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IoT-Based Flood Monitoring System Using ESP32

Gneskumar A/L Kumaran[1], Jais Lias[1]*

[1] *Faculty of Electrical and Electronic Engineering, Universiti Tun Hussein Onn Malaysia, Batu Pahat, Johor, 86400 MALAYSIA*

*Corresponding Author: jaisl@uthm.edu.my
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TOF10120 laser sensor, ESP32, flood monitoring, Internet of Things (IoT), early detection, Blynk notification

Abstract

This work aims to develop an IoT-based flood monitoring system using ESP32 that detects the water depth level to alert authorities and nearby people. The system utilizes a TOF10120 laser sensor, an LCD, an ESP32, an ESP32 cam, and 3 LEDs as indicators and a buzzer. The system detects water depth levels and categorizes flood severity into three ranges, triggering corresponding LED lights and audible alerts. The green LED indicates an alert level (1401-2000 mm), the yellow LED a warning level (801-1400 mm), the red LED a danger level flood situation (1401-2000 mm) and a buzzer as an alarm. The ESP32 module facilitates wireless connectivity, enabling remote monitoring and alert notifications via smartphone applications. Implementing this IoT-based flood monitoring system offers several advantages, including early detection of flood situations, prompt alerts to concerned authorities and nearby people, and the ability to monitor and manage flood conditions remotely. Such a system can significantly contribute to reducing the impact of floods by enabling timely responses and proactive measures to mitigate potential damages. The IoT application is Blynk. An ESP32 cam is also included as an additional feature to monitor water depth levels visually. Additionally, an LCD is integrated to provide continuous updates on the water depth level as a Blynk notification.

1. Introduction

Natural disasters like flooding have the potential to seriously harm people, property, and infrastructure. 510). Floods are one of the natural disasters that often occur, which cause heavy losses and casualties. It often happens during the North East Monsoon season from November to March every year. In 2022, overall losses due to floods were RM622.4 million [1]. Early warning systems and monitoring technologies are essential for reducing the impact of floods. Nowadays, mathematical modeling has replaced physical modeling at every prediction level. The strategies for flood alerting systems using the Internet of Things (IoT) are covered in this work. Floods in Peninsular Malaysia are regular natural disaster that frequently occurs in Malaysia which happen every year during the monsoon season. Especially the second inter monsoon (October) to early North-East monsoon (November - December) [2].

In this work, a TOF10120 laser sensor will be placed at some base level such that the transmitter and receiver will face the water surface. The TOF10120 laser sensor will send a signal to the water surface and the signal will be reflected back to the receiver. The time taken by the signal to travel from the transmitter to the receiver will be calculated and this time will be used to calculate the distance between the sensor and the water surface. An alert will be sent using a buzzer when the water depth level exceeds a certain level.

This work aims to detect conditions of flooding in rivers. The system uses sensors to provide information over the IoT using ESP32 [3]. The water depth level monitoring and early warning capabilities of the IoT-based flood monitoring system controlled by the ESP32 aim to decrease the negative impact of floods [4]. The system precisely measures the distance to the water's surface using a TOF10120 laser sensor and an ESP32 microcontroller. The sensor can identify rising water depth levels and possible flood situations by continually monitoring the water depth levels.

The ESP32 is linked to a Wi-Fi module that enables the system to connect to the internet in order to provide remote monitoring. The Blynk app, which serves as the user interface for visualizing the flood level in real time, receives the collected data after that. Users may access and monitor water depth level information through the Blynk app, set alerts or thresholds, and receive messages in the event of emergency situations [5]. This makes it possible for nearby residents and authorities to monitor the flood situation remotely and take the required precautions. The Blynk IoT also sends a notification to the user [6].

The IoT-based flood monitoring system enables fast response and evacuation in flood-prone locations while also offering an early warning system by offering real-time monitoring and alerts to nearby residents and authorities, enabling them to take necessary precautions.

