

Early Detection of Floods Using Water Level Sensor Based on the Internet of Things

Muhammad Fajar Rizky Ardy¹, Habibullah¹, Juli Sardi¹, Ricky Maulana¹

¹Department of Electrical Engineering, Faculty of Engineering, Universitas Negeri Padang, Padang, Indonesia

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ABSTRACT

Indonesia is located at the meeting point of two continental plates and is located on the equator, these conditions make Indonesia one of the countries that has a tropical climate with two seasons each year, namely the rainy season and the dry season. The prolonged rainy season due to weather changes that occur in various regions of Indonesia makes people have to be more careful about the possibility of flooding. Therefore, an effort is needed to minimize the loss of life and losses that occur by designing a flood detection system as a monitor of the water surface level. This early flood detection method uses a Tipping bucket which functions to measure the amount of rainfall, a Water Level Sensor which is used as a water level meter, thingspeak as an Internet of Things data webserver, and Solar Panels as a source of battery charging. After testing and analyzing the early flood detection device using the Internet of Things-based Water Level Sensor in flood-prone areas, the conclusion is that the early flood detection device functions effectively and the results obtained are in line with the objectives and performance of the device.

Corresponding Author:

Muhammad Fajar Rizky Ardy

Department of Electrical Engineering, Faculty of Engineering, Universitas Negeri Padang

Kampus UNP Pusat, Jl. Prof. Hamka, Air Tawar, Padang 25131, Indonesia

Email: muhammadfajarizkyardy@gmail.com

1. INTRODUCTION

In Indonesia, natural disasters are a problem that frequently occurs in various locations. The geographical position of Indonesia is one of the causes [1],[2]. Indonesia is located at the convergence of two continental plates and lies on the equator, which makes Indonesia one of the countries with a tropical climate, having two seasons each year: the rainy season and the dry season. The prolonged rainy season due to weather changes occurring in various regions of Indonesia causes the community to be more vigilant against the occurrence of floods. Floods are one of the disasters that frequently strike various regions in Indonesia. Flooding is a condition where drainage channels (rivers) cannot absorb water or the flow of water in the drainage channels is obstructed [3],[4]. Various factors that can cause flooding include the condition of the rain catchment area, the duration and intensity of the rain, topographic conditions, and the capacity of the water drainage network. Flooding generally refers to the rise in river water levels above normal conditions or the overflow of water exceeding the normal capacity of a channel. The city of Padang is one of the cities vulnerable to flood disasters. Flood disasters continue to be a major concern for the government [5]-[7]. The impact of flood disasters is very detrimental because it can cause environmental damage in the form of homes and belongings, even leading to loss of life. These losses arise due to the residents' unpreparedness in facing floods, which can occur suddenly at any time when they are off guard or unable to predict the onset of a flood disaster. With early warning of a flood disaster, residents can evacuate before the flood strikes. Therefore, an effort is needed to reduce the occurrence of casualties and losses by designing a flood detection system to monitor water surface levels. Information about the current weather conditions is very much needed by the community because many activities depend on the weather.

Weather conditions can change rapidly and extremely at any time, causing residents to become less responsive to the effects produced. [8]-[10]. According to BMKG data in March 2024, the distribution of rainfall in the West Sumatra region falls within the medium to high criteria. Currently, obtaining information is very easy because of the extensive internet coverage. The use of the internet can provide any information in a short amount of time. In addition to serving as a tool for distributing information, the internet can also be utilized to monitor objects and even provide instructions (remote control) to those objects through an internet connection with IoT (Internet of Things). The next goal is to provide interaction and easy access with various tools such as monitoring sensors, household devices, actuators, CCTV, displays, vehicles, and others. [11]-[13].

In flood management, a system based on the Internet of Things is also needed, which functions as an early warning alarm for water levels in real time, thereby providing information to the community and reducing the occurrence of casualties and material losses due to the flood disaster. In this study, the development of an early flood detection tool using a tipping bucket as an input to measure rainfall is presented. The use of the tipping bucket is carried out to obtain the value of the rainfall that occurs. This tool also uses a water level sensor as a sensor to detect water height and uses solar panels as the power source needed by the tool and also uses the Internet of Things to provide real-time information on water height and rainfall intensity. With this research, it is hoped that the development of early flood detection tools can be improved while also reducing the risk of losses caused by flood disasters. In addition, this research is also expected to provide information to the public to be more vigilant against flood disasters.

