

Design of Flood Early Warning Monitoring System Using a ESP32 Microcontroller Ultrasonic Sensor Based on Website and Telegram Chat Bot

Wildan Faturachman¹, Popon Dauni², Erwin Teguh A³, Adam Husain⁴, Iim Abdurrohman⁵

^{1,2,3,4}Department of Information System, Univ. Kebangsaan Republik Indonesia, Indonesia

⁵Department of Informatics Engineering, Univ. Kebangsaan Republik Indonesia, Indonesia

Article Info

Article history:

Received Oct 30, 23

Revised Nov 22, 23

Accepted Dec 13, 23

Keywords:

Flood

Microcontroller

Ultrasonic Sensor

Monitoring

ABSTRACT

Floods are devastating natural disasters that frequently occur in Indonesia, particularly during the rainy season. The losses incurred by this disaster are significant, as it happened suddenly, leaving little time to evacuate valuables or move to a safer location. The financial and material losses, as well as the loss of lives, are overwhelming, as there is no early warning system in place to minimize the damage. However, a solution may exist in the form of an early warning system that uses ultrasonic sensors and microcontrollers to gauge water levels and alert the public of impending danger. To this end, we have developed a flood early warning monitoring system that utilizes the HC-SR04 ultrasonic sensor as a water level meter and the ESP32 microcontroller as an automatic early warning controller that sends alerts via telegram and sounds an alarm when river water levels reach the surface. Based on the research results, the water level calculations provided by the system are the same as conventional measurements and provide up to date height information via telegram.

Corresponding Author :

Wildan Faturachman,

Information System Department, Faculty of Computer Science and Information Systems, Univ. Kebangsaan Republik Indonesia.

Jln. Terusan Halimun No.37 (Pelajar Pejuang 45) Bandung, Jawa Barat, Indonesia. 40614

Email: jesii@ukri.ac.id

1. INTRODUCTION

Floods are a natural disaster that frequently occurs in many countries, including Indonesia. This disaster can lead to serious losses, both in terms of property damage and loss of lives. To reduce the negative impact of floods, it is important to have an effective early warning system that can inform the public about the potential occurrence of floods so that they can take appropriate preventive measures and reduce risks.

However, in many areas of Indonesia, especially in rural areas, adequate flood early warning systems are still not available. This limitation can result in a lack of timely information delivery to the public about the dangers of floods, ultimately increasing the losses and risks faced by the community [1].

In this context, this research aims to design and build an early warning flood monitoring system using the HC-SR04 ultrasonic sensor based on the ESP32 microcontroller[2]. The HC-SR04 ultrasonic sensor will be used to detect water levels in rivers or flood-prone areas. This system will be connected to the ESP32 microcontroller, which will process data from the sensor and provide early warnings to the public through communication channels such as the Telegram application [3][4].

This monitoring system will also be equipped with real-time monitoring features that allow authorities to directly monitor river water levels through a website[5]. Understanding water level conditions accurately can maintain the stability of the water management system and provide protection against the threat of flooding or drought[6]. With timely information about water levels, authorities can take necessary actions, such as sending evacuation teams or providing instructions to the surrounding community[7].

Furthermore, this system will also be able to store historical water level data in a database, which will help in post-flood analysis and future planning. This information can be used to identify flood patterns and trends and improve early warning systems for the future.

By implementing the design and construction of an early warning flood monitoring system using ultrasonic sensors and microcontrollers based on a website and Telegram chatbot, it is hoped that it can reduce the losses and risks caused by floods. Communities will be better prepared and vigilant against the dangers of floods, and the proper preventive measures can be taken to protect lives and property.

2. METHOD

2.1 Research Methodology

In this research, the system design method known as the waterfall method is utilized. The reason for using this method is its systematic and sequential nature, starting from the design phase to unit testing. Therefore, the waterfall method facilitates the implementation of this research.

