value to the value of the master read does not exceed the accuracy level based on the sensor datasheet and has a MAPE value less than 10% so it is very accurate and the software testing has input and output according to design while in the testing of the entire system on Semani's Pump House Drainage System has a reading of the object with an error less than 1%.

The prototype monitoring system was tested in a single point observation environment. Further research is needed to test the system in a real-world scenario such as obtain and aggregate result from multiple nodes. Additionally, the system was only tested with one type of sensor for each measurement reading. Further research is needed to test the system with different types of sensors to determine the robustness of the system and its ability to accurately measure a variety of environmental conditions.

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