2. METHOD

The method used in this research is research and development. The research phase includes a literature study related to the technology and components used in this tool. The literature study conducted includes an analysis of the use of tipping buckets in measuring rainfall and water level sensors as a measure of water height [14]-[16]. By utilizing data and information from the conducted literature study, various theories emerge that can be tested for their validity and applied in this research. The development stage in this research includes the planning and management of the research to demonstrate the obtained results. The development process consists of three phases: system planning, system assembly, and system testing [17]-[23]. System planning includes the development of software, hardware, and mechanics. In the software design, block diagrams and flowcharts are created to map the workflow of the tool. Figure 1 shows the block diagram of proposed system.

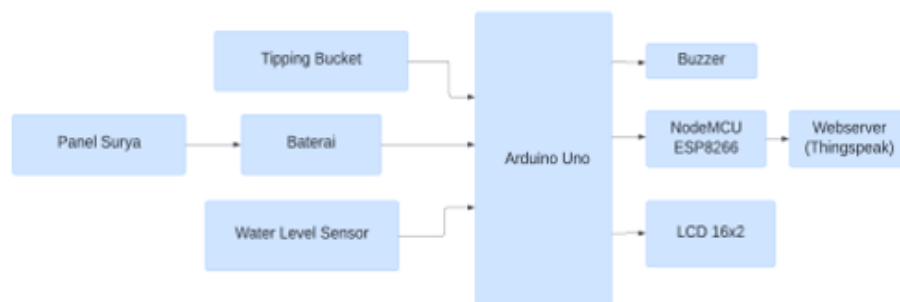


Figure 1. Block Diagram

In the image above, it is the design of an early flood detection system using a water level sensor as the water height sensor and a tipping bucket as the rainfall measurement, which is directly connected to an Arduino microcontroller. The working principle of the tipping bucket is that inside the tipping bucket, there are 2 buckets resembling a seesaw and a magnet used to activate the reed switch sensor within the tipping bucket. When one of the buckets is filled to capacity, it will move downward and trigger the magnet to activate the reed switch sensor inside the tipping bucket. In addition to the tipping bucket, this device also uses a water level sensor to measure the water height. The data successfully obtained from both sensors will be sent to the microcontroller as a processing component and then forwarded to the output component. The data received by the system will serve as the basis for the operation of this early flood detection device. In the image above, there are also solar panels and batteries that serve as the power source for this device, where the solar panels will convert sunlight into electrical energy, which will then be stored in three 18650 lithium batteries. In the installation of the battery on the Arduino, a component is also needed to reduce the voltage, namely the LM2956 DC-DC converter, which functions to lower the voltage from the battery to 5 volts so

that the Arduino does not get damaged. In Figure 1, there is also a NodeMCU ESP 8266 as a Wi-Fi module in the circuit that will be connected to the internet. An internet connection is required so that information can be sent to ThingSpeak, allowing the detected water level and rainfall to be viewed on ThingSpeak. The data on ThingSpeak consists of graphs showing the water level and rainfall that occur. In real time, the status of the situation can also be seen on a 16x2 LCD on the device, which will display the water level and rainfall data in text form. If the status indicates a flood alert or warning, the buzzer will activate and sound as a marker of the flood alert or warning status.

The entire system has a well-structured workflow, starting with detecting the amount of rainfall and water level, sending data to the microcontroller, connecting the Internet of Things through NodeMCU ESP 8266, activating a danger indicator in the form of a buzzer, and finally displaying it on a 16x2 LCD. The workflow of the system is organized and presented in the following flowchart in Figure 2.

