

## Faculty of Electrical and Electronic Engineering Technology



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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# Bachelor of Electronics Engineering Technology (Industrial Electronics) with Honours

#### DEVELOPMENT OF FLASH FLOOD EARLY TRIGGERING SYSTEM BASED ON RAINFALL INTENSITY AND LEVEL INCREASING RATE USING NODEMCU ESP32

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#### DECLARATION

I declare that this project report entitled "Development of Flash Flood Early Triggering System Based on Rainfall Intensity and Level Increasing Rate Using NodeMCU ESP32" is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.



### APPROVAL

I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electronics Engineering Technology (Industrial Electronics) with Honours.

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#### DEDICATION

This thesis is dedicated to those who have helped me from the beginning to the finish of the project's development

To my beloved mother and father, My supervisors, My lecturers, and

All my friends.

Thank you for all of the guidance, support, and encouragement up to this point.



#### ABSTRACT

Flooding in urban can happen suddenly, leaving residents with little time to prepare. Notifying the people who are most at danger helps to mitigate the disaster's effects. Residents can get flood alerts in some places, but most of them are for organizations and only cover a short distance. When flooding occurs, it takes time to reach closest neighbours, and most of them are unable to rescue their belongings. Floods cause chaos on people's homes, schools, and bridges. As a result, early warning and triggering systems can help citizens and governments avoid flood damage. The objective of developing this system is to analyze water level increasing rate of river or drainage system at urban area for flash flood early detection and notification system. Besides, to develop a system that able to estimate and measure rainfall intensity for early detection of flash flood. In addition, to develop a flash flood early detection and notification system based on evaluation of objective stated before. This proposed system use a flow rate sensor and an ultrasonic sensor to monitor rainfall intensity and the increasing rate at which the water level in a river or drainage rises. The siren and the Blynk apps will be used to alert residents in the surrounding region. An authority entity, such as BOMBA or APM, will be notified by Telegram Bot and will take appropriate action. Therefore, it is predicted that the system will aid in the process of relocating individuals in order to prevent substantial property damage and loss of life.

#### ABSTRAK

Hujan lebat yang berterusan selama beberapa jam serta sistem saliran yang tidak baik menyebabkan paras air sungai atau longkang meningkat dengan pantas di kawasan bandar dan menjadi penyumbang utama kepada faktor kejadian banjir kilat yang merosakkan penempatan penduduk serta fasiliti awam. Kesan banjir kilat di kawasan bandar dapat dikurangkan dengan memberikan informasi awal kepada penduduk yang terdedah kepada risiko banjir kilat seperti yang tinggal di kawasan yang mudah dinaiki air. Di Malaysia, sistem amaran banjir hanya terdapat di kawasan tertentu sahaja seperti di lembangan sungai. Oleh sebab itu, sistem pengesanan awal banjir kilat dan sistem notifikasi boleh membantu rakyat dan kerajaan dalam menangani masalah banjir kilat di kawasan bandar. Antara objektif sistem ini dibangunkan adalah untuk menganalisis kadar peningkatan paras air sungai atau sistem saliran di kawasan bandar bagi pengesanan awal dan notifikasi berkenaan banjir kilat. Selain itu, sistem ini menganggar dan mengukur kadar kelebatan hujan untuk pengesanan awal banjir kilat serta sebagai sistem pengesanan awal dan notifikasi banjir kilat berdasarkan penilaian terhadap kadar kelebatan hujan dan sistem saliran di kawasan bandar. Sistem ini menggunakan sensor kadar aliran air dan sensor ultrasonik bagi memantau kelebatan hujan dan kadar peningkatan air sungai atau longkang. Siren dan aplikasi Blynk digunakan untuk menyampaikan amaran kepada penduduk di kawasan sekitar. Pihak berkuasa seperti BOMBA atau APM, akan menerima notifikasi melalui Telegram Bot dan akan mengambil tindakan yang sewajarnya sekiranya menerima pemberitahuan awal berkenaan banjir kilat. Oleh itu, sistem amaran awal banjir kilat ini dapat membantu mengelakkan kerosakan harta benda yang besar dan kehilangan nyawa akibat banjir kilat di kawasan bandar.

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### LIST OF SYMBOLS

- V Volts -
- Ampere Litre A \_ L
  - -
    - \_
      - \_
      - \_
      - \_
      - \_



### LIST OF ABBREVIATIONS

DBKL DID GSM	- - - -	Kuala Lumpur City Hall Drainage and Irrigation Department Global System for Mobile Communication
	-	





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#### **CHAPTER 1**

#### **INTRODUCTION**

#### 1.1 Background

The worst natural disaster Malaysia has ever seen was a flash flood. Heavy rains that continued for several hours as well as poor drainage systems caused the water level of rivers or drains to rise rapidly in urban areas and became a major contributor to flash floods that damaged residents and public facilities. Flash floods are the most common and disruptive hydrometeorological event in Malaysia. They happen most often in urban area like Kuala Lumpur and Kajang. But flash floods can also occur in unexpected areas like the one that recently happened in 2021 in Shah Alam. These flash floods can occur at any time of the year, not just during the monsoon season, and they can cause a lot of damage and loss. So, to deal with flash floods, especially in urban area, it's important to take a number of steps and make some estimates.

Flash floods occur when heavy rain falls quickly and can cause major traffic jams. Thus, it's necessary to notify the most at-risk people to limit the effects of disasters. In some circumstances in Selangor and Kuala Lumpur, the water level rises quickly, leaving inhabitants little time to prepare for escape. Some places have flood alert systems for citizens, although most are intended for organisations, and the system can only cover a certain distance. When flooding occurs, it takes time to reach close residents, and most cannot preserve their belongings as water rises swiftly. The worst case is when floods destroy buildings, houses, schools, and bridges. Flooding is unavoidable and cannot be controlled, but early detection and warning systems can help citizens and governments avert losses. As we know, flash flood occurs when water overflows within a few minutes or hours of excessive rainfall with high intensity and bad drainage system especially in urban area. This project is proposed to measure rainfall intensity and water level increasing rate of river or drain using flow rate sensor and ultrasonic sensor. People at the surrounding area will be notified using siren and Blynk application. An authority body like BOMBA and APM will be trigger through Telegram Bot in order to take a proper action. So, it expected that system will help the process to relocate people to avoid significant property damage and lost of life.

#### **1.2 Problem Statement**

Floods in urban areas can occur suddenly and unexpectedly, leaving residents with little time to prepare. The impact of disasters can be reduced by providing early information to the most at-risk populations. Nowadays, residents can receive flood warnings in some places, but most are for organizations and only cover close distances. When floods occur, most of them are unable to rescue items due to ineffective flood early warning systems and do not cover long distances. Furthermore, poorly maintained structures with clogged drains and inadequate drainage, as well as poor canal design and construction, have all contributed to the occurrence of flash floods on a regular basis. Flash floods can also cause catastrophic loss and devastation. The floodwaters also damaged homes and public facilities such as schools and bridges that connect people. Therefore, flash flood early detection and notification systems can assist citizens and governments in preventing and minimize the effects of flash floods.

#### **1.3 Project Objective**

The main aim of this project is to propose a systematic and effective methodology to detect early signs of flash floods based on rainfall intensity and level increasing rate. Specifically, the objectives are as follows:

- a) To develop a system that will be able to analyze water level increasing rate of river or drainage system at urban area for flash flood early detection and notification system.
- b) To develop a system that will be able to estimate and measure rainfall intensity for early detection of flash flood.
- c) To develop a flash flood early detection and notification system based on evaluation of objective (a) and (b).

#### 1.4 Scope of Project

The urban region in Selangor and Kuala Lumpur that was recently impacted by flooding is the primary focus of this project. Both a river and a drain are suitable testing locations for the proposed system. The data on the water level was gathered and then updated on a regular basis in order to keep track of any changes in the water level or the rate at which it was rising. The project makes use of NodeMCU ESP32, which already has wireless networking built right into the board itself. The most recent information regarding the flood situation is uploaded to the Blynk application, and a Telegram Bot is utilised in order to notify the relevant authorities, such as BOMBA and APM.

#### **CHAPTER 2**

#### LITERATURE REVIEW

#### 2.1 Introduction

Flash floods are a typical occurrence in Malaysia's capital city. Every year, the city is hit by a series of flash floods. The city is located in the center of a valley, in the river basins of two large rivers (the Klang River and the Gombak River). As a result, floods are an unavoidable occurrence in the urban area [1]. Flash floods are usually produced by seasonal monsoon rain, which causes insufficient drainage systems to channel the water flow effectively. The overflow of rivers is also a key cause of flash floods in the city. The city's two independent departments deal with flash floods: Kuala Lumpur City Hall (DBKL) handles drainage and street-related flash floods, while the Drainage and Irrigation Department (DID) handles river-related flash floods.