2. Methodology

From this block diagram in Fig. 1, the TOF10120 laser sensor will detect the water depth level of the river. ESP32 is a microcontroller that collects data from a laser sensor. Three colors of LED will be used as green, yellow and red to indicate the 3 different water depth level. The LCD will display the distance of laser sensor to water level of river. Data that is gained will appear in the IoT system for authority and nearby people. The buzzer acts as an alarm. An ESP32 cam used to monitor the place visually.

The flowchart in Fig. 2 explains the flow of this system. When the power supply is turned on, ESP32 is activated. Then, the laser sensor starts to detect the water depth of the river. By measuring the distance of the water's surface from laser sensor, we can detect 3 types of water depth levels. First, the alert and green LED will light up. If the warning level is yellow, the LED will light up and a notification will appear in the IoT system. When the water depth level rises to a danger level, the buzzer starts to alert, a red LED will light up and a notification will be sent to nearby people and authorities to alert. Blynk notification only appear for ranges for Danger level and Warning level.

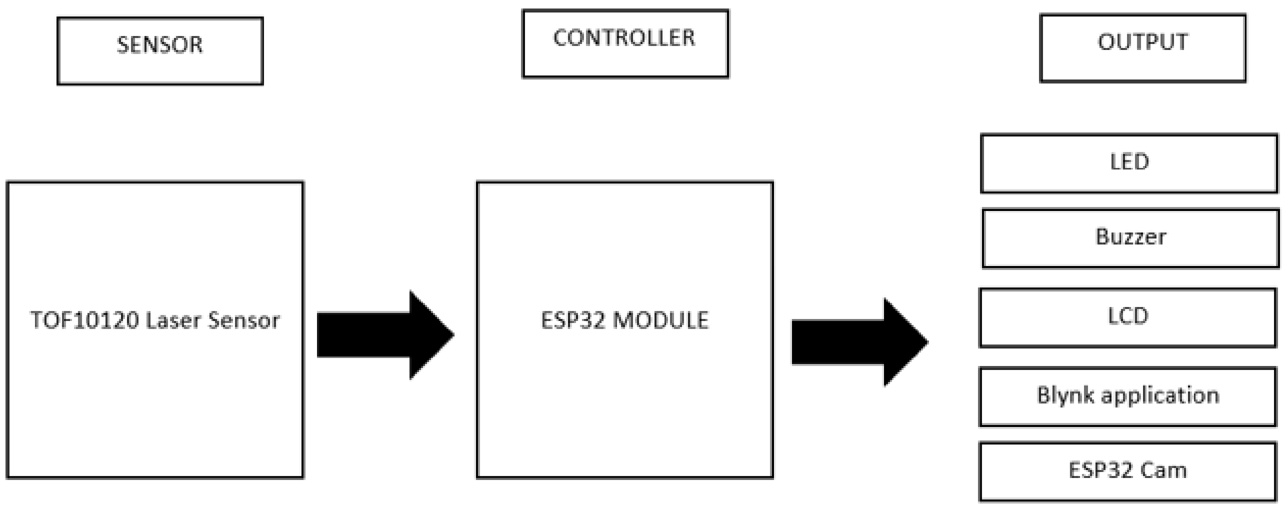


Fig. 1 *Block diagram of the system*

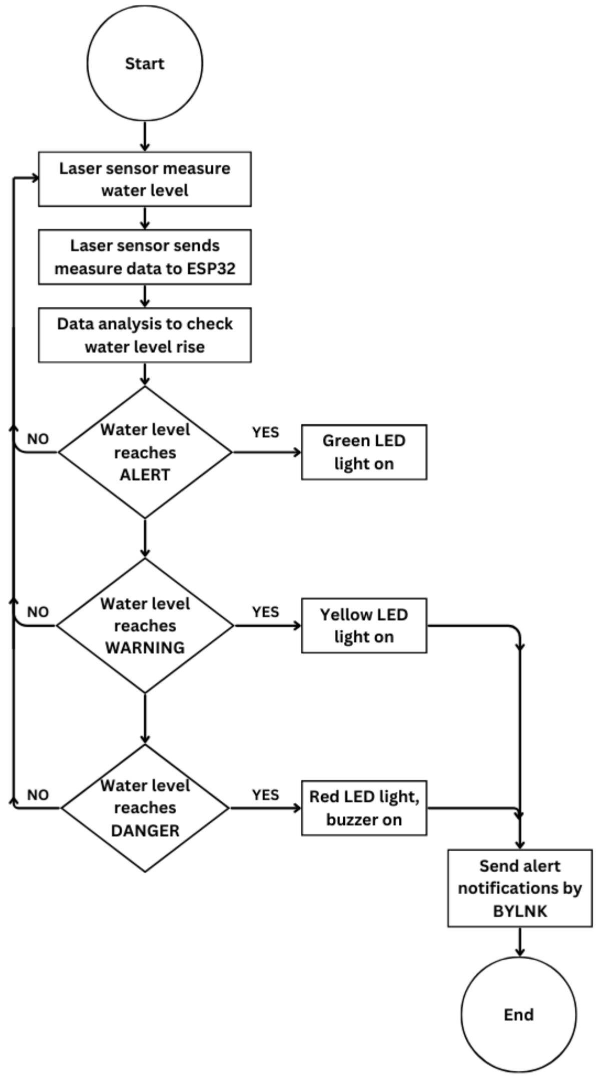


Fig. 2 *Flowchart of the system*

3. Result and Discussion

In this section, the enlightened focus is on testing the function of hardware and software. Thus, the design for this system is based on two fundamental points as follows.

(i) Designing hardware and developing software to measure water rising levels.
(ii) Designing the IoT application using the Blynk platform to monitor the device.

3.1 Prototype Setup

