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Prototype Flood Detection Water Level Monitoring IoT Web Based With Ultrasonic Sensor HC-SR04

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ABSTRACT

Flood, which is one of the natural disasters, has an impact that can affect people's productivity. This study aims to design a flood control system based on the Internet of Things (IoT) in real time to anticipate and deal with flood disasters in areas with a high potential for flooding. This research is conducted to create design and produce a prototype of a water level monitoring system and the concept of flood prevention in the community. The device object takes the smart home theme, intending to produce applications that can be used as displays monitored via computer or smartphone. In this research, the sensor used is the HC-SR04 Ultrasonic module as the main data source that provides a variable level of water level. The data collection process is carried out in a glass tube container with no object and then provides solid objects as a sensor barrier against the water surface. Then with observation, the data collection is carried out in stages by raising the water level and comparing the height using a ruler in real time applications, or the value can see in ESP8266 serial monitors. The design of the flood control will later support the concept of an IoT-based smart home which is expected to be applied for disaster management in areas with a high flood potential. This Research is expected to produce a prototype smart home flood control system that is integrated with web and can be accessed anytime.

1. Introduction

Flood disasters disasters are created by static natural conditions (such as geography, topography, and river channel geometry). Or in another situation, a flood can happen by dynamic natural events such as heavy rain, reduced water catchment areas, damming from the sea/tidal on the main river, and silting due to sedimentation [1]. Floods can occur when high rainfall is experienced for a relatively long time. Areas in Indonesia often experience floods when the rainy season arrives. When the flood conditions have submerged half the houses, that situation is very disruptive to activities [2] [3].

Moreover, suppose there is no preparation in the face of flooding. In that case, the community can experience losses such as goods being submerged in water and difficulty accessing daily needs [4][4]. To prevent the magnitude of the impact of problems that occur due to flooding, which can occur at any time, a prototype tool that can monitor the water level is designed to provide indications of flooding in an area [2]. The tool system can display the water level and provide warnings in high water conditions. The application of an integrated website tool makes it easier for the public to access real-time water level information [5]. It is hoped that in the future, the original form of the tool prototype can be made so that it can be used by the community and institutions that need a water level monitoring device.

The system designed in this research is a unified system designed to observe real-time data on changes in surface elevation. The system can be said to be a digital water level that functions as alternative monitoring that enters the interface display on the website. Sensors in the system function as a database referring to the Ultrasonic Sensor HC-SR04. The ultrasonic sensor measures the distance between the upper

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boundary layer and the water surface. The sensor detects the vulnerable distance between the tool and object by emitting ultrasonic waves (40 KHz), provided that t = min 10 us, then the return wave width is converted to distance. The data obtained by the Ultrasonic Sensor HC-SR04 is processed and then sent using ESP8266 to a website that has been designed. With a system designed to let website users know the water level in an area without going to a location[5][6][7].