Small yet regular climatic and hazardous occurrences make urban areas vulnerable. A flash flood that strikes an urban area unexpectedly can cause a slew of problems for the city and its residents. Multiple aspects of the productive sector could be disrupted or shut down, putting a disproportionately high number of assets at risk. A flash flood can also wreak significant destruction and damage to individuals and assets that are more vulnerable.

In study on some literature review, other researchers implement different methods for flash flood early triggering system. Most of the article is study on developing a real-time water level monitoring system using different sensor and controller, and different application for notification system. The purpose of this literature review is to search for new approaches to monitor water level and improve flash flood warning system based on rain intensity which is more reliable.

#### 2.2 Past Related Research

#### 2.2.1 Flash Flood in Malaysia

Fluvial flash floods and drainage system-induced flash floods are two types of flash floods that occur in Kuala Lumpur throughout the year[1]. Separate stakeholders are responsible for handling and monitoring each form of flash flood. DID handles river flash floods, while DBKL handles drainage and street-related flash floods. Rainfall is a crucial factor in both forms of flash floods. Clogged drains, narrowing water channeling ways, littering behavior of humans, and urbanization all contribute to flash flood hazard occurrences.



Figure 2.1(a) Fluvial Flash Flood (b) Drainage Related Flash Flood

Both types of flash floods, as in the city, have a direct impact on some common features such as roads, buildings, vehicles, train stations, and so on. Due to the limited amount of detail data, this could be a lower bound computation. Figures 2.1 (a) and 2.1 (b) depict the elements of the city that were immediately damaged by flash floods. Roads and highways, buildings, and automobiles are the most often and severely impacted elements by both forms of flash floods. In terms of fluvial flash flood, it is difficult to estimate the number of automobiles that were affected.

#### 2.2.2 Flash Flood Data

The flash flood data were obtained from the Selangor Department of Irrigation and Drainage (DID) and the Malaysian Meteorological Department's websites (MMD). The DID gave data on water levels and rainfall, while the MMD provided weather information as well as minimum and maximum temperature readings[2]. The dates were gathered during the course of this research. Data from numerous areas in Selangor were also collected, including the area, district, main basin, and sub-river basin. A total of 9,665 datasets were collected from 32 different locations between June 2020 and March 2021.

Area	Weather	*Rainfall	*Water	Min	Max	Flash
S.	10 A		level	Temp.	Temp.	Flood
Kg. Asahan	Sunny	80.00	7.80	26.00	33.00	Yes
Sri Aman	Sunny	5.00	4.85	25.00	33.00	No
Parit Mahang	Sunny	2.00	2.56	25.00	33.00	No
Kg. Delek	Sunny	0.00	-0.59	26.00	33.00	No
Pekan Meru	Sunny	0.00	2.92	26.00	33.00	No
Taman Sri Muda	Thunder	0.00	2.33	26.00	33.00	No
Tugu Keris	Sunny	0.00	2.88	26.00	33.00	No
TTDI Jaya	Thunder	0.00	3.43	26.00	33.00	No
Batu 3	Thunder	0.00	2.48	26.00	33.00	No
Taman Mayang	Thunder	7.00	14.51	26.00	33.00	No
Puchong Drop	Thunder	0.00	5.16	26.00	33.00	No
Jalan 222	Thunder	75.00	17.03	26.00	33.00	Yes
Seri Kembangan 🗧 🗌	Thunder	0.00	35.34	26.00	33.00	No
Taman Tun Teja	Rainy	1.00	33.16	25.00	33.00	No
Sungai Batu	Sunny	17.00	49.28	25.00	33.00	No
Country Homes	Rainy	36.00	16.02	25.00	33.00	No
Serendah	Thunder	10.00	34.77	25.00	33.00	No
Jambatan SKC	Sunny	25.00	17.24	25.00	33.00	No
Tanjung Malim	Sunny	80.00	36.67	25.00	33.00	Yes
Kg. Sungai Selisek	Sunny	0.00	24.47	25.00	33.00	No
Kg. Sungai Buaya	Thunder	33.00	14.36	25.00	33.00	No
TNB Pangsun	Thunder	0.00	132.60	25.00	33.00	No
Batu 12	Sunny	0.00	40.93	25.00	33.00	No
Kg. Pasir	Sunny	0.00	47.99	25.00	33.00	No
Pekan Kajang	Thunder	0.00	22.33	25.00	33.00	No
Sungai Rinching	Thunder	0.00	20.42	25.00	33.00	No
Batu 20	Thunder	0.00	88.27	25.00	33.00	No
JPS Sungai Manggis	Rainy	0.00	0.87	25.00	33.00	No
Kg. Kundang	Thunder	0.00	1.50	25.00	33.00	No
Dengkil	Thunder	0.00	3.43	25.00	33.00	No
Kg. Labu Lanjut	Rainy	0.00	3.01	25.00	33.00	No
Kg. Salak Tinggi	Thunder	0.00	6.92	25.00	33.00	No

Table 2.1 A sample of dataset in Selangor

1 1 1 1 1 m



Table 2.2 Rainfall Classification

Table 2.3 Water Level Classification

	Water	Level Classification	
	Normal	< 5 (m)	
A.Y.	Alert	<b>□</b> 5 − 6 (m)	
EKW	Warning	■ 6 – 7 (m)	
E	Danger	► > 7 (m)	
693V	No.		

### 2.2.3 Flood Monitoring and Warning System

The concept utilises GSM technology and an ultrasonic sensor to determine the depth of water and then transmits that information to a rescue squad in order to serve as a warning [3]. The rescue team can acquire data processing based on the results of the point prediction model in order to trigger timely alerts through the Short Message System and distribute the information to the stakeholders who are vulnerable to floods. As a marker or detector of the water level in the river, the ultrasonic sensor will be utilised for the warning system that uses ultrasonic sensors, and this system will send an SMS alert using a GSM system. GSM can also function as a modem for transmission to the satellite, allowing the rescuer to obtain information on the water level in a river that is prone to floods.

This project makes advantage of the solar system in order to power the system. The GSM shield is utilised by the system. The ultrasonic sensor will provide a signal to the GSM shield, and the GSM shield will then process the data in order to send a short message to the relevant authorities or communities that have been impacted by floods. When acting as an input, the Ultrasonic Sensor does its job. Microcontrollers are used in this system, which also includes ultrasonic sensors and a GSM shield. The architecture of the system is displayed in Figure 2.2.



Solar panels produce electricity, and this electricity will generate 5.5 volts to activate the wireless sensor network. Solar panels that charge the battery during the daytime act as a battery switch for the wireless sensor network at night. During the day, the battery is charged by the solar panels. To activate both the ultrasonic sensor and the GSM Shield, you need simply provide 5V and 0.2A.

The following flow chart illustrates how an ultrasonic sensor works and how it transmits a signal to a GSM shield. There will be testing and installation of ultrasonic sensors. When the water level in the set reaches an abnormally high level, the device will send a signal to the GSM shield, but when the water level is at a regular level, the device will not take any action.



Figure 2.3Flow Chart Sensing Device

MAI

These data will be transmitted to the GSM shield system so that it may begin the process of sending an SMS. The components in this setup are able to communicate with one another. For instance, after the GSM shield is on, it will send an SMS alert whenever it receives a new signal from a detecting device. In the meantime, the sensing system is able to interact with GSM configuration if it has ultrasonic sensor data on the condition of the river's water.

Alongside the ultrasonic sensor, the GSM Shield is inserted into the microcontroller as part of the GSM configuration. The primary function of GSM Shield is to process data in the form of SMS and then deliver those messages to either those who are at risk of flooding or to authorities. This system needs to be programmed in order to function properly before it can send an SMS. GSM shields typically come equipped with an antenna as well as a place for a network SIM card. For the purpose of transmitting SMS, this project makes use of a CELCOM network. When GSM is turned on, the antenna will automatically locate a network in order to send SMS.

#### 2.2.4 Flood Monitoring System Using Thingspeak Web Server And Ifttt

This system is used to detect the flood and alert the authorities by monitoring the water level and water flow of the river or dam or lake or flood-prone area so that it is monitored continuously time o time and the flow sensor detects the flow rate of the water and updates it in the web application thing speak and if the level of dam or river cross it limit then the water level sensor is submerged in water and if the hed then an SMS alert is sent to the authorities [4].



The network architecture for the flood monitoring system is depicted in Figure 2.4. For this particular project, we are utilising three sensors in order to collect data on three distinct factors. The first is a water level sensor, which is used to detect the water level of a river. The second is a water flow sensor, which is used to determine the flow rate of the river. They utilized the IFTTT web server in order to send the SMS to the authorities in order to inform them to the issue when there is flooding. An external web server known as ThingSpeak is being utilised by our team in order to monitor the data associated with these three criteria. A water flow sensor (referring Figure 2.5) is what is utilised to determine the flow rate, which then allows us to determine the volume of water that is moving through the river. There are three pins in all. VCC, GND and Data pin. To function properly, it needs 5V. The NodeMCU's Data pin is linked to D2, the VCC pin is connected to 3.3 volts, and the GND pin is connected to the NodeMCU's GND pin. The force that is created by the water as it flows into the sensor causes the wheel that is positioned inside of the sensor to rotate. This happens as the water flows into the sensor. Calculating the number of times the wheel has turned provides a method for determining the volume of water that is being moved.