One of the objectives of this work is to develop software and design hardware that can measure the water depth level. Fig. 3 shows the overall prototype of the system. As an output, an LCD screen is placed on the top with 3 different color LEDs and an ESP32 cam. Furthermore, the TOF10120 laser sensor was placed on the bottom to measure the water depth level readings based on the program. The 3 levels of water depth level which are danger, warning and alert. If the water depth level is between 0 and 800 mm, the red LED and buzzer turn on, indicating a high-water depth level. For water depth levels between 801 and 1400 mm, the yellow LED turns on, indicating a moderate water depth level. For water depth levels between 1401 and 2000 mm, the green LED turns on, indicating a low water depth level. In addition, an ESP32 cam was also placed on the top to visually monitor water depth levels. The input of this system is a 12 V battery, which is connected to a solar charge controller and solar panel.

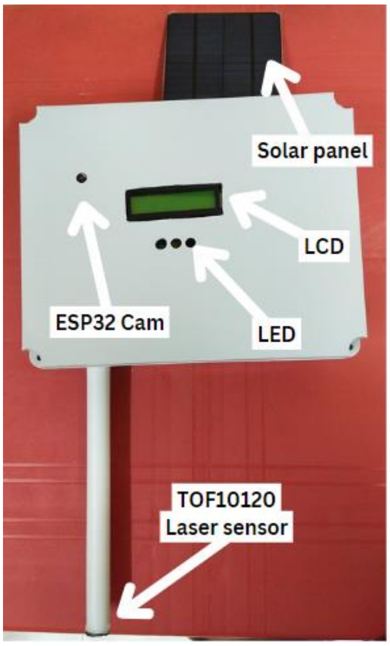


Fig. 3 *Hardware setup of prototype*

3.2 Result

In this work, a flood monitoring system was developed using ESP32 and IoT applications using the hardware and software described in the previous chapter. The system can detect water depth levels and send data to the users using the Blynk IoT system. Once completed, the hardware and system will be tested to ensure all parts are properly connected and functioning properly. If we find any issues during testing, we need to do troubleshooting. This system can detect 3 water depth level which danger, warning and alert. For danger condition level, the depth of water is 0 mm to 800 mm and for warning level the water depth ranges from 801 mm to 1400 mm. The last water depth level will be alert condition which ranges from 1401 mm to 2000 mm. Buzzer which act as sound alert will only trigger for danger condition. There will be 3 different color LED's, red for danger, yellow for warning and green for alert. Blynk application used to give alert notification for danger and warning condition. Each condition level is simply in Table 1. This prototype was tested indoor and outdoor. Fig. 4 shows images from JPS Selangor which shows each water levels.