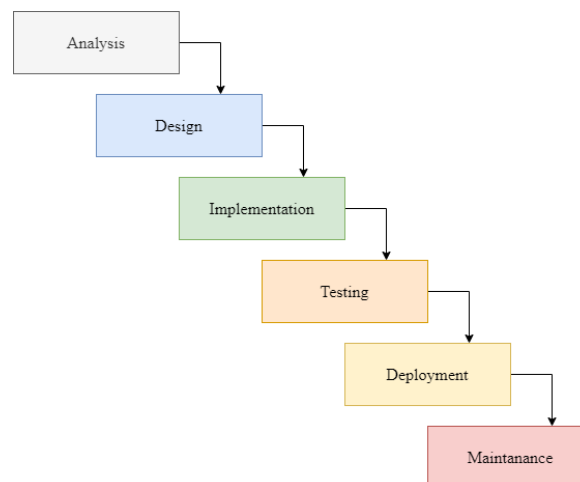


Figure 1. Waterfall Method

This method follows a series of steps or phases. Each phase has different tasks and objectives, which together form a complete cycle from the beginning to the end of software development. However, in this research, only four phases of the waterfall method are used, namely analysis, design, implementation, and testing or evaluation of results. This choice was made because the researcher wanted to focus on testing the validity in terms of content and also testing the prototype of the monitoring system that has been built [8].

2.2 Data Collection Method

Data Collection Method in this research involves a literature review, such as theses, dissertations, textbooks, and scientific journals. Additionally, supplementary information is gathered from the internet. Before conducting the research, several relevant previous studies are also used as references to formulate the research questions. Literature review may encompass scientific journals, books, or other reference sources. Literature review serves two important functions in research: to provide answers to previously posed questions and to suggest or formulate new questions relevant to the research topic [9].

3 RESULT AND DISCUSSION

3.1 Flowchart

The system workflow flowchart illustrates the entire workflow of the device from being powered on to sending warning messages. Below is the flowchart diagram of the early warning flood monitoring system :

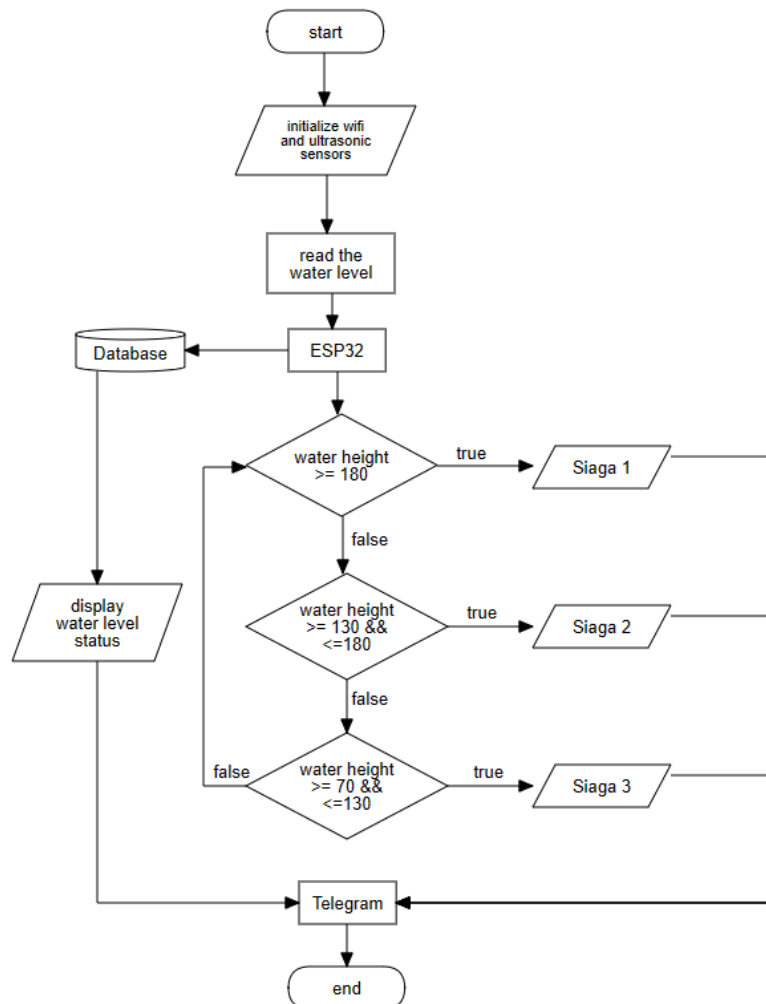


Figure 2. Flowchart

3.2 System Design

To comprehend the designed system, the system design flow is created meticulously using various system visualization methods.

