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Flood Early Detection Using Internet of Things Based on Flood-Ramped Areas

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ABSTRACT

Indonesia is a tropical country that experiences very high rainfall. Very heavy rainfall is the reason for flooding. During the rainy season, continuous rain causes the volume of water in the river to increase and has the potential to cause flooding in several areas. Therefore, an early flood detection tool is needed as an alarm to detect and monitor the increase in water volume in the river and as a measure of rainfall that occurs by utilizing Internet of Things technology to make it easier for people to obtain information about the flood alert status in the area. This early flood detection tool method uses the JSN-SR04T sensor which is used to measure the water level in the river, the YL-83 sensor which is used to estimate the rainfall that occurs, Telegram as an Internet of Things media, and Solar panels as Off Grid PLTS. After testing and analyzing the early flood detection tool using ESP8266 based on the Internet of Things in flood-prone areas, the conclusion is that the early flood detection tool works well and the results achieved are in accordance with the function and work of the tool.

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1. INTRODUCTION

Floods are one of the natural disasters that often occur in residential areas, especially in areas close to riverbanks [1]. During the rainy season, rainfall can be high and last for a long time. Continuous rain causes the volume of water in the river to increase and has the potential to cause flooding in several areas. In addition to bad weather conditions, floods can be caused by several other factors, namely damaged environmental conditions, bad habits of people in littering, and illegal logging which causes a lack of water absorption areas in the soil. If flooding occurs, the community will experience many losses. According to Kompas.com, from data collected by the Padang City BPBD, as of 2021 there were 16 flood-prone points in the city of Padang [2]. The absence of initial information provided resulted in a slow response in flood management, resulting in losses both in terms of material and human lives for people in flood-prone areas and densely populated urban areas..

At this time, technology can be said to be very developed. Technological innovations that can be developed when there is an increase in water volume in the river are early flood detection systems [3]. Of course, the community needs information on rising water levels on riverbanks that can help the community improve their readiness and preparedness to face floods. A technological system that can provide information to the community on an early flood detection system is using the IoT (Internet of Things) system. The Internet of Things (IoT) is a type of technology that is always connected to the Internet. IoT is about connectivity with different protocols. IoT can see, hear, think and act, communicate and share information [4].

In this context, the development of early flood detection tools for flood-prone areas is very important. This study presents a development in the application of early flood detection tools that use the

JSN-SR04T ultrasonic sensor as an input in reading the water level value on the river surface. The use of the JSN-SR04T ultrasonic sensor is based on the accuracy of reading the value and waterproof sensor technology, so that when the sensor is exposed to water in the application of the tool, it will not cause a Short-Circuit on the tool. This tool is also designed using the YL-83 rain sensor which is used to estimate the amount of rainfall that occurs, and also uses solar panels as an off-grid PLTS system to supply power to the tool, and also uses the Internet of Things as public information to the public in real time in providing information about the water level in the river before, during, and after a flood. Thus, this research is expected to contribute to the development of early flood detection technology, and to be able to increase the level of public awareness of flooding in the surrounding area. In addition, this research is also expected to provide useful information for related parties in steps to realize public awareness of flood disasters.

2. METHOD

The method used in this study is research and development. The research stage includes a literature study related to the research to be carried out. In this study, the literature study conducted includes a comparison between the HC-SR04 ultrasonic sensor and the JSN-SR04T [5], studying previous research that has been done and knowing the right method in detecting water levels in rivers [6]. By utilizing data and information that has been collected from the literature study that has been carried out, a number of theories have been produced that can be tested for truth and applied to this study. The development stage in this study includes planning and managing research so that the research results can be shown. The development process of this research includes three stages, namely system planning, system assembly, and system testing. In general, system planning and assembly includes three parts, namely; software, hardware, and mechanics. Software planning involves creating block diagrams and flowcharts. Figure 1 shows the block diagram of the system proposed in this study.