Table 1 *Result analysis for each level*

Condition level	Water depth level (mm)	Buzzer	LED	Blynk alert notification
Danger	0-800	✓	Red	✓
Warning	801-1400	x	Yellow	✓
Alert	1401-2000	x	Green	x

Fig. 4 *Image from JPS Selangor for each level [3]*

3.2.1 Indoor Result

The initial phase of this prototype needs to be tested indoors before testing outdoors. The assignment involves testing three different water levels in a bucket to simulate other outdoor conditions. All this testing with sensors will transmit data to the Blynk application. Then, Blynk will display gauge meter readings, graph will record data and video will stream in real-time or "live". The goal of this complete testing plan, which is described in Table 1. Firstly, before testing with water in a pail, the TOF10120 laser sensor was tested with range accuracy. For this testing, the prototype needs to be placed on the floor, and measuring tape is used as a scale to measure distance. Random readings were tested for each level. The next test for this prototype is with water in a pail. In addition, we tested with Blynk notification on mobile for alert notification. The height of the prototype needs to be higher to detect warning and alert levels. Fig. 5 shows prototype indoor testing which the prototype placed on the floor with measuring tape and tested distance from sensor and object. Meanwhile, Fig. 6 shows indoor testing with water in pail before testing in outdoor water.

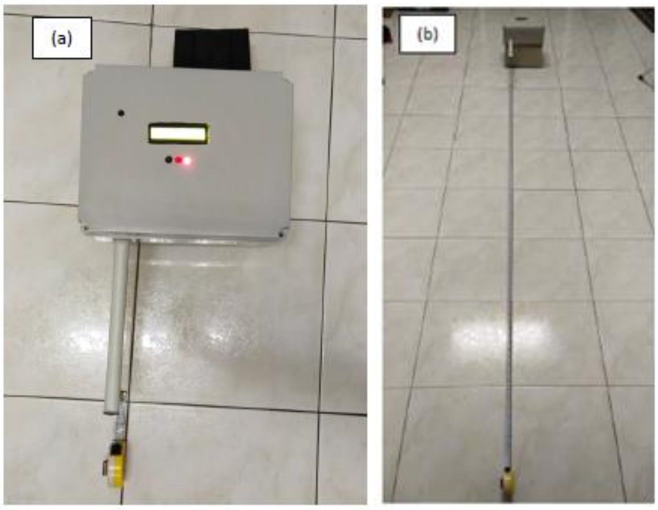


Fig. 5 *Prototype indoor testing (a) Prototype placed on floor with measuring tape (b) Measuring tape's range 2M placed on floor to measure each level*

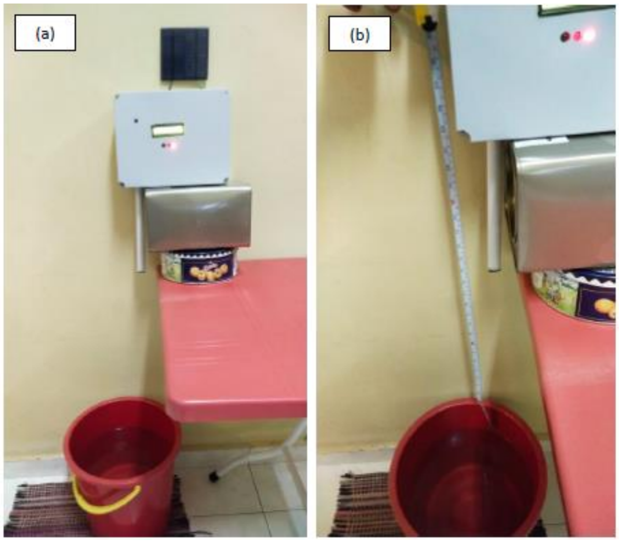


Fig. 6 *Prototype indoor testing with water in pail (a) Setup for measuring 3 different water level (b) Check measured value in measuring tape and LCD*