3.2.1 Use Case Diagram

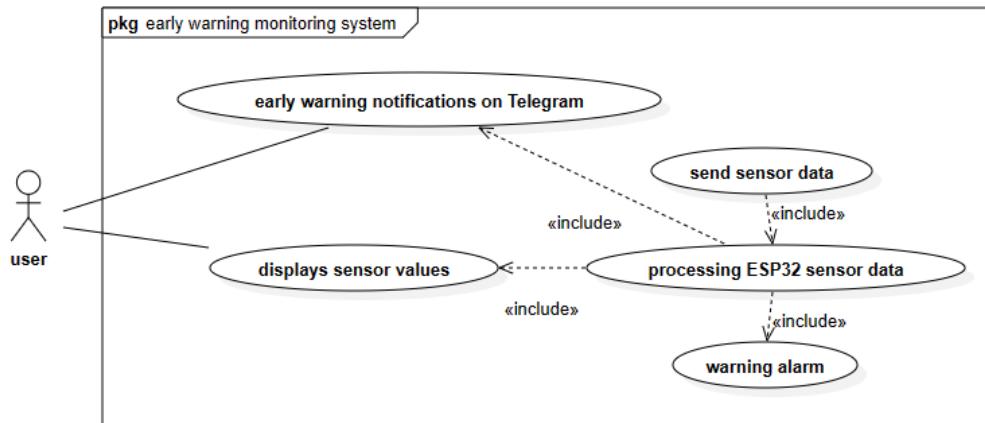


Figure 3. Use Case Diagram

A use case diagram is a visual tool used to depict the various ways in which users can interact with a system and the functionalities present within the system from a user perspective. This diagram provides a functional description of the system and outlines its primary processes. Additionally, the use case diagram identifies the actors or users involved in using the system. In this design, the use case diagram includes only one user role, which represents a single user or actor interacting with the system. The user in this use case functions as a member of the community or residents who are part of a Telegram group chat.