2. Research Method

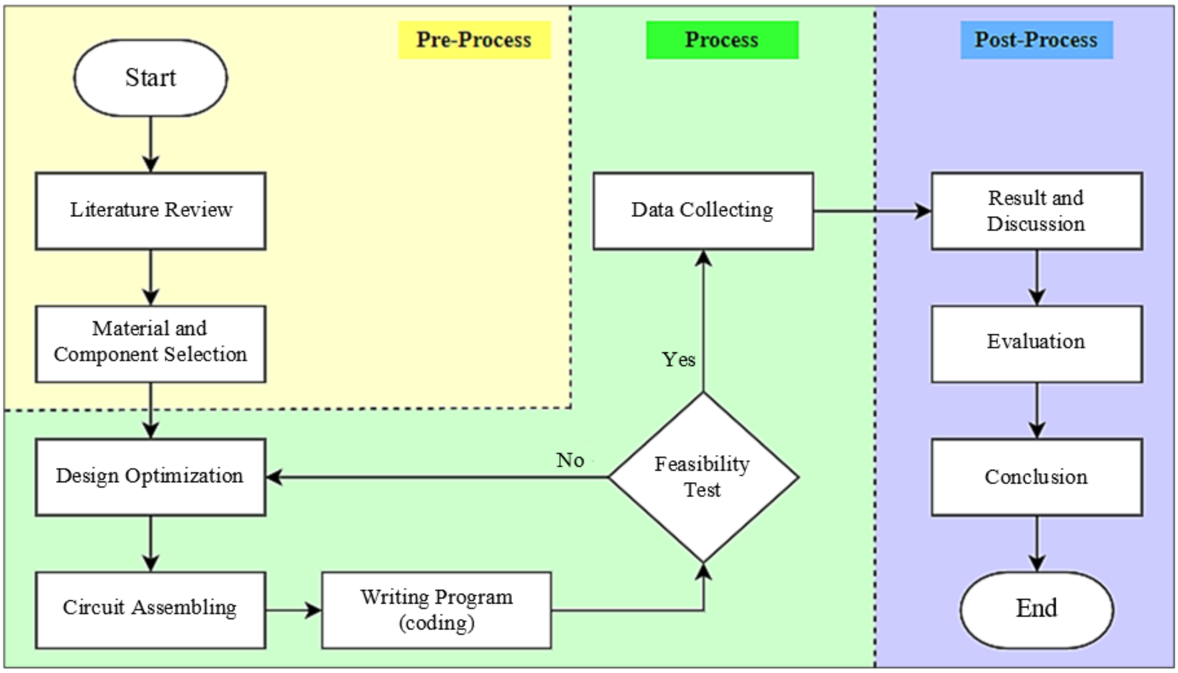

Figure 1. Research Flow Chart

This research method uses literature study, quantitative data analysis, and experimental observation using tools/tools as prototypes. Quantitative data is obtained through testing the sensor distance to the water surface and real-time web server testing[5]. The collection of water level distance data uses a different treatment from the sensor reflection test treatment on the water surface directly. Then the next test is carried out by giving objects placed on the water surface. This water level research was through several stages. The first process was collecting literature studies and literature reviews on problems related to water level detection devices. Then, the writer looked for devices that discussed IoT-based sensor monitoring. The following step process is design and the collection of components needed. After that, a test is carried out to test the prototype that matches what is expected. If the resulting target has not been reached, then the design optimization is carried out to achieve the desired initial target[2]. The tool's design that has passed the testing stage is analyzed, and data collection is carried out. From the data, the writer can get analysis to create conclusions about the prototype.

The main difference from the research made with previous research, namely, using the Open source IoT platform into the server, then further analysis can be carried out on the collected data. The system consists of IoT platform/website, Node MCU ESP8266, then ultrasonic sensor HC- SR04, then there are two modeling outputs, namely the buzzer as an alarm, displaying the water level status on the website in real time. The public can receive notifications (passive) and request information (active) via smartphones or computers in the form of early warnings of flood hazards and automation of flood prevention water pumps. The following is an explanation of some of the devices used on the system:

a. Microcontroller and Sensor

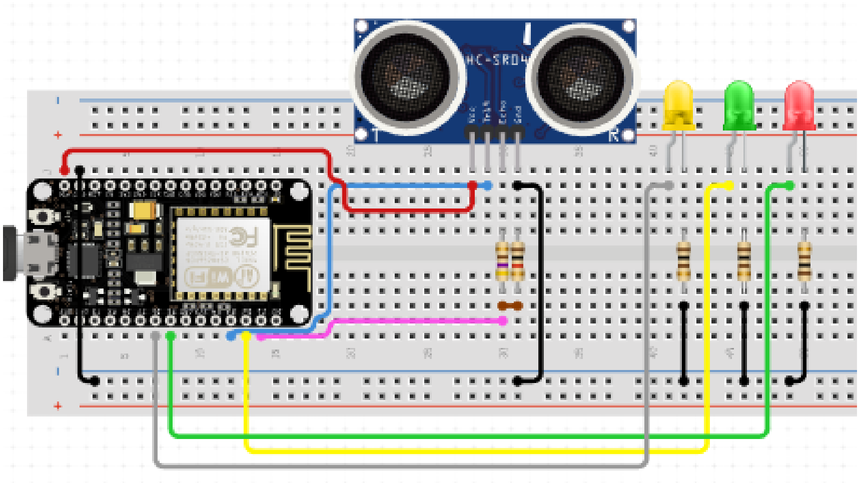

Figure 2. Circuit Diagram Flood Monitoring System

The device comprises the main components, sensors, microcontrollers, and LED lights. The microcontroller serves as the main control device that receives distance information from the sensor and is in charge of turning on the LED lights. The microcontroller is also integrated with the ESP8266 chip, which is a chip that is able to communicate via a wifi network. The ESP8266 chip is used for microcontroller communication with the database server [2], [5]. Ultrasonic sensors measure the distance between the water surface and the sensor and send distance data back to the microcontroller, then the data is sent to the server [2]. The LED is used as an indicator of the flood level. If the flood level is in an emergency, the red LED will light up followed by siren sounds from piezo as a warning, the yellow LED will light up if the flood level is still moderate and the green LED will light up if the flood level is low.

b. Water Pump

Water pumps used in areas experiencing flooding result in a significant reduction in flood volume. Adding a pump to the prototype scheme helps complete the process as a countermeasure for possible flooding. The pump functions to drain from a particular scope to be distributed to other parts of the pump[8]. So when the water status is in a state of flood hazard, the pump works to move the overflowing water to a lower point by flowing it to an area that does not affect community activities [8], [9]. The pump will work with the red indicator and the siren to avoid overflow, making the condition worse if not treated immediately. So to minimize the impact of the system on diverting air to another place with a pump.

c. Flood Detection Website

Real-time server creation is designed using MySQL works as a database for measuring value data. Data HC-SR04 sent from the ESP8266 to the MySQL database via HTML request, which will be received with the help of the PHP programming language as a protocol between the Client Microcontroller and the MySQL Server. In making the user interface, the website is designed using HTML, CSS, and Java script[10].