An open source Internet of Things application and application programming interface, ThingSpeak enables users to aggregate, visualise, and analyse live data streams in the cloud. The HTTP Convention is what is used for communication in ThingSpeak. We are able to transmit data to ThingSpeak from your devices, and we are able to utilise graphs and numerical display to monitor the data that is updated via sensors via the internet. Besides, we can provide data to ThingSpeak from your devices. In addition to this, it is able to generate quick visualisations of live data and deliver warnings through the use of web services such as Twitter and Twilio. The most significant benefit offered by ThingSpeak is the ability to activate a specific link when specific circumstances are satisfied.



Figure 2.6ThingSpeak

The values of the river's water level and water flow are read through NODEMCU, and then these values are updated in ThingSpeak. The new water level will be compared with the threshold by the ThingSpeak, and if the water level is above the threshold, the ThingSpeak will immediately activate an external website known as IFTTT.com, where the applet is located. At the very instant that the URL is triggered by ThingSpeak, an SMS request will be sent to the mobile device in the form of an alert message.

# 2.2.5 The Implementation of an IoT-Based Flood Alert System

In this study, a flood warning system is proposed that has the capability to detect the water level as well as measure the rate at which the water level is rising. The result of the measurement is delivered as an alarm to a mobile phone via short message service in order to provide the society with an early notification to evacuate before the water rises to the unsafe level (SMS) [5]. The data from the sensor is collected at the mini-processor, and an alert is generated and sent as an SMS message to a smartphone.



Figure 2.7Flood Alert System Design

During the design process, the system design that was given was the one shown in Figure 2.7. There are two sensors involved in this process, and they are located at two distinct heights. The first one will be put in a position on a level below the current one. This is the height of the possible flood that will be anticipated in the future. When the water reaches this level, it activates the water sensor, and the data is sent to Raspberry Pi, where it is then passed to the GSM module to generate an SMS alert for the residents. This serves as a cautionary message to be watchful and ready in the event of an emergency. If the water level continues to rise and reaches the second water sensor, then it is regarded to be dangerous, and an alarm SMS is once again sent to the resident as well as to the authorities.

Testing is being done on the SMS-based flood early warning system that is powered by Raspberry Pi to determine whether or not the system is capable of sending the early warning. Additionally, the sensor will be examined to see whether or not it accurately detects the presence of the liquid. It is important to test the GSM Module to determine whether or not it is able to send an SMS notification to the mobile phone. Before the system can be put into use, it is necessary to first validate and test it in this phase, which is why it is considered an important phase.



Figure 2.8The Prototype of The System

The actual water is used for testing in this project, and the sensor for the water will be placed in a basin (see Figure 2.8). Then, when the water begins to rise and reaches the first sensor, an alarm message will be automatically sent to the authorised user or the head of the society to inform them about the water increase. Later on, when the water reaches the second sensor, which is significantly higher than the first one, an alert message will be sent to inform that the water is now at a dangerous level, and it will also calculate the time for the water to reach the second sensor along with the speed at which the water is rising too. This will inform the user that the water is now at a dangerous level.

The maintenance phase ensures that the sensor continues to collect data whenever water levels rise. In addition, it is essential that the GSM Module is prepared to deliver SMS alerts as necessary. Periodically, maintenance must be performed so that, in the event of an error or malfunction, the right action can be taken. The system must be constantly updated with any new software or efficient code in order to maintain peak performance. This step is crucial, as it determines the system's performance and durability.

### 2.2.6 The Development of Smart Flood Monitoring System using Ultrasonic sensor with Blynk Applications

This paper describes the creation of a smart flood monitoring system utilising the Blynk platform for data transmission. This system is built on two NodeMCU development boards that are integrated via the Blynk (iOS or Android) application. The first NodeMCU is installed in the flood zone, while the second NodeMCU serves as the control unit. During floods, a NodeMCU-based transmitter device with an ultrasonic sensor will detect the water level and show it on an LCD [6]. The data detected by the ultrasonic sensors will then be wirelessly transmitted to the Blynk application.

Instantaneously, the data are captured and saved in a specialised database for recording reasons. In order to alert the individual in charge of the control unit, the data will be sent to a second NodeMCU over a Blynk bridge to activate the buzzer and LED. According to the findings, system access between the first and second NodeMCUs can be made inside or beyond 50 metres. In the findings, it was determined that the system functions well when the ultrasonic sensor data is displayed on the Blynk application and both the buzzer and LED are operational. The acquired results demonstrated that the system is capable of addressing the flooding issue in the impacted area.



Figure 2.9Block Diagram of The System

Figure 2.9 depicts the system's general block diagram. The first flood level will be detected by the ultrasonic sensor linked to the first NodeMCU. The data will then be shown on an LCD panel. The data will be transmitted wirelessly to the Blynk application. The data will also be presented within the Blynk application. Simultaneously, the data is stored in a CSV database, can be transformed into Excel format via email, and is delivered to the second NodeMCU over Blynk Bridge. Once the level reaches the warning and critical levels, which activate the buzzer and LED, this data will alert the local government to take additional action.

Blynk is an Internet-accessible platform with iOS and Android applications for controlling Arduino and Raspberry Pi. It is a digital dashboard that can generate a graphical user interface by dragging and dropping widgets. Using the cloud-based Blynk server as a central transaction manager, it may connect all of its projects. In the same Blynk application, a database was also constructed for the purpose of recording the flood level detected by the ultrasonic sensor.



Figure 2.10 The Flow of Database via Blynk Application

Through these Blynk application, the flood level will also be displayed. The level indicator (safety, warning, and critical) will be displayed through LCD. The value display will then indicate the flood level as detected by an ultrasonic sensor. In addition, the LED will illuminate based on the current level. Finally, the history graph will track the level of the flood and store the data in a database.

### 2.2.7 Real Time Water Level Monitoring for Early Warning System of Flash Floods Using Internet of Things (IoT)

If adequate preparation is made, the negative effects of the flood can be lessened. Since of this, a water monitoring system is absolutely necessary because it can provide individuals in the surrounding area with advance warning so that they may take measures like as evacuating their homes, making preparations for various contingencies, and so on. In the course of this study work, an Internet of Things (IoT)-based water monitoring system was proposed for use in a real-time setting. The system was also intended to send SMS notifications to users in advance of impending flood conditions [7].

By monitoring the height of the water in rivers, this portable technology can function as an early warning system for sudden flooding. The ESP8266 NodeMcu V3 Board microcontroller is utilised in this project as the main controller. An ultrasonic sensor is used to measure the water level, and the data from both devices is transferred to the ThingSpeak IoT platform. When the measured water level reaches the threshold value that was previously specified, the microcontroller sends an SMS message to the authorised person who is responsible for disseminating the information and triggers an alarm as well as a warning sign for the people.



Figure 2.11 NodeMCU ESP8266

IoT device development is made easier with the support of NodeMCU, an opensource firmware and development kit. The goal of the development of NodeMCU was to simplify the process of using complex API for hardware IO. The application programming interface (API) can cut down on effort that is unnecessary for configuring and managing hardware. NodeMCU's input-output architecture is modelled after that of Arduino hardware (IO). The ESP 8266, which is the lowest cost Wi-Fi MCU, is used in the Development Kit. The ESP8266 is the Wi-Fi chip with the highest level of integration.

The chip's dimensions are 5 millimetres on each side. The ESP8266EX requires minimal external circuitry and integrates a 32-bit Tensilica MCU, standard digital peripheral interfaces, antenna switches, RF balun, power amplifier, low noise receive amplifier, filters, and power management modules - all in one small package. Additionally, the ESP8266EX requires minimal external circuitry.

The Arduino IDE, also known as the Integrated Development Environment, is a piece of open-source software that allows for improved and assisted code editing, compilation, and debugging. The environment is built on Processing as well as other open-source tools and is written in Java. Therefore, this Arduino IDE is equipped with pre-programmed functions and commands that, despite being compatible with the Java platform, have been adapted to work with the Arduino board. As a result, the Arduino IDE can be utilised for the editing of code, as well as its compilation and debugging, before finally burning the code into the Arduino board.