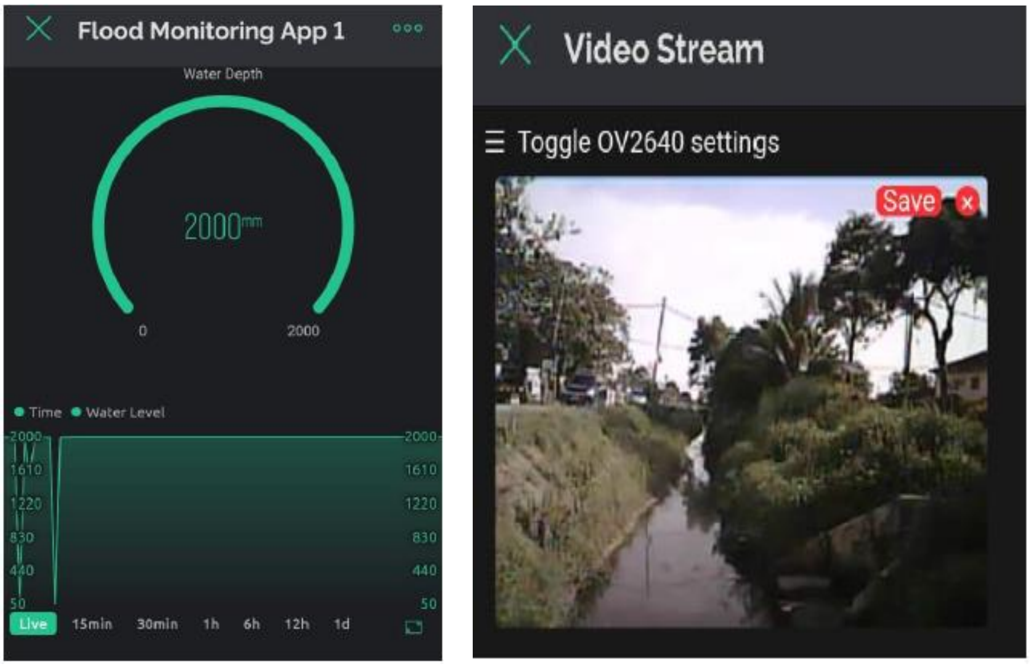
3.2.2 Outdoor Result

To take some real data, the system is tested outdoors. The work involves collecting data from three remote locations. The data collection process may include gathering information and measurements related to the goals of this work. We investigate these outdoor environments and draw conclusions based on data obtained from each of the three locations. The 3 locations are the river beside Hotel Pintar Parit Raja, Pintu Air Parit Jambul and the lake beside PKU, UTHM.

3.2.2.1 Case Study at River Beside Hotel Pintar

This system was tested at the river beside Hotel Pintar. Each sensor output was measured and noted. Due to low water, the prototype measured alert level, which ranges between 1401 mm – 2000 mm. Green LED light up and gauge meter in Blynk app received TOF10120 laser sensor data. ESP32 cam also visually visualizes the river's condition. Fig. 7 shows prototype placed at river beside Hotel Pintar for testing and Fig. 8 shows the testing of Blynk for gauge meter, graph and video view.