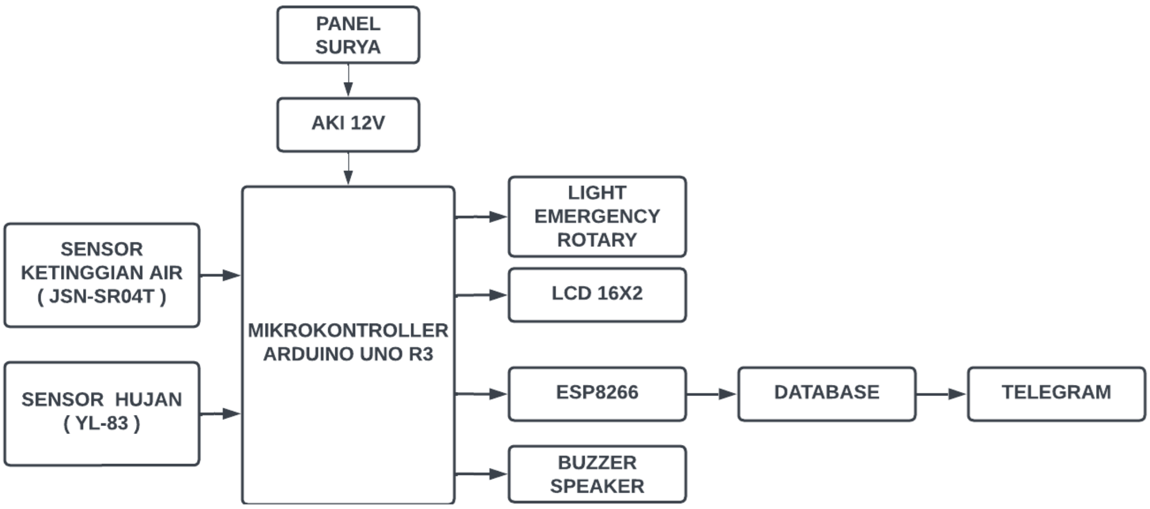

Figure 1. Diagram block of proposed system

The image above shows the design of the JSN-SR04T ultrasonic sensor connected to the Arduino microcontroller. The ultrasonic sensor works with a trigger pin reflecting waves that have a frequency of 20kHz which are received by the echo pin so that it can be known how far the sensor is from the object [8]. Data that is successfully detected by the ultrasonic sensor will be sent to the microcontroller as a process component, then will be forwarded to the output component. The data received by the system will be the basis for the work of this early flood detection tool. Arduino will process the data received, then will send the process to the output component. In image 1 above, the solar panel and battery function as the power source for this tool, where the solar panel will convert sunlight into electrical energy in the photovoltaic process [9], then the electrical energy will be stored in the 12V battery installed in the circuit. In installing a 12V battery on the Arduino circuit, a component is needed, namely the LM2956 DC-DC converter which functions to reduce the voltage produced by the battery from 12V to 5V [10]. If the battery installation to the circuit does not use a Stepdown DC-DC converter, the circuit will burn because Vin on the Arduino is only 5V. The installation of the NodeMCU ESP8266 aims to be a wifi connection for the circuit that will be connected to the internet [11]. The resulting internet connection is needed to connect the telegram to the device, so that when the sensor detects the water level, the sensor detection data can be seen on the telegram channel that has been programmed using the telegram father bot [12]. So that the results that will be displayed by the text message on the telegram are in the form of processing water level data, estimated rainfall that occurs, and the status of the situation that occurs in real-time. Light Emergency Rotary or Warning Light functions as an output from the system's work, the Warning Light will light up when the status is in Alert 2 and Flood, the status of the situation will also be displayed on the telegram bot and LCD16x2 on the device. LCD16x2 and I2C function as outputs from the microcontroller that provide visualization in the form of text.

The entire system has a well-structured workflow, starting with detecting the water level in the river, sending the height data to the microcontroller so that it can be processed, connecting the internet of things through the use of NodeMCU ESP8266, turning on the danger indicator in the form of a warning light and also a buzzer, to displaying data visualization on the LCD16x2. The workflow of the system is structured and presented in a flow diagram in Figure 2 below.