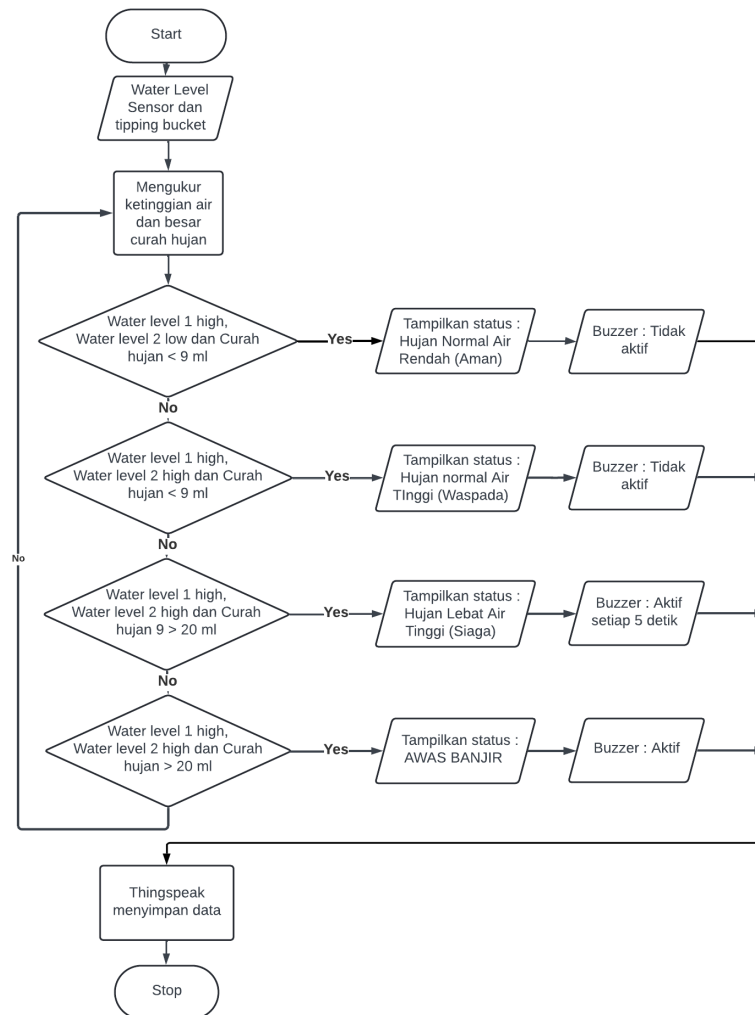


Figure 2. Flowchart

In the above image 2, the flowchart explains the workflow of the early flood detection system in detail. The process begins with turning on the system in the operation of the device. Tipping bucket and water level sensor as the second step in the operation of the system, where the tipping bucket measures the amount of rainfall and the water level sensor measures the water level. When these sensors detect the amount and height of the water, the data will be sent to the Arduino microcontroller for processing. The processed data will be displayed in real-time on a 16x2 LCD. If at the time the water level sensor detects Water Level 1 high and Water Level 2 high with rainfall exceeding 20 mm, the status will display WARNING FLOOD and activate the buzzer every 10 seconds. Next, all the information on the device will be sent to ThingSpeak. The system used will remain powered on to obtain accurate and real-time information. Figure 3 shows the overall system circuit.

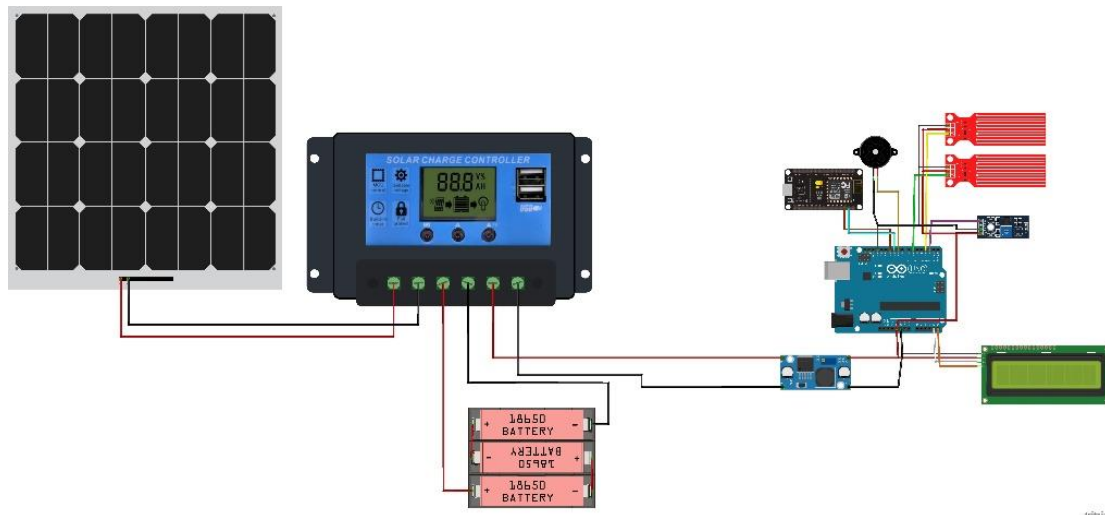


Figure 3. Overall system circuit.