In the context of this project, researcher created NodeMCU applications using the Arduino development environment and a well-known Arduino integrated development environment (IDE). Rather of having to learn a new scripting language and integrated development environment (IDE), this makes things simpler for developers working with Arduino.

interrupt_water_l	evel   Arduino 1.8.19			
File Edit Sketch To	ols Help			
interrupt_wate #define CM_	Auto Format Archive Sketch Fix Encoding & Reload Manage Libraries Serial Monitor Serial Plotter	Ctrl+T Ctrl+Shift+I Ctrl+Shift+M Ctrl+Shift+L		
float dista	WiFi101 / WiFiNINA Firmware Updater			
float water float water float water float level float level hw_timer_t void IRAM_A Serial.pr Serial.pr	Board: "ESP32 Dev Module" Upload Speed: "921600" (CPU Frequency: "240MHz (WiFi/BT)" Flash Frequency: "80MHz" Flash Mode: "QIO" Flash Size: "4MB (32Mb)" Partition Scheme: "Default 4MB with spiffs (1.2MB APP/1.5MB SPIFFS)" Core Debug Level: "None" PSRAM: "Disabled" Port Get Board Info	> > > > > > > > > > > > > > > > > > >	Boards Manager Arduino AVR Boards 2 ESP32 Arduino 2	∆     ESP32 Dev Module     ESP32 Wrover Module     ESP32 Pico Kit     TinyPICO     S.ODI Ultra v1     MagicBit     Turta IoT Node     TTGO LoRa32-OLED V1     TTGO T1     TTGO T1     TTGO T7 V1.3 Mini32
<pre>} void setup() Serial.begi</pre>	Programmer Burn Bootloader { n (115200); // Starts the serial communication	>		TTGO T7 V1.4 Mini32 XinaBox CW02 SparkFun ESP32 Thing SparkFun ESP32 Thing Plus u-blox NINA-W10 series (ESP32)
pinMode(tri pinMode(ech	<pre>gPin, OUTPUT); // Sets the trigPin as an Output oPin, INPUT); // Sets the echoPin as an Input</pre>			Widora AIR Electronic SweetPeas - ESP320

#### Figure 2.12 Arduino IDE for NodeMCU

The JSN SR-04T sensor (see Figure 2.13) was utilised to construct a water level measuring system that was used in this study. Due to the fact that both the sensor and the wire it is attached to are waterproof, this apparatus can be utilised for the measurement of the water level in real time. The operation of an ultrasonic distance sensor is accomplished by the emission of ultrasound pulses or waves at predetermined intervals. When these ultrasound waves come into contact with an item, the object causes the waves to bounce back as echo signals, which are then picked up by the ultrasonic sensor.

The distance between the sensor to an object can be determined by calculating how much time occurred between sending and receiving the sound waves. This allowed to compute the distance based on the time that elapsed between the sensor and the item delivering the signal and receiving the echo. The ultrasonic waves are sent out and received by this transducer, making it a kind of transmitter and receiver in one.


Figure 2.13 Waterproof Ultrasonic JSN SR-04T sensor

Distance (cm) = Speed of Sound  $\left(\frac{cm}{\mu s}\right) \times Time (\mu s)/2$ 

Where Time is the amount of time in microseconds that passes between the transmitting and receiving of the sound waves.

In this study effort, an ESP8266 NodeMCU ESP-12E Module with CP2102 is utilised as the core controller. Additionally, a waterproof JSN SR-04Tultrasonic sensor is employed as a distance metre sensor of water level. Because NodeMCU is a wifi SOC (system on a chip) device and is based ESP8266 -12E WiFi module, the microcontroller will retrieve the data from the ultrasonic sensor and then process the data by utilising a wifi connection. This is because the microcontroller is based on NodeMCU. The data on the water level is updated around once per minute and can be viewed on the channel on ThingSpeak.

When the water level reaches the predetermined figure, the microcontroller will sound an alarm, which will consist of a buzzer that will continuously ring and an LED warning light that will flash. At the same time, Thingspeak uses one of the Thingspeak apps called ThingHTTP to send an SMS using Twilio. Figure 2.14 depicts the comprehensive block diagram of the system in its entirety.



Figure 2.14 Block Diagram of the proposed system

In this study, ultrasonic sensors called JSN-SR04T with a waterproof sensor were used. The transducer sensor and the control module are the two parts that make up this sensor. The JSN-SR04T can measure distances between 0 cm and 600 cm at an angle of 75 degrees and at a frequency of 40 KHz. Compared to the HCSR04 sensor, this sensor is more popular and effective for measuring water levels. The sensor pin (RX- Trig) was connected to NodeMCU's D5 and the pin (TXecho) was connected to NodeMCU's D6. At 3.3volts, the sensors work. So, the Vcc pin of the control module was hooked up to the 3.3 V power pin of the NodeMCU. LED Anode is connected to NodeMCU GPIO5 (D1) through a 200-Ohm resistor, and a Pizzo buzzer is connected to NodeMCU GPIO4 (D2). Figure 2.15 shows a circuit diagram for a system that checks the level of water.



Figure 2.15 Circuit Diagram for Water Level Monitoring

## 2.2.8 Development of Detection and Flood Monitoring Via Blynk Apps

This paper details the process of developing a prototype that can be utilised for the purposes of detection and monitoring. Flash floods have the potential to cause significant damage to both houses and infrastructures. This system is built on two pieces of technology that are based on NodeMCU and are integrated using the Blynk application (IOS or android) [8]. The wireless sensor network systems can be of assistance to the populace by determining the levels of the water and providing an early warning in the event of a flood in a way that is both straightforward and quick. In its most fundamental form, the system may be broken down into two components: the sensor node and the base station.

The current water level is displayed by the sensor node once it has been determined using an ultrasonic sensor to detect the water level. The first NodeMCU is installed at the location that has been determined to be at risk for flooding, and the second NodeMCU is used as the control unit. The data that is gathered from the ultrasonic sensors is then transferred over to the Blynk application using the wireless connection. Two experiments have been carried out in order to examine the performance of the proposed system. It has been discovered that this prototype is capable of detecting, monitoring, and sounding an alarm in the impacted area in the event that a flash flood occurs in the future.



Figure 2.16 Block Diagram of The System

The overall structure of the system is depicted in Figure 2.16 as a block diagram. At initially, the flood level is determined by the first NodeMCU, which attached to an ultrasonic sensor. After then, the information will be presented on the LCD panel. Through a wireless connection, the data is transmitted to the Blynk application. Additionally, the data will be presented through the application known as Blynk. Once the level reaches a warning and critical level, which activates the buzzer and LED, this data will send an alert to the local authority to notify them that additional action is required. The concept of the planned work is derived on the system that is now in place in Damansara River, which is located in TTDI Jaya.



Figure 2.17 Flood Status Display Via Blynk Apps

The reading of data sensed from the ultrasonic sensor is displayed in Figure 2.17 and was performed by the first NodeMCU in the Blynk application platform. There are three different mode displays that may be seen on the screen of the LCD, and these are mirrored on the screen of the smart phone when the Blynk application is used. It alerted the person in charge of the situation by displaying the level of water on the screen as either a safe level, a warning level, or a critical level.

Additionally, the distance to the water is displayed on the widgets, and LED was utilised as the indication for each one (green for safety, orange for warning and red for critical). Utilizing the history graph, one may monitor the progression of the flood level over time. There will be three different states, labelled level 1, level 2, and level 3, which are intended to raise people's levels of concern. The data that is sensed by the sensor will initially be displayed on the LCD of the NodeMCU, and this display will represent both the level indicator and the distance. Once the data is received by the second NodeMCU, and level 1 detects that nothing has happened, level 2 causes the LED and buzzer to flash, and level 3 causes the LED to turn ON and level 3 triggers the buzzer.

# 2.2.9 Development of Advanced Flood Detection System with IoT

Residents living near water, particularly rivers that are impacted when dams release their water, are provided with early notice by sophisticated flood detecting systems. Because of this, lives will be spared and valuable property will be preserved because the warning system will alert the user in enough of time for them to evacuate. A sensor module, a microprocessor, and an output module are the constituent parts of an advanced flood detector. The output module is installed on the interior of the homes of the residents. It has an ultrasonic sensor to determine the level of the water, as well as IoT, and the data is sent to the microprocessor [9].

The utilisation of Internet of Things technology is the element that sets this flood detector apart from similar products on the market. The output module includes notifications, sometimes known as app alerts, which are generated by the IoT function. In the event that there is an increase in water level, users will first receive a notification from the app itself, or an alert will be sent by a nearby dam via IoT. In the event that the dam opened the water gates, both the user and the siren will receive a notification from the app.



Figure 2.18 Block Diagram of The System

Figure 2.18 presents the block diagram of an improved flood warning system that makes use of the Internet of Things. The ultrasonic sensor and the voltage sensor will function as the device's inputs. After that, Arduino will issue a command to the output, which consists of the buzzer as well as the Wi-Fi module. The Blynk app will display both the current water level of the river and the remaining battery life. When the water level becomes too high, an Arduino will generate a warning message, which will then be transmitted over a Wi-Fi module. When the signal for a high-level alarm is triggered, the buzzer will provide the signal. A notification will be sent to the Blynk app in the event that the battery life is getting dangerously low.