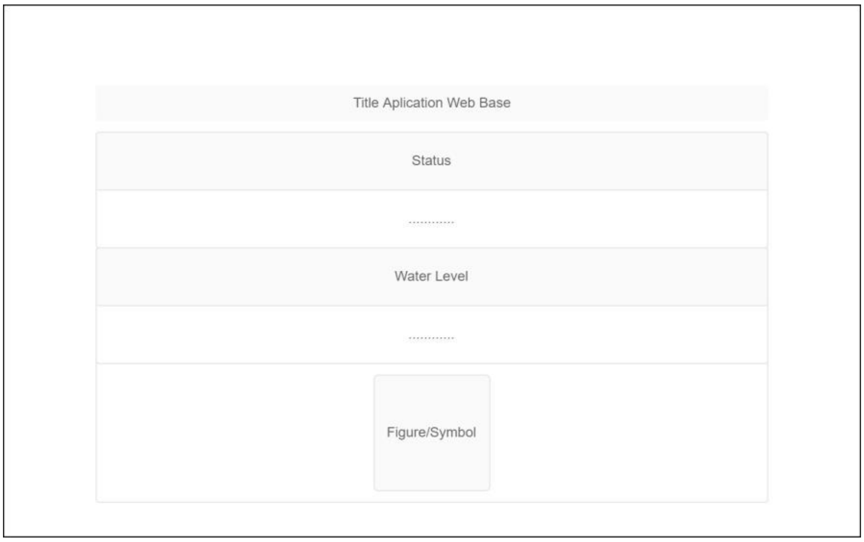

Figure 3. Design Interface Flood Monitoring Website

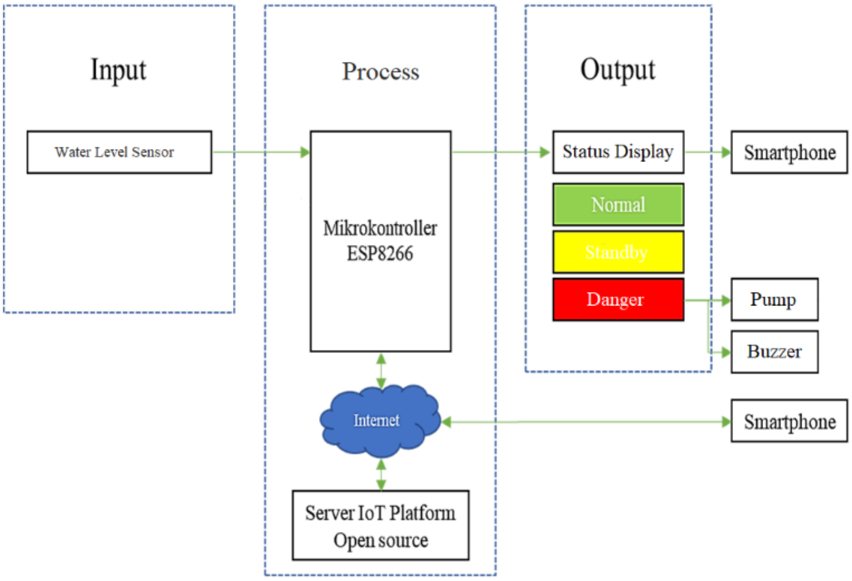

Figure 4. Schematic Water Level Monitoring System

Based on the three systems formed, all are integrated into one unit. Overall, the system will work as follows the ultrasonic sensor will measure the distance between the water surface and the sensor. If the water level has reached a specific value, the system will display the status (normal, standby, danger). When the sensor detects certain conditions, the data will automatically be sent via ESP8266 on the website server[2]. If the sensor detects a dangerous situation, the system will sound an alarm and trigger the first pump to start. The second pump will turn on when the discharge sensor shows a specific value. The pump will stop automatically if the water level is normal. Homeowners can check via smartphones from anywhere as long as they are connected to the internet[11][12].