In the above image 3, it shows how the overall system circuit is used. This circuit includes all the components used, which are visible in the system's operation. Where in Figure 3 it can be seen that the power source of the device comes from 3 lithium 18650 batteries connected to a solar panel, and the voltage entering the batteries is also controlled through a solar charge controller to ensure the input voltage is more stable and the batteries do not overcharge. The batteries are also connected to a step-down DC-DC converter that reduces the voltage from the batteries to 5V before entering the Arduino's Vin.

3. RESULTS AND DISCUSSION

This research was conducted with several experiments, namely tipping bucket testing, water level sensor testing, and testing the entire system. This test is done to measure how much water enters the tipping bucket. This Tipping Bucket test is done by spraying or pouring water into the Tipping Bucket funnel; this aims to find out how the tool works, namely calculating how much water enters the funnel. The tipping bucket will be dripped with 30 ml, 60 ml, and 90 ml of water to see how much tip is read when water enters the tipping bucket. The following is a table of measurements of the amount of water entering the tipping bucket.

Tabel 1. Tipping bucket measurement

No	The amount of water	A readable tip	Recorded rainfall
1	30 ml	17	6,8 mm
2	60 ml	35	14,0 mm
3	90 ml	54	21,6 mm

Based on table 8 above, this test is done by spraying 30 ml, 60 ml, and 90 ml of water to see how many water tips are read. It can be seen that the more water is sprayed, the greater the tip read on the tipping bucket. The test is done by spraying to get results like a rainy day because on a rainy day the water that enters does not flow rapidly but little by little. This water level sensor testing is done by measuring at the measuring point (TP) on the digital pin of the water level sensor with the ground pin. Testing is done with a measuring tool, namely a multimeter. This measurement aims to measure the active voltage value when the sensor touches water or does not touch water. Measurements are made by placing the positive (+) cable of the multimeter on the digital pin and the negative (-) cable on the ground pin of the sensor. The following are the results of measurements that have been carried out on the water level sensor.

In Figure 4, it can be seen that the results of the measurements using a multimeter measuring instrument that reads the active voltage value by attaching the positive (+) and negative (-) cables of the multimeter to the positive and negative pins of the water level sensor. In the image above, the output voltage produced is a DC (Direct Current) voltage of 4.52 VDC according to the magnitude measured by the multimeter. Furthermore, this test is carried out by inserting the water level sensor into a glass filled with water to see what the voltage value is when the sensor detects the water level. When the sensor reads the water level value, the output voltage produced by the sensor will increase. The following is a table of water level sensor measurements that have been carried out.

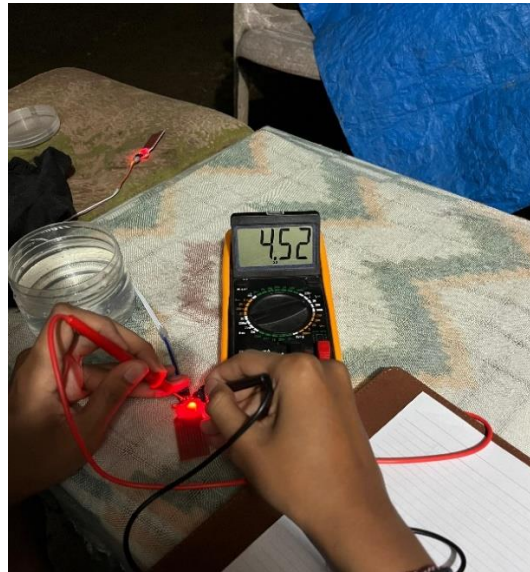


Figure 4. Water Level Sensor Voltage

Table 2. Water Level Sensor Measurements

No	Sensor	Voltage	Exposed to water	Keep away from water
1	Water Level 1	4,52 V	2,96 V	0,19 V
2	Water Level 2	4.52 V	2,67 V	0,28 V