Figure 2.19 Circuit Diagram of the Project

Figure 2.19 presents the pin assignments that were used for the Arduino UNO board. One 12V battery served as the source of power for the entirety of this circuit. The output of the Arduino 5V supply supplies power directly to the electronic components that require 5V for operation. The next step is to make a direct connection between the battery and the microhydro generator. There will be a connection made between the ultrasonic sensor and pin analogue (0) and analogue (1). The Wi-Fi module's transmitter and receiver pins are linked to the Arduino's pins two and three, respectively. Because there is no library for ESP266 and voltage sensors, the simulation is unable to replicate either of those components.

# 2.2.10 Flood Warning And Monitoring System Utilizing Internet Of Things Technology

The system is built on top of technology that is integrated utilising the Blynk application and is based on NodeMCU [10]. The wireless sensor node can be of assistance to the victims by determining the amounts of water and the strength of the rain, as well as providing an early warning in the event that a flood or heavy rain takes place. The sensor node is made up of ultrasonic sensors and a rain sensor, both of which are controlled by NodeMCU, the system's microcontroller. It is positioned in the area that has been determined to be at risk of flooding. When the flood reached a particular threshold of danger, a buzzer and an LED began to activate and inform the danger.

The Blynk programme receives data transmitted over a wireless connection from the sensors as they are detected. The victim will be able to determine the current status of the flood and rain by examining the interface and receiving a push notification that is available in the Blynk application that can be accessed on cellphones running either iOS or Android. The data on the amount of flooding that was given to the email could be helpful to a variety of organisations for the purposes of further developing the system and making flood forecasts. As a consequence of the testing that was carried out, it was discovered that this prototype has the ability to monitor, identify, and provide an early warning along with notification to the victim prior to the occurrence of floods.

In the conduct of this study, a flood monitoring system that makes use of wireless sensor nodes was constructed. Its purpose was to observe the condition of floods in Selangor state, Malaysia, and to inform people who lived in areas that were prone to flooding on a regular basis. The system is made up of a sensor node that utilises an Ultrasonic Distance Sensor (HCSR04) and a rain sensor, one at a time, to determine the height of the water level and the intensity of the rainfall. The device will generate an alarm system with three different colours of LEDs signifying three levels of detection for flood level in order to inform people on incoming flood in that region that could put their lives in risk when the water level and rain intensity reach a specific level of dangers.



Figure 2.20 Blynk IoT-cloud Based Architecture

The circumstances that prevailed at the particular location just before the rain began to fall are depicted in Figure 2.21. The amount of rain intensity that is represented by the colour green indicates that it has only recently started to rain. This suggests that individuals who reside nearby should be on high alert since they are aware that their location will be subject to a very devastating calamity if the rain began to fall in significant amounts. A notification reading "Rain Warning!!" is given to the user for the goal of raising their awareness. According to what is shown in Figure 2.22, the level of rainfall intensity has reached a particular point that the victims who are most likely to be affected by flooding in their area need to take into consideration. This is due to the fact that when the rain started falling heavily, there was a higher chance that a flood could take place at any time at that location. When it begins to rain heavily, the system will notify the victim by sending the notice "Raining Heavilly, Please be Aware!!" This is done as an alert purpose and ensures that the victim will be warned whenever and wherever the rain begins to fall heavily.



# 2.2.11 Flood and Notification Monitoring System using Ultrasonic Sensor Integrated with IoT and Blynk Applications: Designed for Vehicle Parking

Heavy rain fell across the state of Terengganu during the Northeast monsoon, which typically occurs between October and March [11]. As a result, the entire state is prone to experiencing catastrophic flooding on a yearly basis, on average. In addition to the significant rainfall that occurred during the monsoon season, the flooding that occurred in the Dungun area of the Terengganu state was caused by a combination of physical variables. These factors include the area's elevation and its proximity to the sea. The goal of a flood warning system is to quickly warn the people who own the vehicle that flooding is coming. When the water level is detected by the system using an ultrasonic sensor, a message will be sent to the owner's phone through the Blynk app. A water level sensor will be put in two places, one 0.05 metres above the ground and the other 0.09 metres above the ground. When the water gets to this level, a light-emitting diode (LED) and an alarm buzzer will go off, alerting the owner and the authorities. IoT technology was used to connect the Blynk app to an ESP8266 Wi-Fi module, which sends alerts to users when there are signs that the water level is getting too high.

The declaration of this port in the Arduino software comes first in this straightforward circuit, which then moves on to the initialization process. After that, two sensors are positioned at a specific height, with the first sensor positioned at 0.05 metres and the second sensor positioned at 0.09 metres. When the water level reaches a height of 0.05 metres above the ground, LED 1 will begin to illuminate, and Buzzer 1 will begin to sound. If both outputs are activated at the same time and data are directly sent to the application in order to monitor the present situation, then the server will obtain the data. If the server was unable to process the data for some reason, the system will start all of the stages over again from the beginning, which includes initialising the port.



Figure 2.23 Block Diagram of Water Level Sensor Using Ultrasonic Sensor

Input, processing, and output are the three processes that make up the Flood Warning System that makes use of an ultrasonic sensor for vehicle parking. This system accepts data from a single input device, which is an ultrasonic sensor. Arduino will then proceed to process all of the input in order to generate an output. The water level sensor can be placed at either one of two sites, 0.05 metres or 0.09 metres, and will activate an LED and a buzzer depending on the depth of the water at those spots. The information will subsequently be transmitted to the user's smartphone by means of the Blynk application.

#### 2.2.12 Flood Monitoring and Early Warning System Using Ultrasonic Sensor

[12] This study is only concerned with the detection of water levels and the early warning system (through website and/or SMS) that warns concerned individuals and organisations to the possibility of a flood occurring. Individuals in the community are able to inquire the actual water level and status of the desired area or location affected by flood through the use of an SMS keyword, which is another component of the inquiry system that has been incorporated into this research in order to make the study more interactive. The purpose of the study is to assist local residents in being more informed and prepared for any future flooding that may occur.

The utilisation of an Arduino, ultrasonic sensors, GSM module, web-monitoring, and an SMS early warning system is the innovative aspect of this work. Its purpose is to assist stakeholders in reducing the number of casualties that are caused by flooding. The idea behind this paper is to provide assistance to communities located in flood-prone locations, which are frequent in the Philippines. In particular, this assistance would go to towns located within the province. In point of fact, it does meet the requirements for the protection and well-being of the community, thus it is relevant and significant.

# 2.3 Comparison Literature Review

The comparison on objective, project scope and method are shown in Table 2.4.

No	Title	Author	Objective	Project Scope	Method
1	Flood Monitoring and Warning System	Muhammad Ramizu Ab and P. Darul Ridzuan	<ol> <li>Design a water level sensor using a sensor network.</li> <li>To create GSM- based processing and transmission devices.</li> </ol>	<ol> <li>Water level data was gathered and updated on a regular basis to track changes in the water level.</li> <li>Use the mobile GSM network to notify the user of flood incidents.</li> </ol>	1. Using GSM technology and an ultrasonic sensor, the water level is detected, and data is sent to a rescue squad as a warning.
2	FLOOD MONITORING SYSTEM USING THINGSPEAK WEB SERVER AND IFTTT	K. Sundar المركة	<ol> <li>To notify authorities of an impending flood.</li> <li>To keep a close eye on the water level in flood-prone locations.</li> </ol>	1. Use the ThingSpeak web server platform for data storage and reception from systems that use the HTTP over LAN protocol.	<ol> <li>It is made up of two NodeMCUs.</li> <li>Flow rate The flow rate is sent to the ThingSpeak web server through a water flow metre.</li> </ol>
3	The Implementation of an IoT-Based Flood Alert System	W. Md Shah	<ol> <li>To determine the water level and the rate at which it rises.</li> <li>To notify the public to evacuate before the water level</li> </ol>	1. Designed on an IoT- based platform, where sensor data is collected by a mini-processor and an SMS alert is issued and sent to a smartphone.	<ol> <li>Raspberry Pi, water sensors, and a GSM Module.</li> <li>The Raspberry Pi and Huawei mobile</li> </ol>