3.2.1 Activity Diagram

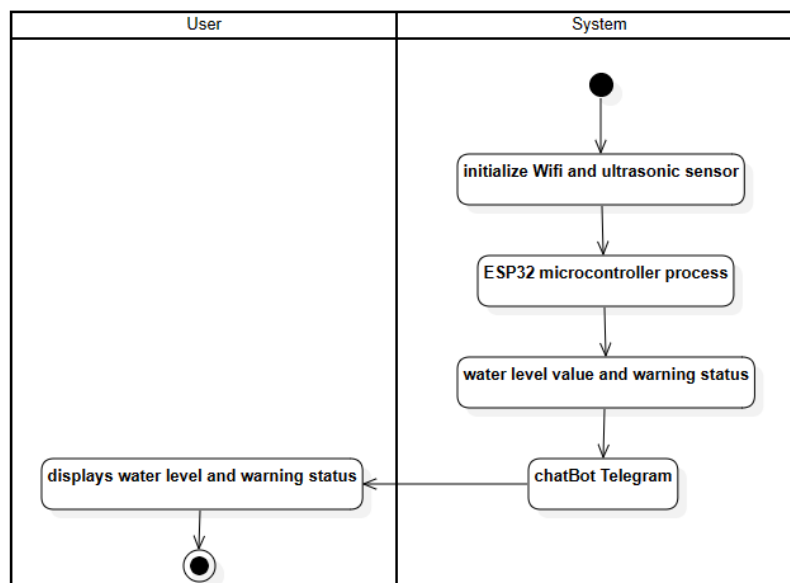


Figure 4. Activity Diagram for Telegram Early Warning Notification

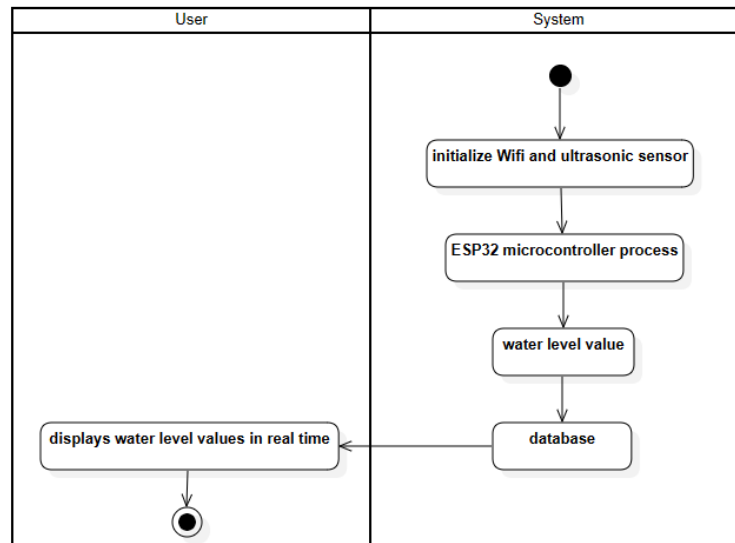


Figure 5. Activity Diagram for Displaying Sensor Values on the Monitoring Website

By developing this activity diagram, the goal is to make the processes within the system more easily understandable. Users will have the ability to monitor water levels either through messages delivered by the Telegram Bot in the group or through the available display on the website page.

3.3 Hardware Design

To facilitate the understanding of the operation of the designed hardware, the flow or design of the hardware is typically created in such a way through the use of diagrams and illustrations of the device's circuitry.

3.3.1 Block Diagram

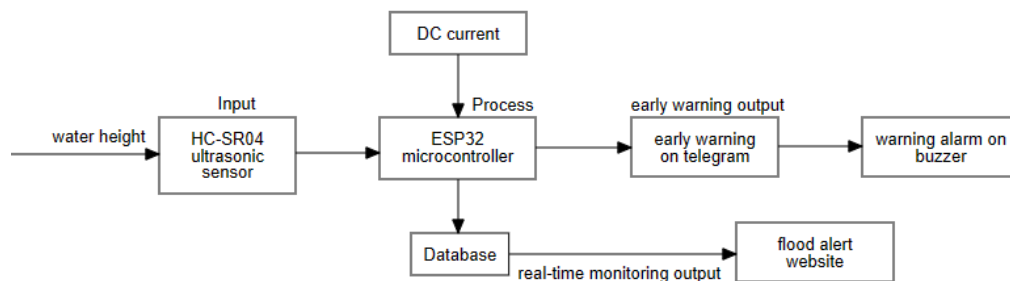


Figure 6. Block Diagram

The block diagram system illustrates the system's structure, emphasizing inputs and outputs. Inputs are from the HC-SR04 ultrasonic sensor, measuring distance. The sensor produces digital output based on ultrasonic wave travel time. A microcontroller processes input data and sends distance data to a database, displaying it on the flood alert website. The system also provides early warnings through Telegram messages and activates a warning alarm. The microcontroller used is the Esp-Wroom-32 (Esp-32) [10].

3.3.2 Circuit Architecture

As the foundation of the research, an architectural diagram is created. Therefore, all supporting components of the device design in the research, including sensors, are assembled into one product, as depicted in the image below.