Fig. 7 *Prototype testing at river beside Hotel Pintar*



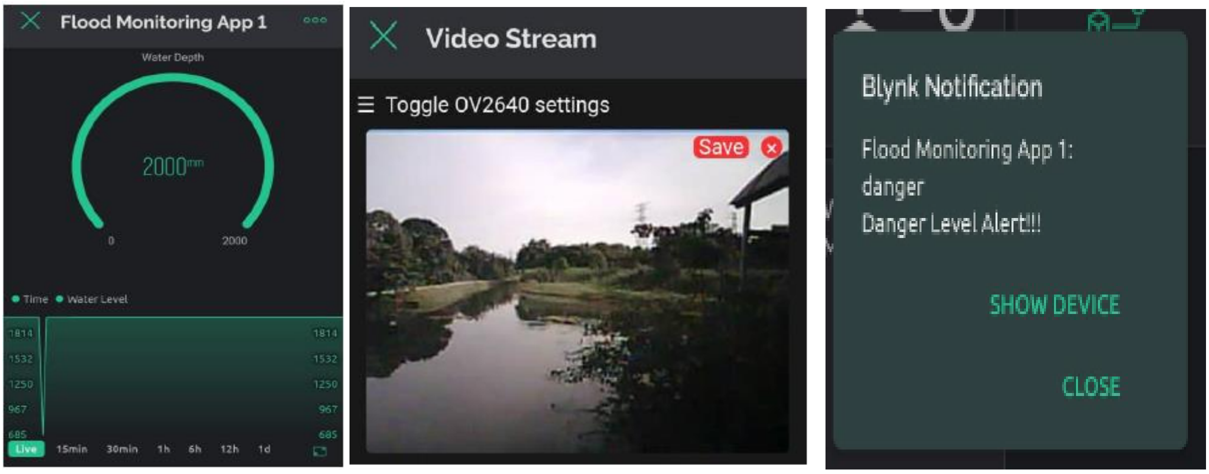
(a) **(b)**

Fig. 8 *Blynk interface (a) Gauge meter reading (b) Live video stream*

3.2.2.2 Case Study at Pintu Air Parit Jambul

This system was tested at the Pintu Air Parit Jambul. The prototype was tested at a high-water level, the prototype measured danger level, which ranges between 0 mm – 800 mm. The Red LED light-up and gauge meter in Blynk app received TOF10120 laser sensor data. Alert notification for danger level and gauge meter reading received in mobile phone. ESP32 cam also visually visualizes the river's condition. Fig. 9 shows prototype placed at Pintu Air Parit Jambul and Fig.10 shows Blynk interface with gauge meter, graph and video view.

Fig. 9: *Prototype placed at Pintu Air beside flood gauge*



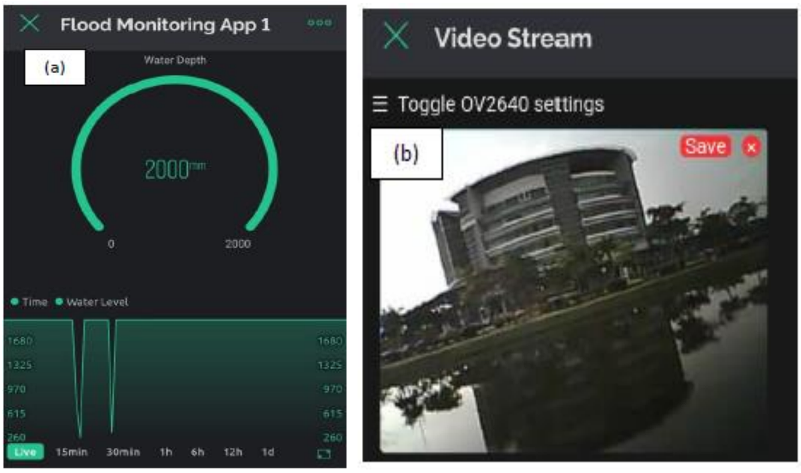
(a) **(b)** **(c)**

Fig.10 *Blynk interface (a) Blynk reading (b) Live video stream (c) Blynk notification for Danger level*

3.2.2.2 Case Study at Lake beside PKU, UTHM

This system was tested at the lake beside PKU, UTHM. Each sensor output was measured and noted. Due to low water, the prototype measured alert level, which ranges between 1401 mm – 2000 mm. Green LED light up and gauge meter in the Blynk app received TOF10120 laser sensor data. ESP32 cam also visually visualizes the river's condition. Fig. 11 shows prototype placed at Lake beside PKU, UTHM and Fig. 12 shows Blynk interface with gauge meter, graph and video view.