Table 2.4 Comparison Literature Review

			reaches a dangerous level.			broadband will be linked together.
4	The development of smart flood monitoring system using ultrasonic sensor with blynk applications	N. A. Z. M. Noar and M. M. Kamal	1. To build a system, use both NodeMCU- based architecture and low-cost ultrasonic sensor networking devices to predict floods and issue a community	1. Built using two different NodeMCU development boards and the Blynk application to integrate them (IOS or android).	1.	<ul> <li>First NodeMCU is in the flood zone, while the second NodeMCU serves as the control module.</li> <li>During flooding, an ultrasonic sensor will sense the water</li> </ul>
		TEKIII	notice.	TeM	3.	<ul> <li>level and show it on the LCD.</li> <li>The data collected by the ultrasonic sensors would be wirelessly transmitted to the Blynk application.</li> </ul>
5	Real Time Water Level Monitoring for Early Warning System of Flash Floods Using Internet of Things (IoT)	Z. L. Oo, T. Win, L. #1, Z. Lin Oo, and A. Moe	<ol> <li>To design and build a low-cost, actual water level monitoring system that relies on an ESP8266 NodeMcu microcontroller with an integrated WiFi module and IoT.</li> </ol>	<ol> <li>Water level monitoring systems based on the Internet of Things that use ultrasonic sensors and the ESP8266 NodeMcu V3 Board microcontroller to measure water level in real-time.</li> <li>The ultrasonic sensors' real-time data will be delivered to the ThingSpeak IoT platform via a wireless link, where</li> </ol>	1. 2. A 2. 3.	<ul> <li>The core controller is an ESP8266 NodeMCU ESP-12E Module with a CP2102 chip.</li> <li>A water resistant JSN SR-04T ultrasonic sensor measures the level of water as a distance metre.</li> <li>One of Thingspeak apps, ThingHTTP, is</li> </ul>

				it may be viewed and used to send an SMS
				avaland by users on their through Twilie
				explored by users on their through 1 wino.
				mobile phones or PCs via
				the internet cloud.
				3. The ESP8266 NodeMcu
				V3 Microcontroller
				activates the alert by
		-1 AV1		triggering the buzzer with
		MALAI	IA .	a flashing red LED if the
		2	ALCO	water level surpasses the
		2		specified threshold value.
		S.	12	4 The ThingSpeak IoT
		×	>	nlatform's action
		<u> </u>		ThingHTTP user Twilie's
				aland communications
		5		ADL to 11 line CMC
		(a) =		API to deliver SMIS
		95 -		notifications to users in
		1140		the community.
	Development of	M. M. Kamal, N.	1. To develop a flood-	1. Sensor node and base 1. Blynk application
	detection and	A. Z. M. Noar,	detection prototype.	station are system parts. merged two
	flood monitoring	and A. M. Sabri	2. To identify, monitor,	2. An ultrasonic sensor NodeMCU
	via blynk apps		and warn of	detects and displays the technologies (IOS or
			impending flash	water level at the sensor android).
			floods.	node.
6		UNIVERSI	TI TEKNIKAL N	3. One NodeMCU is
				positioned in the flood
				zone, while the other is
				the control unit.
				4. Ultrasonic sensor data is
				wirelessly transferred to
				Blvnk.

	Development of	E. Daud, & Mohd,	1. To provide	1.	Residents' homes have		1.	The device's inputs
	Advanced Flood	and I. A. Bakar	communities near		output modules. It has an			are ultrasonic and
	Detection System		bodies of water,		ultrasonic sensor to			voltage sensors.
	with IoT		particularly rivers,		measure water level, IoT,		2.	Arduino commands
			with early warning		and a microcontroller.			the Wi-Fi module
			when dams release	2.	The microprocessor			and buzzer.
			their water.		collects, processes, and		3.	Blvnk shows river
		1. 6.1/2			sends out selected output.		-	level and battery life.
7		MALATS	NA .	3.	Output module includes			j
		2	Ma		IoT app alerts.			
		S.		4.	Users will receive a			
		2	1		notification from the app			
		*	>		or a local dam via IoT if			
		Ë C-			the water level rises.			
				5.	If the dam's water gates			
		8			open, the siren and app			
		2			will alert.			
	Flood Warning	M. S. Mohd	1. To create a real-time	1.	The sensor node, which is		1.	The level of the
	and Monitoring	Sabre, S. S.	checking and early		located at the specified			flood can be
	System Utilizing	Abdullah, and A.	detection for floods	· · · · ·	flood area, is made up of			discovered with an
	Internet of Things	Faruq	using wireless sensor		ultrasonic sensors and a	A \		ultrasonic distance
	Technology		nodes in a flood-		rain sensor operated by	7.1		sensor.
			prone area.		NodeMCU, the system's		2.	Using Blynk, an
0					microcontroller.			application for
0		UNIVERSI	TI TEKNIKAL N	2.	When the flood reached a	A		monitoring data
					specific threshold of			from a NodeMCU
					danger, the buzzer and			connected to
					LED began to activate			ultrasonic and rain
					and inform the sufferer.			sensors over the
				3.	Data from the sensors is			internet and viewed
					transmitted to the Blvnk			

				<ul> <li>app through a wireless connection.</li> <li>4. The flood level data supplied to the email could be useful to a variety of organizations for system improvement and flood forecasting</li> </ul>	on a smartphone was made.
9	Flood and Notification Monitoring System using Ultrasonic Sensor Integrated with IoT and Blynk Applications: Designed for Vehicle Parking	A. Hasbullah.	1. To design, develop, and construct a flood alert system specifically for parking that will notify and warn vehicle owners, in addition to creating an interface that can be tracked easily using the most advanced wireless connection technology.	<ol> <li>An ultrasonic sensor detects water level and sends a notification to the owner's smartphone via the Blynk App.</li> <li>Place a water level sensor at 0.05m and 0.09m above ground. When water reaches this level, an LED and buzzer inform the owner and authorities.</li> <li>IoT-connected ESP8266 Wi-Fi module sends water level alerts to the Blynk app.</li> </ol>	<ol> <li>The ultrasonic sensor is the input.</li> <li>Arduino will take all of the data and use it to make an output.</li> <li>There are two places to put the water level sensor, at 0.05m and 0.09m. Depending on how high the water is, the LED and buzzer will go off.</li> <li>The data will then be sent to the user's phone through the Blynk app</li> </ol>
10	Flood Monitoring and Early Warning System Using Ultrasonic Sensor	J. G. Natividad and J. M. Mendez	1. To build a real-time flood monitor and alert system (through website and/or SMS) which warns concerned	1. This work constructs a system that detects Cagayan River water level using ultrasonic sensors.	1. Two monitoring devices use Ultrasonic sensors to measure water level.



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# 2.4 Summary from Literature Review

From the comparison of literature review table (see Table 2.4), the difference between this proposed project and past related projects in terms of early flood detection method and notification system is that this project uses a flow rate sensor that measures rainfall intensity and has an advance notification system that can send early notification to authority bodies using Telegram Bot platform. Besides that, this project also utilized Blynk application to display the measured parameter i.e. level increasing rate, current level of river, rainfall intensity and estimation time.



#### **CHAPTER 3**

#### METHODOLOGY

#### 3.1 Introduction

This chapter will review the primary aspects of the project, as well as the methods and procedures that were utilized to accomplish the project objectives. This part also provides a concise overview of the stages that are involved, as well as an explanation of the hardware and software that was utilized in the development of the system. The application of the methodology process is critical in order to guarantee that the system development is accurate and functions perfectly in accordance with the requirements.

#### 3.2 Methodology

The development of early warning systems for flash floods that are determined by the amount of rain that has fallen and the rate at which the water level is rising can be broken down into two categories: hardware and software. The experimental setup block diagram is done in Section 3.4 to illustrate the prototype of the system. The prototype is crucial in order to prove the concept of flash flood early triggering system. Besides, the block diagram for actual setup of the system also been discuss in Section 3.5, so that the picture of the actual system can be seen and understood by anyone. The hardware that is essential for the completion of this project is going to be covered in this part. The Arduino IDE and the Blynk Application are the pieces of software that are being utilized in the construction of this project. The procedures and materials that were employed will be analyzed and explained in Sections 3.5 and 3.6, which may be found below.

#### **3.3 Block Diagram**

A flash flood is an unexpected event that causes economic and human loss. Early triggering systems are essential to reduce the risks posed by flash floods. The system in this project incorporates numerous parts, including a current water level measurement system, a communication system, water flow, and level increasing rate. The proposed project block diagram, as illustrated in Figure 3.1, provides a real-time monitoring system for water level utilizing an ultrasonic sensor HC-SR04. Rainfall intensity is measured using a flow rate sensor.



Figure 3.1 Block Diagram of Flash Flood Early Triggering System Based on Rainfall Intensity

Not only that, referring to block diagram in Figure 3.1, this system would detect the intensity of rainfall as well as the rate at which the water level in a river or drain is rising by utilizing a flow rate sensor and an ultrasonic sensor. The buzzer and LEDs were used as alarm and siren that alert those in the surrounding area. Through a wireless connection, the

data of level increasing rate, rainfall intensity, estimation time and current level of water in a river or drain were transmitted to the Blynk application by using built-in Wi-Fi in NodeMCU ESP32. In order for there to be appropriate action taken, an authoritative body such as BOMBA and APM will be triggered by Telegram Bot. It is therefore anticipated that the system will assist in the process of relocating individuals to prevent substantial property damage and the loss of life.

# 3.4 Experimental Setup

The experimental setup is done to prove the concept of the system because the actual setup for flash flood early triggering system in urban area requires a relatively high cost.



Figure 3.2 Block Diagram for Experimental Setup

In the experimental setup for triggering a flash flood, the block diagram for the experimental setup can be found in Figure 3.2. Meanwhile, the actual prototype for flash flood early triggering system was constructed as in Figure 3.3 and the main parts of the system was labelled in the figure.