Based on Table 2 above, the difference in voltage produced by the water level sensor is influenced by a condition. When the water level sensor touches the water completely, the output voltage is greater than when it is not exposed to water. This shows that when the sensor detects the water level, the output voltage will be higher. The overall system testing was carried out by placing the device on the riverbank in the Parak Jambu Tunggul Hitam area, where the testing conditions were carried out for 2 days during sunny conditions and during rainy conditions. The placement of the Water Level 1 sensor is at a height of 50 cm, and Water Level 2 is at a height of 1 m. This water height was obtained by asking local residents when the water rises during rainy conditions. Based on the confessions of local residents, the water height during rain is at a height of 50 cm, and when full, water is at a height of 1 m. When the device detects 1 tip of rainfall, the device will send data to the Thingspeak database and display the readings of rainfall conditions and water height on the LCD and Thingspeak web. The following is a test Table of the entire series.

Table 3. Overall testing of the device under clear weather conditions

No	Testing Time	Water Level 1	Water Level 2	Tip / Rainfall	Buzzer	State
1	13.00	Low	Low	0 tip / 0mm	off	-
2	14.00	Low	Low	0 tip / 0mm	off	-
3	15.00	Low	Low	0 tip / 0mm	off	-
4	16.00	Low	Low	0 tip / 0mm	off	-
5	17.00	Low	Low	0 tip / 0mm	off	-

Table 4. Table of overall device testing during rain.

No	Time	Water Level 1	Water Level 2	Tip / Rainfall	Buzzer	Status
1	13.00	Low	Low	0	off	-
2	14.00	Low	Low	6 tip / 2,4mm	off	-
3	15.00	Low	Low	6 tip / 2,4mm	off	-
4	16.00	Low	Low	9 tip / 3,6mm	off	-
5	17.00	Low	Low	9 tip / 3,6mm	off	-

Based on the overall test results in Table 3 and Table 4, the rainfall that enters the tipping bucket is influenced by the amount of rain that occurs at that time. And from both overall tests, the condition achieved is only the amount of rainfall obtained so that Water Level 1, Water Level 2, and the buzzer do not turn on. During the testing period, the river water conditions could not reach flood status. To meet the objectives of testing and measuring the circuit as a whole, a flood status test was carried out through simulation, which was carried out by immersing the water level sensor in a container filled with water and then dripping water into the tipping bucket to obtain the required rainfall value and test whether the tool can work properly.

Simulation testing is divided into 4 predetermined conditions. Testing is carried out by spraying water into the tipping bucket and immersing the water level sensor according to the conditions. Where, when the tipping bucket detects a rainfall of 8 tips or 3.2 mm, then water level 1 has a high value and water level 2 has a value of 0, then the status displayed is Normal Rain Low Water (Normal). In the next test, namely when the tipping bucket detects a rainfall of 8 tips or 3.2 mm, then water level 1 has a high value and water level 2 has a value of 1, then the status displayed is Normal Rain High Water (Alert). Next, when the tipping bucket detects a rainfall of 25 tips or 10 mm, then water level 1 has a value of high and water level 2 has a value of 1, then the status displayed is Heavy Rain High Water (Alert), and the buzzer will be on every 5 seconds. In the last test, when the tipping bucket detects a rainfall of 54 tips or 21.6 mm, then water level 1 has a value of high and water level 2 has a value of 1, then the status displayed is FLOOD ALERT, and the buzzer will be active every 10 seconds. The following is a measurement table when testing flood status.

Table 5. Measurement table for flood condition simulation.

No	Water Level 1	Water Level 2	Tip / Rainfall	Buzzer	Status
1	1	0	8 Tip / 3,2 mm	off	Normal Rainfall Low Water Levels (Normal)
2	1	1	8 Tip / 3,2 mm	off	Normal Rainfall, High Water Levels (Waspada)
3	1	1	25 tip / 10 mm	On 5 sec	Heavy Rain, High Water Levels (Siaga)
4	1	1	54 Tip / 21,6 mm	On 10 sec	AWAS BANJIR

In this simulation test, each sensor works well. The programmed system is able to work well, so there are no errors in identifying conditions. With good performance, the tool can be implemented in real conditions.

4. CONCLUSION

Based on the test results and trial results of the early detection tool for flooding above, several outputs are that this tool can measure the amount of rainfall and water height in real time, which can be monitored from the ThingSpeak website, and the tool can provide notifications for every water level and rainfall that has been set to help the community get early notification of flood disasters and also help the community minimize losses caused by flood disasters.

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