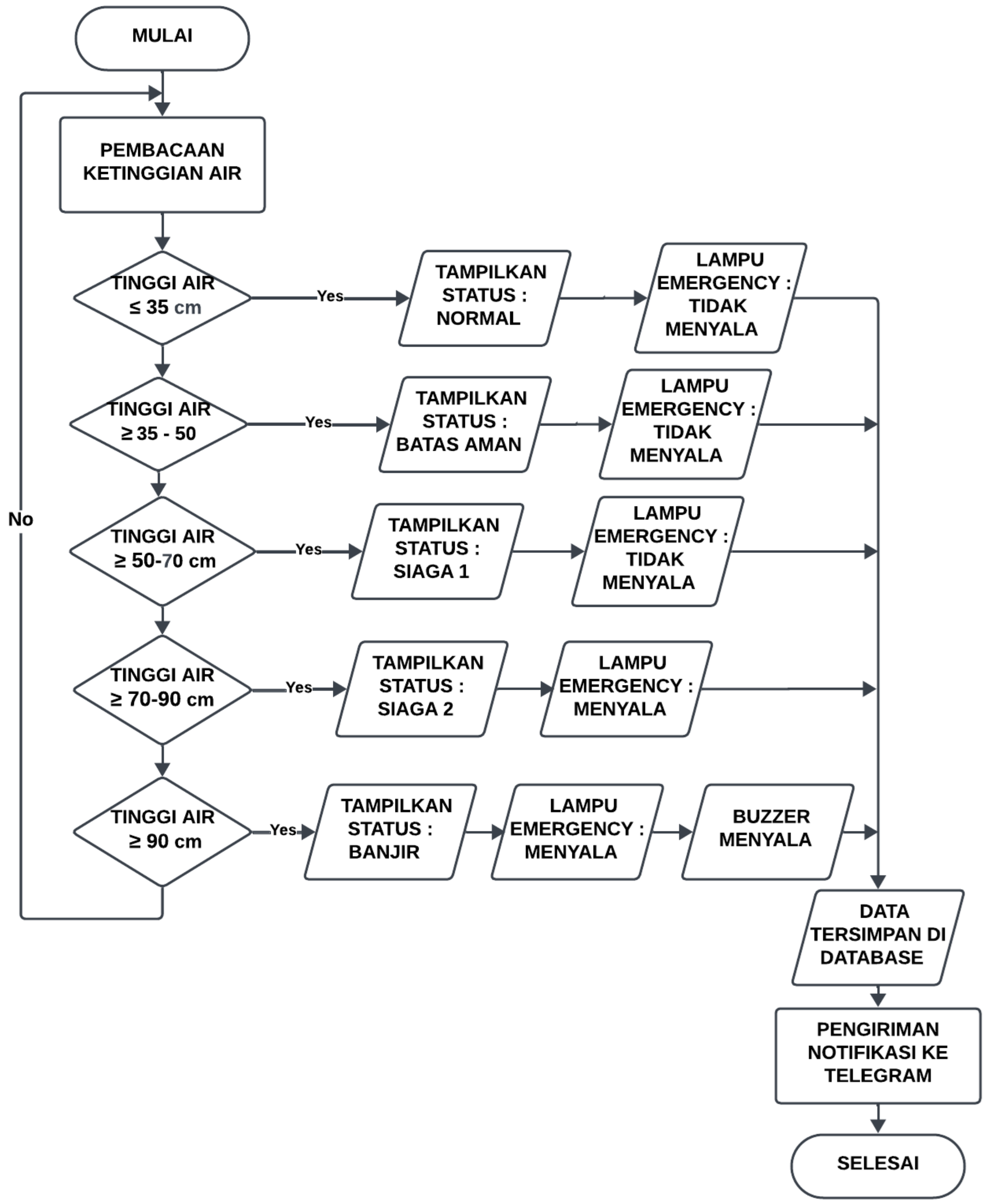

Figure 2. Flowchart of proposed system

In Figure 2 above, the flowchart presented provides a detailed explanation of the system workflow. Starting the system is the first step in the operation of the tool. The JSN-SR04T ultrasonic sensor reads the water level as the second step in the system operation, where the JSN-SR04T ultrasonic sensor functions as the main input in the early flood detection tool. When the sensor detects the water level, the measurement data will be sent to the Arduino microcontroller for processing. The processed data will be displayed in real-time on the LCD16x2, then the LCD will show how the water level changes. If the water level read by the sensor is more than 100 cm, the status that will be displayed on the LCD is Flood, with the emergency indicator light on and the buzzer also on. The data displayed in real-time on the LCD can also be accessed via the telegram bot that has been programmed by sending a text message "Status" on the interface display of the telegram bot, then the data that has been obtained will be displayed in the telegram message. The system used will continue to be on to get water level information periodically, so that the process of reading this sensor will continue to occur using a looping system. Figure 3 shows the overall circuit of the system.