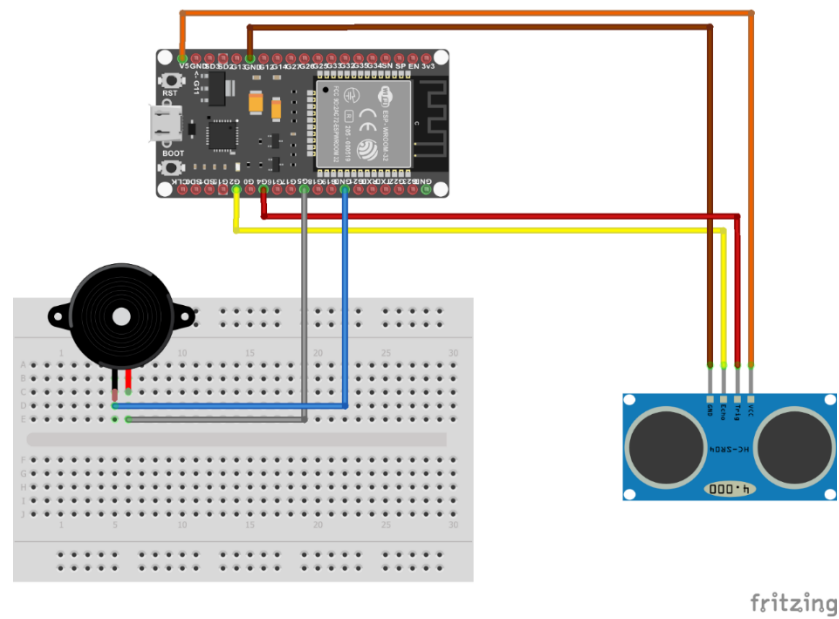


Figure 7. Circuit Architecture

3.4 Implementation

3.4.1. Implementation

After the analysis and architectural design of the device, the implementation of the flood early warning monitoring device is carried out. Below is the image of the implementation of the flood early warning monitoring device.

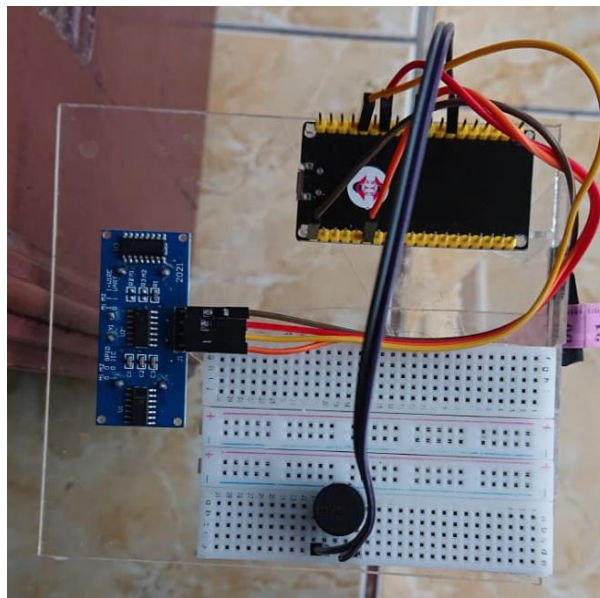


Figure 8. Implementation Tools Design

The image above represents the circuitry of the early flood warning monitoring system, following the components and input/output pin descriptions as explained in the architectural diagram of the device. In the flood early warning monitoring system, water level measurements use an ultrasonic sensor connected to the ESP32.

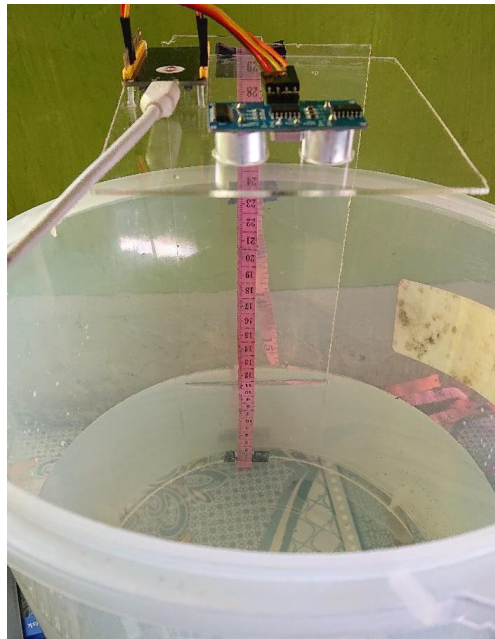


Figure 9. Implementation of a Flood Early Warning Monitoring System

The following is a display of the flood alert chat group which is used to send flood alert status in real time. The information conveyed includes flood alert status, water levels and actions that must be taken by users.