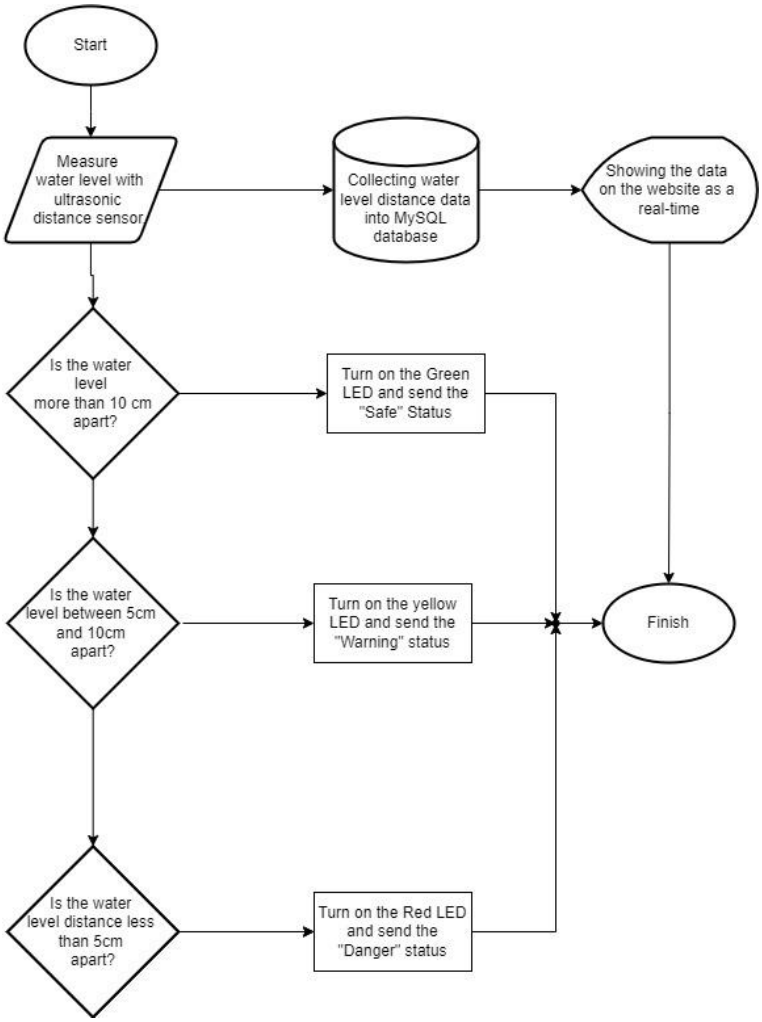

Figure 5. Flowchart Water Level Monitoring System

The flowchart above easier for explains how the system works and helps to create the algorithm. The work process flow of the tool is divided into data retrieval, microcontroller processing, input into the database, and delivery to applications[13] or websites.

3. Results and Discussion

Experiments were carried out using a measuring cup 15 cm long, a ruler on the side, and an ultrasonic sensor at the top of the circuit. Then the sensor is connected to the programmed ESP8266. After the process, the ESP8266 is connected to the server and sends sensor data directly to the website. Then on the microcontroller device as a water level display based on the LED light level as an indicator. Data collection in this study will be carried out with the following explanation:

1. Comparing ultrasonic sensor accuracy levels to determine what conditions affect the sensor and have good accuracy for design.
2. Comparing the rate of increase in water level (water discharge) between mathematical calculations and the results of experiments carried out using this design to validate the level of design accuracy.
3. Measuring the response of the prototype in providing an early warning when the water has reached a predetermined level where the device will turn on the buzzer as the primary warning response.
4. Measuring the system's response in sending data to the data transfer process on the website and th

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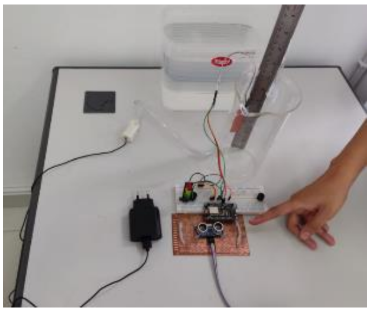
appearance of water surface conditions in real time.

The microcontroller hardware is used as a direct water level [14] gauge and indicator, namely green (water within safe limits), yellow (water in flood-prone conditions), and red (water in flood emergency conditions). Then the siren/buzzer sounds when the device starts showing an emergency indicator or a high risk of flooding.