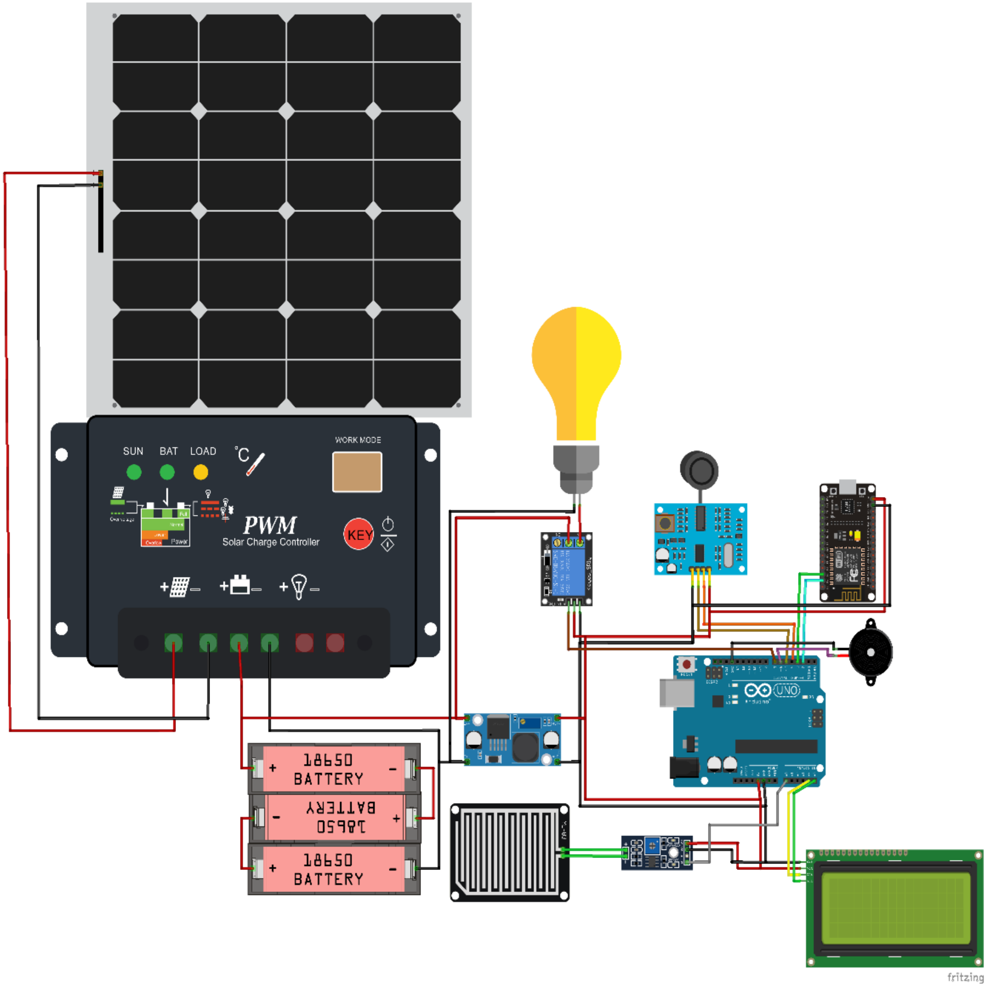

Figure 3. Whole System Circuit

In figure 3 above, it shows how the overall system circuit used. This circuit includes all components used, which are involved in the operation of the system. Where in figure 3 it can be seen that the voltage source from the device comes from a battery connected to the solar panel and solar charge controller, the battery is also connected to a stepdown DC-DC converter which functions to lower the battery voltage from 12V to 5V before entering the Vin pin of the Arduino. In controlling the use of Warning Light in the circuit, a relay is used so that the installed Warning Light can be controlled through programming on the Arduino IDE, where if the relay is in High condition, the warning light will light up, and if it is in Low condition, the Warning Light is not lit. The use of High and Low logic in programming is also used on the buzzer, when the data that has been processed by the microcontroller is High logic, the buzzer will light up, and if it is Low logic, the buzzer will not light up [13].

3. RESULTS AND DISCUSSION

This research was conducted with several experiment, namely solar panel voltage testing and overall system testing. First, the solar panel voltage test was carried out. The solar panel circuit is a circuit consisting of several other components in the form of solar panels, solar charge controllers, and batteries. Where these three components have the function of supplying the voltage needed by the entire circuit of the device. The solar panel will absorb sunlight which will then be controlled through the SCC and will be stored in the battery, where later the power stored in the battery is used as a voltage generator for the device. The output from the solar panel itself is in the form of DC voltage which will later be stored in a 12 V battery. So when the battery is used as a voltage source for the entire circuit of the device, the 12 VDC voltage must first be reduced to 5V to enter the Arduino microcontroller. The measurement results from the solar panel are shown in Figure 4(a).

(a) (b)

Figure 4. Solar panel testing, a) Solar Panel Voltage Measurement Without SCC Connection, b) Solar Panel Voltage Measurement Connected to SCC.