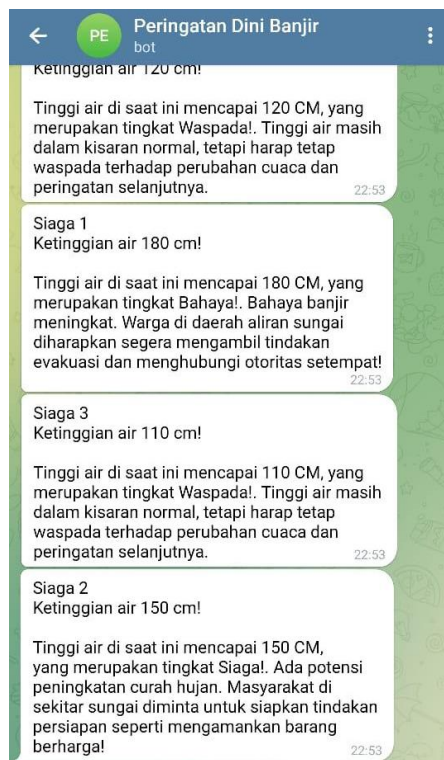
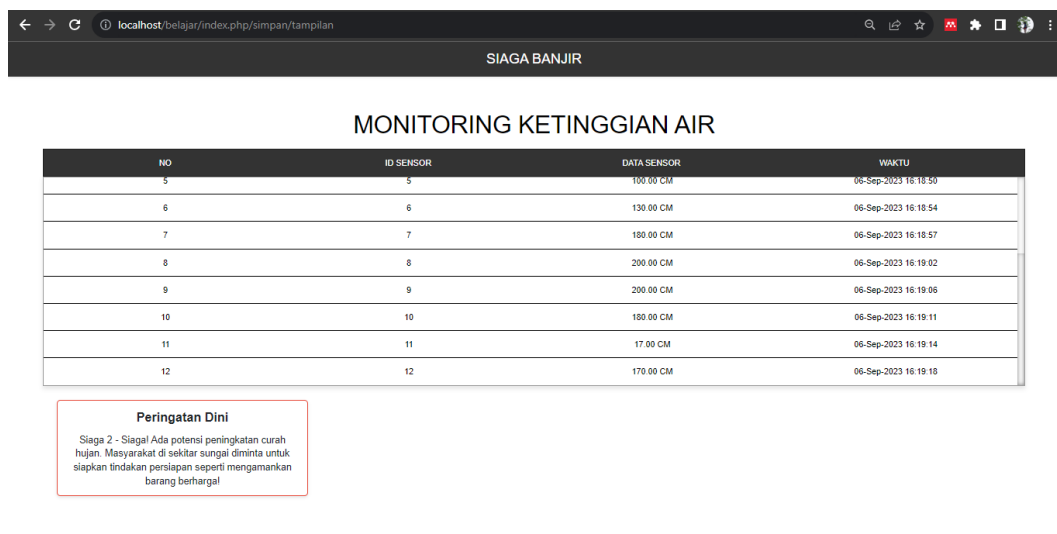


Figure 10. Implementation of a Flood Early Warning Monitoring System

Below is an implementation of the flood early warning website page display which displays the water level in real time.



NO	ID SENSOR	DATA SENSOR	WAKTU
5	5	100.00 CM	06-Sep-2023 16:18:50
6	6	130.00 CM	06-Sep-2023 16:18:54
7	7	180.00 CM	06-Sep-2023 16:18:57
8	8	200.00 CM	06-Sep-2023 16:19:02
9	9	200.00 CM	06-Sep-2023 16:19:06
10	10	180.00 CM	06-Sep-2023 16:19:11
11	11	17.00 CM	06-Sep-2023 16:19:14
12	12	170.00 CM	06-Sep-2023 16:19:18

Peringatan Dini

Siaga 2 - Siaga! Ada potensi peningkatan curah hujan. Masyarakat di sekitar sungai diminta untuk siapkan tindakan persiapan seperti mengamankan barang berharga!

Figure 11. Implementation Flood Early Warning Website Page

3.4.1. Testing

To determine the performance of this design, it is necessary to test the Flood Early Warning Monitoring System to measure the water level. A simulation was created to determine the water level and early warning status.