Figure 3.3 Actual Prototype for Flash Flood Early Triggering System

As shown in the diagram (Figure 3.2 and Figure 3.3), water from the pipe will flow through the flow rate sensor and control valve 1, and it will then enter the water tank. An ultrasonic sensor is going to be utilized in order to monitor the water level value. A flow rate sensor is used to obtain information of the intensity of the rainfall. If the flow of water from the pipe is slow, the intensity category of the rainfall is light; nevertheless, if the flow is fast, the intensity category of the rainfall is dangerous. Three LEDs (Green, Yellow, Red) and a Buzzer are used as alarm signal and alarm sound for water level condition. Green LED light up if water level in Normal condition while the Yellow LED light up if water level in Warning condition and lastly Red LED light up then the Buzzer sounds if water level is in Danger condition. Meanwhile control valve 2 is representative of the flow of the drain or river. If control valve 2 is opened with only a tiny gap, yet the rate at which the water rises is considerable, this demonstrates that the water drainage is inadequate and may result in flash floods. On the other hand, if the drainage at control valve 2 is working properly and there is a drop in water level, then this will not be a factor in the occurrence of flash floods. Besides that, the LEDs and buzzer were utilized as an alarm and siren to inform anyone who were in the surrounding region. The data of level increasing rate, rainfall intensity, estimation time, and current level of water in a river or drain were communicated to the Blynk application through a wireless connection thanks to the built-in Wi-Fi in NodeMCU ESP32. Telegram Bot will trigger an authorized body such as BOMBA and APM, so that there would be appropriate action taken. This will allow for proper action to be performed. As a result, it is predicted that the system will lend a hand in the process of moving people in order to minimize major damage and the fatality.

# 3.5 Actual Implementation Setup

The actual implementation setup of flash flood early triggering system based on rainfall intensity and level increasing rate is as shown in Figure 3.4. Referring to the figure, the system utilizes ultrasonic sensor, which are typically used in industries to measure water levels or liquid levels. A tipping bucket or rain gauge are widely used to measure rainfall intensity. In the meantime, observation of the current water level and the rate of rainfall intensity can be done through the Blynk application with the help of built-in WiFi on the controller. The alarm light will turn on at the normal level, the alert level, and the danger level if the water level reaches specific predetermined thresholds. If it reaches a danger level, a siren will be activated as a warning to the locals while a notification will be sent to the authority body via Telegram Bot.



Figure 3.4 Actual Setup for Flash Flood Early Triggering System

Meteorology uses many rain observation methods. Malaysia uses conventional and automatic technology to observe rainfall. Rain gauges are used to measure rainfall (rain gouge). A 5-inch-diameter, 18-inch-high rain gauge is standard. Manually collecting and reading rainfall daily. Tipping buckets and weighing precipitation are employed for automatic observation. Rain observation equipment employs lasers. Tipping buckets are popular in Malaysia due to their low cost, accurate data, and quick calibration. A tipping bucket's funnel carries rainwater to two containers. Two containers are seesawed. When 0.2 mm of rainfall is gathered, the container tilts and empties. When the container is tilted downward, it sends an electrical signal that records the rainwater over time. Maximum rainfall is 200mm/hour.

#### 3.6 Hardware

The hardware consists of the following components:

- 1) NodeMCU ESP32 : Main controller
- 2) Ultrasonic sensor HC-SR04 : To measure water level
- 3) Water Flow rate sensor YF-S201 : To measure rainfall intensity
- 4) LEDs : Local indication light
- 5) Buzzer : Local indication sound

# 3.6.1 NodeMCU ESP32



The ESP32 is a low-cost, low-power system-on-a-chip (SoC) microcontroller with built-in Wi-Fi and dual-mode Bluetooth. Tensilica Xtensa LX6 dual-core or single-core microprocessors, Tensilica Xtensa LX7 dual-core microprocessors, or single-core RISC-V microprocessors with built-in antenna switches, RF baluns, power amplifiers, low-noise receive amplifiers, filters, and power-management modules are used in the ESP32 series. The communication stack overhead of the primary application processor can be decreased by using the ESP32 either as a complete stand - alone systems. ESP32 has this capability. And through SPI / SDIO or I2C / UART connections, the ESP32 may communicate with other devices to provide Wi-Fi and Bluetooth features. The design of the ESP32 was enhanced in a variety of ways compared to that of the ESP32. It provides both Bluetooth and BLE, which stands for Bluetooth Low Energy, in contrast to the ESP8266, which only provides WiFi. It operates at a higher speed and comes in a design with a dual-core architecture. Additionally, it is able to function in a mode that uses an extremely minimal amount of power, making it an excellent choice for applications that are powered by batteries. Programming the ESP32 is possible using a wide variety of different development environments. Either C++, which is used by the Arduino, or MicroPython can be used to write the code.



# 3.6.2 Ultrasonic sensor HC-SR04

Figure 3.6 Ultrasonic Sensor HC-SR04

The HC-SR04 ultrasonic sensor measures the distance to an object using sonar. This sensor has a reading range of 2centimetres to 400centimetres (0.8in to 157in) with a precision of 0.3cm (0.1in), making it suitable for many projects. Additionally, this module includes ultrasonic transmitter and the receiver modules. The ultrasonic transmitter, also known as the trig pin, produces a sound at a very high frequency (40 kHz). The sound waves move through the air around them. If it locates an object, it will relay that information to the module. The reflected sound is picked up by the ultrasound receiver, also known as the echo pin (echo) as shown in Figure 3.7 below.



Figure 3.7 Ultrasonic Sensor HC-SR04 Working Principle

When the HC-SR04 is activated, it emits eight 40 kHz sound waves to the water's surface. The wave is echoed back to the sensor when it reaches the water's surface, and the microcontroller reads the echo pin to measure the time between triggering and receiving the echo. We can compute the distance using formula below because we know the speed of sound is roughly 340m/s. Distance to an object =  $((speed of sound in the air) \times time)/2$ 



Figure 3.8 Water Level Measurement using Ultrasonic Sensor HC-SR04

In order to calculate how far the water has travelled inside the tank, we need to be aware of its overall length. This value is what will make it possible for us to calibrate the tank.

# 3.6.3 Water Flow Rate Sensor YF-S201



Figure 3.9 Water Flow Rate

The YFS201 Hall effect Water Flow Sensor, which can be shown in Figure 3.9, is the sensor that will be used to detect the rate of water flow as well as the velocity of the water. The sensor consists of a pinwheel sensor that rotates when the liquid moves through it. This allows the sensor to measure how much liquid has moved through it. When it rotates, it activates an integrated magnetic hall effect, which results in the production of an electric pulse. The electric pulse that is produced is a straightforward square wave (refer Figure 3.10), and it is possible to translate it into litres per minute by using the formula:



Figure 3.10 Flow Rate Sensor Pin

#### 3.6.4 LEDs



Figure 3.11 LED Green, Yellow and Red

The water level condition is shown by the system through the use of three different colored LEDs, and they indicate Normal (green), Warning (yellow), and Danger (red) levels of rainfall respectively. The LEDs are considered as the output of flash flood early triggering system as it will notify the user.

Figure 3.12 5 Volts Buzzer

The 5 volts buzzer in this system serves not only as a siren or alarm but also notifies the user if the water level is in a category that is dangerous. Users will be alerted to the situation by the buzzer sound, giving them sufficient time to gather their belongings and organize themselves for the move to safe place.

#### 3.7 Circuit Diagram

Figure 3.13 below shows the circuit diagram of the system. The connection of the input and output components to the NodeMCU ESP32 referred to the datasheet and pin out of the microcontroller to identify the appropriate digital and analog pins to use. These pins are then declared in Arduino IDE, so that the circuit can functioning as desired.



The ultrasonic sensor and flow rate sensor are the input to the NodeMCU ESP32. Trig and Echo pin of ultrasonic is connected to digital pin D5 and D18 while the Signal pin of flow rate sensor connected to D27. Both Vcc or Power and Gnd wire of these sensor are connected to Vin and Gnd pin of the microcontroller, so that the sensor can be powered up. Meanwhile, LED Green, Yellow and Red and also buzzer are the output to the microcontroller. The three LEDs are connected with resistor 330 ohm before respectively connected to pin D21, D22 and D23. Lastly, a buzzer with resistor 100 ohm is connected to digital pin D25 so that it can be sounded as the alarm signal if water level exceeds danger state.

#### 3.8 Software

After the completion of the hardware setup, now is the time to complete the project's software configuration. The Arduino Integrated Development Environment (IDE) and Blynk were the software application that were utilized in developing flash flood early triggering system.



#### **3.8.1** Arduino IDE

The Arduino IDE, or Integrated Development Environment, is a piece of accessible software that enables enhanced and assisted code editing, compilation, and debugging. It is also known by its alternative name, the Integrated Development Environment. This software is used to program the input and output of the NodeMCU, so that the water level increasing rate and rainfall intensity can be measured and monitored using the sensors. To be able to work with the ESP32, a new source is added to the Arduino IDE Board Manager, and then the ESP32 boards are installed. Due to the efforts of the Espressif team, this is actually much easy than it sounds. They've provided an URL to a JSON file that handles nearly everything for us. JSON is a text file format that enables the exchange of structured data between computers. In this regard, it is comparable to XML.