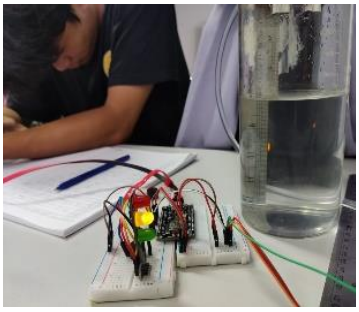


Figure 6. Prototipe Design of Mikrokontroler

TABLE 1
RESULT DATA COLECTING 1

Water Level Measurement (cm)		Error	Red	Yellow	Green	Buzzer
Sensor	Actual Value					
15,67	15,6	0,45%	OFF	OFF	ON	TURN OFF
15,17	15	1,13%	OFF	OFF	ON	TURN OFF
14,67	14,5	1,17%	OFF	OFF	ON	TURN OFF
14,17	14	1,2%	OFF	OFF	ON	TURN OFF
13,67	13,5	1,25%	OFF	OFF	ON	TURN OFF
13,17	12,5	5,36%	OFF	OFF	ON	TURN OFF
12,67	12	5,58%	OFF	OFF	ON	TURN OFF
12,17	11,5	5,82%	OFF	OFF	ON	TURN OFF
11,67	11	6%	OFF	OFF	ON	TURN OFF
11,17	10	11,7%	OFF	OFF	ON	TURN OFF
10,67	9,5	12,3%	OFF	OFF	ON	TURN OFF
10,17	9	13%	OFF	OFF	ON	TURN OFF
9,67	8,5	13,76%	OFF	ON	OFF	TURN OFF
9,17	8,3	10,48%	OFF	ON	OFF	TURN OFF
8,67	7,8	11,15%	OFF	ON	OFF	TURN OFF
8,17	7,3	11,9%	OFF	ON	OFF	TURN OFF
7,67	6,8	12,8%	OFF	ON	OFF	TURN OFF
7,17	6,3	13,8%	OFF	ON	OFF	TURN OFF
6,67	6	11,16%	OFF	ON	OFF	TURN OFF
6,17	5,5	12,18%	OFF	ON	OFF	TURN OFF
5,67	5	13,4%	OFF	ON	OFF	TURN OFF
5,17	4,8	7,71%	OFF	ON	OFF	TURN OFF
4,67	4,3	8,6%	ON	OFF	OFF	SIREN ON
4,17	3,8	9,7%	ON	OFF	OFF	SIREN ON
3,67	3,3	11,2%	ON	OFF	OFF	SIREN ON
3,17	2,5	26,8%	ON	OFF	OFF	SIREN ON
2,67	2,1	27,14%	ON	OFF	OFF	SIREN ON
2,17	1,4	55%	ON	OFF	OFF	SIREN ON
1,67	0,9	85,55%	ON	OFF	OFF	SIREN ON
1,17	0,5	134%	ON	OFF	OFF	SIREN ON

The data shows that the device starts to respond sound to the input on the 13th data, and the buzzer makes a sound. This is due to the condition of the water level rising and approaching the ultrasonic sensor.

However, there is an anomaly in the sensor error percentage value when the water level is increasing, the error value formed is getting increasing.

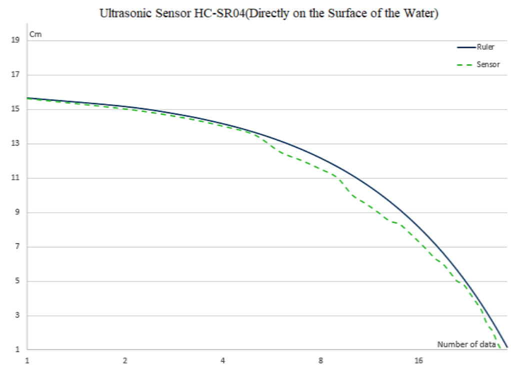


Figure 7. Graph Results of Data Collection 1

TABLE 2
RESULT DATA COLECTING 2

Water Level Measurement (cm)		Error	Red	Yellow	Green	Buzzer
Sensor	Actual Value					
15,22	15,6	2,44%	OFF	OFF	ON	TURN OFF
14,74	15	1,73%	OFF	OFF	ON	TURN OFF
14,28	14,5	1,52%	OFF	OFF	ON	TURN OFF
13,38	14	4,43%	OFF	OFF	ON	TURN OFF
12,68	13,5	6,07%	OFF	OFF	ON	TURN OFF
12,29	12,5	1,68%	OFF	OFF	ON	TURN OFF
11,9	12	0,83%	OFF	OFF	ON	TURN OFF
12,1	11,5	5,22%	OFF	OFF	ON	TURN OFF
11,5	11	4,55%	OFF	OFF	ON	TURN OFF
10,36	10	3,60%	OFF	OFF	ON	TURN OFF
9,21	9,5	3,05%	OFF	ON	OFF	TURN OFF
9,8	9	8,89%	OFF	ON	OFF	TURN OFF
8,76	8,5	3,06%	OFF	ON	OFF	TURN OFF
8,34	8,3	0,48%	OFF	ON	OFF	TURN OFF
7,92	7,8	1,54%	OFF	ON	OFF	TURN OFF
7,3	7,3	0%	OFF	ON	OFF	TURN OFF
6,68	6,8	1,76%	OFF	ON	OFF	TURN OFF
6,26	6,3	0,63%	OFF	ON	OFF	TURN OFF
5,83	6	2,83%	OFF	ON	OFF	TURN OFF
5,38	5,5	2,18%	OFF	ON	OFF	TURN OFF
4,95	5	1%	ON	OFF	OFF	SIREN ON
4,59	4,8	4,38%	ON	OFF	OFF	SIREN ON
4,23	4,3	1,63%	ON	OFF	OFF	SIREN ON
3,57	3,8	6,05%	ON	OFF	OFF	SIREN ON
3,1	3,3	6,06%	ON	OFF	OFF	SIREN ON
2,66	2,5	6,40%	ON	OFF	OFF	SIREN ON
2,41	2,1	14,76%	ON	OFF	OFF	SIREN ON
2,18	1,4	55,71%	ON	OFF	OFF	SIREN ON
1,55	0,9	72,22%	ON	OFF	OFF	SIREN ON
1,11	0,5	122%	ON	OFF	OFF	SIREN ON