In Figure 4(b) 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 SCC pin connected to the solar panel to be measured. The measurements carried out in Figure 5 are voltage measurements on the solar panel connected to the SCC, so that the output voltage produced is a voltage controlled by the SCC. In Figure 5 above, the output voltage produced is a DC (Direct Current) voltage of 11.81 VDC according to the magnitude measured by the multimeter. The results of the measurements carried out are presented in the form of voltage produced by the solar panel, obtained from the results of measurements using a measuring instrument as seen in Figure 4(a) and Figure 4(b). Measurements are made to obtain the voltage value produced by the solar panel when connected to the SCC or without the SCC. The results of measurements and tests of the solar panel in obtaining output voltage can be seen in Table 1.

Based on Table 1, the measurement test of the solar panel voltage was carried out every 4 hours, where the time was adjusted to how the intensity of sunlight that could be converted by the solar panel changed. The measurements in Table 1 were carried out without a Solar Charge Controller (SCC) connection, this was intended to see the amount of voltage produced by the solar panel directly without being controlled first by the SCC. Table 1 also describes the measurement of the solar panel voltage connected to the SCC. The test results in Table 1 show a large difference in the voltage produced by the solar panel. The installation of the SCC on the solar panel can control the voltage that will enter the battery, so that when the battery is charged using the voltage from the solar panel, the battery does not experience overcharging. Table 1 shows that there is a voltage drop that occurs when measuring the solar panel voltage without being connected to the SCC at 13.30 and 17.30. The voltage drop that occurs is 3.48 VDC, while when measuring the solar panel connected to the SCC, the voltage drop that occurs is only 0.72 VDC. In other words, by using SCC, the incoming solar panel voltage will be more stable.