Fig. 11: *Prototype placed at Lake beside PKU, UTHM*



(a) (b)

Fig. 12: *Blynk interface (a) Blynk reading (b) Live video stream*

3.3 Blynk Analysis

The Blynk application was used for IoT construction for this system. This IoT application will be designed and developed to monitor flood detection using the TOF10120 laser sensor. This IoT application can only show some functions in the Blynk application. This application enabled remote control of this system. The ESP32 Wi-Fi is used to connect the device and Blynk. Fig. 12 shows the Blynk interface of this system. This application can be downloaded from your mobile phone's application store. This has a gauge meter to show the TOF10120 laser sensor's reading in Blynk. A line graph is used to monitor readings. The provided charts allow monitoring readings in real-time or "live". It is convenient and easy for users and authorities to monitor environmental parameters. As an additional sensor, the ESP32 cam is used to monitor the place visually. The video streams in real-time or "live" as it is convenient for users and authorities. The Blynk application can easily be installed on the user's phone [7]. When the readings reach the range of each sign, Blynk will trigger an alert notification to alert users and authorities, as shown in Fig. 13.

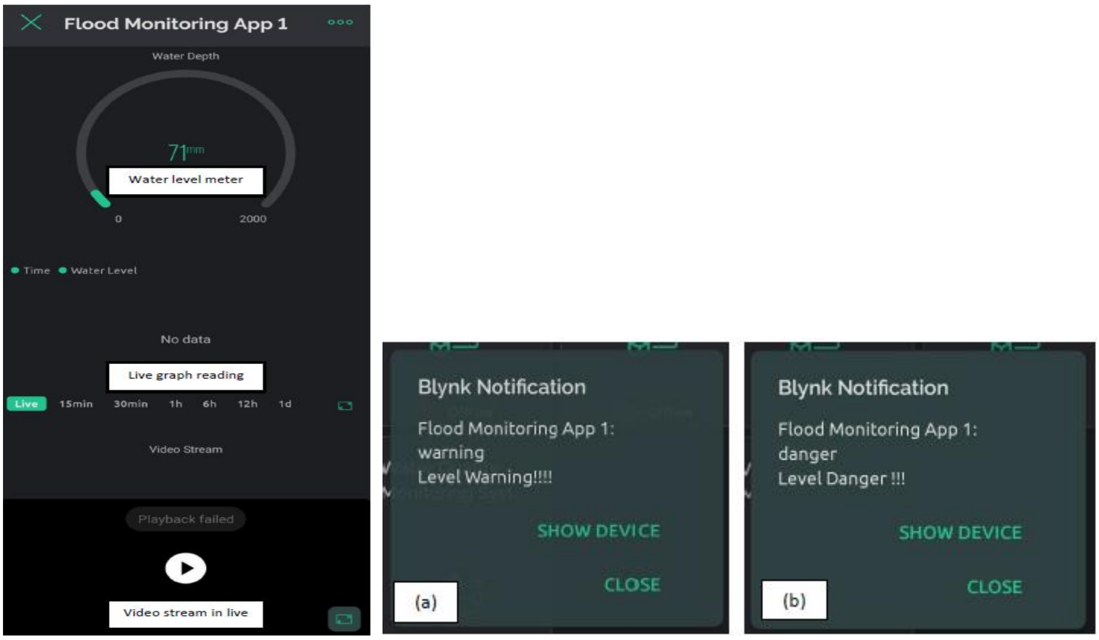


Fig. 13 *Blynk mobile (a) Blynk mobile interface (b) Blynk alert notification for Warning level and Danger level*

4. Conclusion

This work successfully implemented a prototype for a flood monitoring system with an alerting system using IoT technology, specifically utilizing the ESP32 microcontroller and various sensors. The design involved the use of Blynk, an IoT application, for alert notifications to users and authorities based on water level ranges. The software, developed using Arduino IDE and Blynk, enabled the ESP32 to detect water depth levels both indoors and outdoors. Testing was conducted on the hardware, and a protective casing was assembled to complete the prototype. The IoT-based application, facilitated by Blynk, ensured real-time notifications to nearby individuals and authorities when specific water level ranges were reached. The integration of TOF10120 laser sensor, LEDs, buzzer, ESP32 module, ESP32 cam, and LCD provided accurate measurement and classification of water depth levels. Overall, this flood monitoring system offers an effective solution for early detection, quick alerts, and remote management, contributing to mitigating the impact of floods and facilitating prompt responses to potential threats [8].

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The author attests to having sole responsibility for the following: planning and designing the study, data collection, analysis and interpretation of the outcomes, and paper writing.

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