The data shows the device provides a good response to the input data. On the 13th data, the buzzer makes a sound. This is due to the condition of the water level rising and approaching the ultrasonic sensor.

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However, an anomaly occurs in the sensor error percentage value when the water level increases. The error value formed increases.

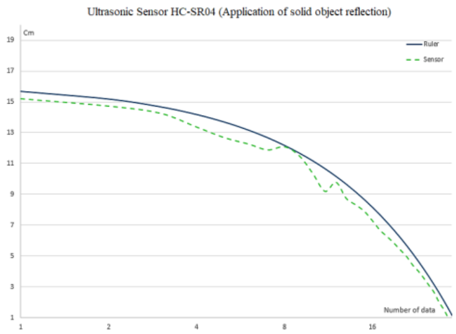

Figure 8. Graph Results of Data Collection 2

The experimental results of stage 1 and stage 2 have similarities in response to warning conditions, where a warning is obtained on the 13th data with the red LED light on and the buzzer sounding. Then the difference was found in the data error value, where the increase in the error value in the 1st stage of the experiment tends to be stable. In contrast to the 2nd stage of the experiment, the shift in numbers on the sensor is unstable and moves dynamically due to the application of solid objects.

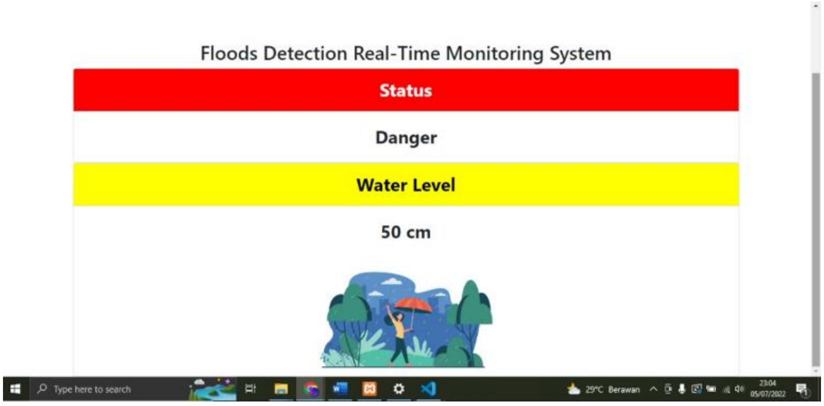

Figure 9. Results of website Design for Data Display

To help the users [15] access water level conditions in real time when weather conditions that may be at risk of causing flooding. The data displayed on the website is a reference to sensor data that can be accessed in real-time via smartphones and computers. The website responds well to changes in data that occur in the microcontroller, and the indicators run according to the water level conditions.

4. Conclussion

Starting from the design, the stage 1 and stage 2 data retrieval processes there were no problems with the device. The most difficult part is designing and integrating the website using Visual Studio and MySQL to the microcontroller. The experimental results show that the accuracy of the ultrasonic sensor when it is too close to an object with a distance of less than 2 cm will experience a significant error value above 10%. Objects on the water's surface also affect the sensor in the data collection process. When the object is applied to the water surface, the sensor cannot stably process the increase in the water level. In contrast, the change occurs when the sensor data moves dynamically due to the object on the water surface and the prototype of the time delay response when giving an early warning that the air has reached a predetermined altitude levelwhere the tool will launch a buzzer in response to the main warning and data changes on the website are still under 1 second.

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