Table 1. Solar Panel Voltage Measurement Without SCC Connection

Status	Time	Voltage (V)	Evidence
Without SCC	13.30 WIB	18,46 Volt	Bright
	17.30 WIB	14,98 Volt	Bright
	21.30 WIB	1,10 Volt	Bright
With SCC	13.30 WIB	12,53 Volt	Bright
	17.30 WIB	11,81 Volt	Bright
	21.30 WIB	0,30 Volt	Bright

Next, the entire tool was tested. The test was carried out with the tool placed on the banks of the Intan Raya Pegambiran river, where the test conditions were carried out during rain and when the weather was bright and sunny. When the weather was bright and sunny, the results were obtained where when the JSN-SR04T sensor detected a height of 83cm, the sensor would send data to the telegram database, and display the reading of the distance, rain and safe limit status conditions on the LCD with the emergency indicator light not on and the buzzer also not on. When the measurement was carried out during rainy conditions, the JSN-SRT04 sensor detected a water height of 74 cm, then the sensor would send data to the telegram database, and it could be seen by typing "Status" on the telegram bot, so that the bot would display a series of rain data, water distance data, and alert condition status 1. Table 2 describes the test results in sunny weather conditions and Table 3 describes the test results in rainy weather.

Table 2. Overall Testing During Sunny Conditions

No	Time	Water level	Condition	
			Buzzer	Emergency Light
1	15.30 WIB	21 cm	Off	Off
2	16.00 WIB	20 cm	Off	Off
3	16.30 WIB	22 cm	Off	Off
4	17.00 WIB	27 cm	Off	Off
5	17.30 WIB	21 cm	Off	Off

Table 3. Overall Testing During Rainy Conditions

No	Time	Water level	Condition	
			Buzzer	Emergency Light
1	15.30 WIB	30 cm	Off	Off
2	16.00 WIB	36 cm	Off	Off
3	16.30 WIB	32 cm	Off	Off
4	17.00 WIB	32 cm	Off	Off
5	17.30 WIB	31 cm	Off	Off

Based on the overall test results in Table 2 and Table 3, the water level read by the sensor can be affected by the ripples in the river. And from both overall tests, the conditions achieved were the safe limit and alert 1, so that the emergency indicator lights and buzzers installed on the device did not turn on. During the test 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 a simulation carried out by measuring the water level in the paint bucket container and testing the system whether it could work properly in providing warnings and alarms when a flood occurs. Table 4 describes the measurements during the flood status test. Table 4 shows the results of the flood condition simulation test that was carried out. The simulation test that was carried out was divided into 3 predetermined conditions. The test that was carried out was by adjusting the water height according to the conditions. Where when the water was detected at a height of 55 cm, the Warning Light installed as an indicator was on and with the buzzer condition that was not on, while the status of the condition displayed was Alert 1. In the next test, namely, the water was detected at a height of 75 cm by the sensor, where the Warning Light as a danger indicator was on, and the buzzer was still not on, the status displayed at a water height of 75 cm was Alert 2. The 3rd measurement was at a water height of 90 cm, at a water height of 90 cm, the Warning Light as a flood indicator was on and the buzzer was also on, in this condition the status displayed was Flood.

Table 4. Flood Condition Simulation Measurement

No	Water level (cm)	Condition status	Warning	
			Buzzer	Emergency Light
1	55 cm	Siaga 1	Off	On
2	75 cm	Siaga 2	Off	On
3	90 cm	Banjir	On	On

In this flood simulation test, each flood indicator works well. The programmed system is able to work well, so that there are no errors or mistakes in identifying the status. With good performance from each system, the tool can work optimally and can be implemented in real conditions..

4. CONCLUSION

In the JSN-SR04T ultrasonic sensor test, the error rate obtained by the sensor is 1 cm. In the measurement process, the water level in the river by the sensor can also be affected by the ripples that occur. So it can be concluded that the ultrasonic sensor works quite well and accurately in measuring the water level on the river surface. These results were obtained by conducting tests for 2 times with different weather conditions. Thus, this early flood detection tool can be implemented in flood-prone areas, in order to provide information on river water levels to the surrounding community.

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