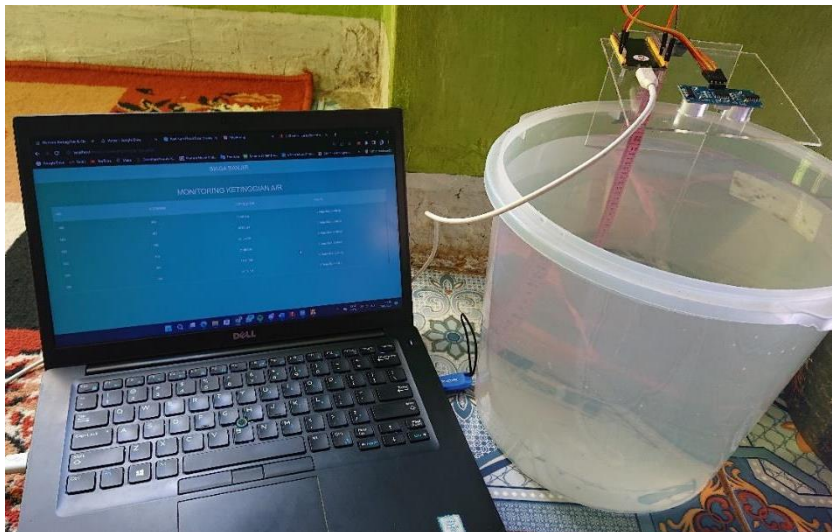


Figure 12. Implementation Flood Early Warning Website Page

The results of the water height test aim to monitor water levels and provide early warning according to predetermined conditions and test the components connected to the ESP32, namely the ultrasonic sensor, telegram bot and flood alert website to function properly.

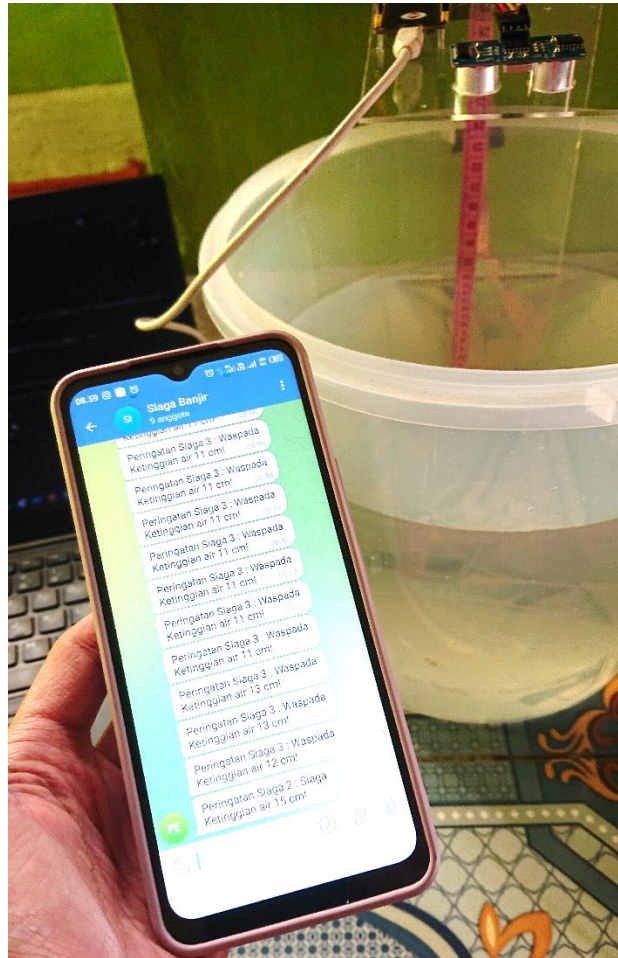


Figure 13. Sensor Testing

Testing the performance of the connection between the ESP32 and Telegram and comparing the calculations with a meter attached to the tool support. Test results, the height warning chat sent via the telegram group corresponds to the water height measured with a conventional meter. The system will continue to send messages until the water level drops according to the alert conditions that have been set.

After designing and testing the hardware and software, the accuracy of the sensor calculations is then carried out by comparing the results of measurements using conventional meters and ultrasonic sensors. The following is a comparison table for water level measurements using ultrasonic sensors and conventional meters:

Table 1. Measurement results

No	Sensor Measurement Results	Conventional Measurement Results
1	6 cm	6 cm
2	8 cm	8 cm
3	11 cm	11 cm
4	13 cm	13 cm
5	15 cm	15 cm
6	16 cm	16 cm
7	21 cm	21 cm

Based on the results of calculation tests between ultrasonic sensors and conventional meters, from 7 experiments carried out the calculation results between the two tools had the same values. It can be concluded that the ultrasonic sensor has precise accuracy and can be used as a tool to measure water level.

4 CONCLUSION

After carrying out analysis, design and testing, it can be concluded that the flood early warning monitoring system using ultrasonic sensors and a microcontroller-based website and Telegram chatbot has been successfully developed. This system consists of components such as ultrasonic sensors and microcontrollers, which work together to collect and transmit water level data. With the appropriate API token, the microcontroller can send early warning messages to Telegram chat groups. Based on the test results, the water level provided by the system is accurate with conventional calculations.

ACKNOWLEDGEMENTS

Thank you to all parties who have supported this research so that it can be completed properly. Especially, for the parents who have always supported and guided me in this research. I'm very grateful.

REFERENCES

- [1] R. Dika Pratama, S. Samsugi, J. Persada Sembiring, J. Z. Pagar Alam No, L. Ratu, and B. Lampung, "ALAT DETEKSI KETINGGIAN AIR MENGGUNAKAN SENSOR ULTRASONIK DENGAN DATABASE," *Jurnal Teknik dan Sistem Komputer (JTIKOM)*, vol. 3, no. 1, 2022.
- [2] Z. Munawar *et al.*, *Fundamental Internet of Things (IoT): Memahami Teori dan Penerapannya*. Bandung: Kaizen Media Publishing, 2023.
- [3] W. Indrasari, B. H. Iswanto, and M. Andayani, "Early Warning System of Flood Disaster Based on Ultrasonic Sensors and Wireless Technology," *IOP Conf Ser Mater Sci Eng*, vol. 335, no. 1, Apr. 2018, doi: 10.1088/1757-899X/335/1/012005.
- [4] M. A. Y. Al Bustomi and Asmunin, "Rancang Bangun Sistem Monitoring Peringatan Dini Bencana Banjir Berbasis Iot Menggunakan Protokol MQTT Dengan Notifikasi Bot Telegram," *J. Manaj. Inform.*, vol. Vol 12, no. 1, pp. 1–13, 2021.
- [5] A. E. Putra and N. Suryana, "Design of home control system prototype using Arduino uno microcontroller based on smartphone," *JESII J. Elektron. Sist. Inf.*, vol. 1, pp. 1–11, 2023.
- [6] A. Gracetantiono dan B. Wasito, "Implementasi Widgets Builder untuk Monitoring Kinerja Sistem Komputer dengan Menggunakan Rainmeter," *Jurnal Informatika dan Bisnis*, vol. 10, no. 1, 2021
- [7] A. Suryo Aminudin dan A. Sujarwo, "Sistem Peringatan Dini Banjir Perumahan Puri Harapan," vol. 1, no. 2, 2020
- [8] F. N. Hasanah and R. S. Untari, *BUKU AJAR REKAYASA PERANGKAT LUNAK Diterbitkan oleh UMSIDA PRESS UNIVERSITAS MUHAMMADIYAH SIDOARJO 2020*. 2021.
- [9] Melfianora, "PENULISAN KARYA TULIS ILMIAH DENGAN STUDI LITERATUR," *Open Science Framework*, vol. 12, no. 1, 2019.
- [10] N. Kristiawan, B. Ghafaral, R. Indra Borman, and S. Samsugi, "Pemberi Pakan dan Minuman Otomatis Pada Ternak Ayam Menggunakan SMS," *Jurnal Teknik dan Sistem Komputer*, vol. 2, no. 1, 2021.