## **3.8.2** Blynk Application



Figure 3.15 Blynk application

Blynk is a control interface for devices such as NodeMCU, Arduino and Raspberry Pi that can be accessed via the web on iOS and Android-based mobile devices. The graphical user interface for the user's project will be created by the user by dragging and dropping controls. It is an electronic control panel. It is also called as the IOP platform, and its primary purpose is to simplify the design, development, and operation of intelligent devices. It is possible to use it for the remote reading of sensor data, the storing of sensor data, and the viewing of hardware. Figure 3.15 depicts the Blynk Application's logo for your viewing pleasure.

# 3.9 Summary

This chapter describes the proposed methodology in order to establish a fresh, effective, and integrated strategy in predicting flash flood with the use of both hardware and software configuration. The goal of this project is to improve upon previous methodologies by making them more integrated. The best systems can be built smoothly and easily by having a clear figure about the system, which can be accomplished by referring to a block diagram or system architecture.

#### **CHAPTER 4**

#### **RESULTS AND DISCUSSIONS**

## 4.1 Introduction

This chapter presents the results and analysis on the development of flash flood early triggering system based on rainfall intensity and level increasing rate using NodeMCU ESP32. The proposed system are focusing on urban area where flash floods usually occur and cause a lot of destruction and damage in a short time. The rainfall intensity value are manipulated using flow rate sensor formula in the programming to get rainfall intensity classification value in unit mm/hour. Meanwhile, water level increasing rate of the tank is measured by generating equation in the coding to get value in unit cm/min. It is important to note that, the simulation depends on Wifi coverage and environment because the sensor used is quite sensitive and sometimes provide data that is not stable over a long period of time. The display of sensor readings on the Blynk app and also the estimation time require the accuracy of the sensor value so that it can be compared with the actual value set on the flood info website by the State Irrigation and Drainage Department. The results are validated based on the time series simulation of the ultrasonic and flow rate sensor as the estimation results.

# 4.2 Sensor Calibration

In order to acquire a value that corresponds to or is very close to the actual value, the ultrasonic sensor and the water flow rate sensor both need to go through the sensor calibration process. This method is crucial because accuracy in a system is important in order to not generate confusion or deliver wrong information. This may be avoided by following this process.

# 4.2.1 Ultrasonic Sensor Calibration : Water Level Measurement



Figure 4.1 Ultrasonic Sensor Calibration for Water Level Measurement

The NodeMCU ESP32 is used as the platform for the ultrasonic calibration procedure (refer Figure 4.1), which begins with the uploading of a programme that has been built in the Arduino IDE software. A connection has been made between the ultrasonic sensor and the input pin on the NodeMCU. The serial monitor in Arduino IDE is used to display readings of the water level, and those readings were afterwards compared to actual measurements taken using a measuring tape. The height of water tank that is measured by ultrasonic sensor is adjusted numerous times in the code to achieve a water level reading as in Figure 4.2 that is closest to the measurement obtained from the measurement tape.

💿 CO	M3			
water	level	(cm):	11.49	
water	level	(cm):	11.49	
water	level	(cm):	11.49	
water	level	(cm):	11.49	
water	level	(cm):	11.49	
water	level	(cm):	11.49	
water	level	(cm):	11.49	
water	level	(cm):	11.49	

Figure 4.2 Serial Monitor Display Water Level Measurement

#### 4.2.2 Water Flow Rate Sensor Calibration : Rainfall Intensity Measurement



Figure 4.3 Water Flow Rate Sensor Calibration with 2L Jug

The procedure of calibrating the water flow rate sensor for rainfall intensity measurement from Figure 4.3 begins after uploading code to the NodeMCU ESP32 once it has been compiled in the Arduino IDE software. A connection has been made between the flow rate sensor and the input pin on the NodeMCU. The water flow rate per minute as well as the output liquid quantity readings were observed through the serial monitor. These readings were then compared to measurements that were taken utilising a 2000 millilitres or 2.0 litre jug. The flow rate value represents a measure of rainfall intensity in which varying water flow rates are controlled from the main pipe at slow, medium and fast rates. The calibration factor is modified multiple times within the code in order to achieve a reading on the serial monitor that is as accurate as possible with regards to flow rate and output liquid quantity as in Figure 4.4.

Flow	rate:	7.86L/min	Output :	Liquid	Quantity:	810mL /	OL	Flow	rate:	0.	00L/min	Output	Liquid	Quantity:	1691mL	/	1L
Flow	rate:	7.73L/min	Output 3	Liquid	Quantity:	938mL /	OL	Flow	rate:	0.	00L/min	Output	Liquid	Quantity:	1691 mL	/	1L
Flow	rate:	7.86L/min	Output :	Liquid	Quantity:	1068mL ,	/ 1L	Flow	rate:	1.	33L/min	Output	Liquid	Quantity:	1713mL	1	1L
Flow	rate:	7.59L/min	Output 3	Liquid	Quantity:	1194mL ,	/ 1L	Flow	rate:	2.	13L/min	Output	Liquid	Quantity:	1748mL	1	1L
Flow	rate:	5.86L/min	Output 3	Liquid	Quantity:	1291mL ,	/ 1L	Flow	rate:	2.	26L/min	Output	Liquid	Quantity:	1785mL	1	1L
Flow	rate:	5.19L/min	Output 3	Liquid	Quantity:	1377mL ,	/ 1L	Flow	rate:	з.	33L/min	Output	Liquid	Quantity:	1840mL	1	1L
Flow	rate:	4.66L/min	Output 3	Liquid	Quantity:	1454mL ,	/ 1L	Flow	rate:	3.	73L/min	Output	Liquid	Quantity:	1902mL	1	1L
Flow	rate:	3.46L/min	Output 3	Liquid	Quantity:	1511mL ,	/ 1L	Flow	rate:	4.	80L/min	Output	Liquid	Quantity:	1981mL	1	1L
Flow	rate:	1.60L/min	Output 3	Liquid	Quantity:	1537mL ,	/ 1L	Flow	rate:	5.	19L/min	Output	Liquid	Quantity:	2067mL	1	21
Flow	rate:	0.40L/min	Output 3	Liquid	Quantity:	1543mL ,	/ 1L	Flow	rate:	5.	46L/min	Output	Liquid	Quantity:	2158mL	1	2L
Flow	rate:	0.40L/min	Output 3	Liquid	Quantity:	1549mL ,	/ 1L	Flow	rate:	5.	73L/min	Output	Liquid	Quantity:	2253mL	1	2L
Flow	rate:	0.40L/min	Output 3	Liquid	Quantity:	1555mL ,	/ 1L	Flow	rate:	6.	391./min	Output	Liquid	Quantity:	2359mT.	1	21.
Flow	rate:	0.27L/min	Output 3	Liquid	Quantity:	1559mL ,	/ 1L	Flow	rate:	7	06L/min	Output	Liquid	Quantity:	2476mT.	1	21.
Flow	rate:	0.27L/min	Output :	Liquid	Quantity:	1563mL ,	/ 1L	Flow	rate.	7	73T./min	Output	Liquid	Quantity:	2604mT.	1	2T.
Flow	rate:	0.00L/min	Output 3	Liquid	Quantity:	1563mL ,	/ 1L	Flor	rate.	8	921./min	Output	Liquid	Quantity:	2752mT	1	21
Flow	rate:	0.00L/min	Output :	Liquid	Quantity:	1563mL ,	/ 1L	Flow	rate.	8	7GT/min	Output	Liquid	Quantity:	2898mT	',	21
Flow	rate:	0.13L/min	Output 3	Liquid	Quantity:	1565mL ,	/ 1L	Flow	rate.	٥.	721/min	Output	Liquid	Quantity:	20.60mT	',	21
Flow	rate:	0.00L/min	Output :	Liquid	Quantity:	1565mL ,	/ 1L	Flow	Tate.	2.	FOT /min	Output	Liquid	Quantity.	2210mT	',	21
Flow	rate:	0.00L/min	Output :	Liquid	Quantity:	1565mL ,	/ 1L	FIOW	Iate.	9.	391/min	output	Timuia	Quantity.	3219IIIL	',	27
Flow	rate:	0.00L/min	Output :	Liquid	Quantity:	1565mL ,	/ 1L	FIOW	rate:	10	./9L/min	Output	Liquid	Quantity:	3398mL	',	3L 27
Flow	rate:	2.93L/min	Output :	Liquid	Quantity:	1613mL ,	/ 1L	Flow	rate:	11	.19L/min	Output	Liquid	Quantity:	3584mL	1	31
Flow	rate:	6.79L/min	Output :	Liquid	Quantity:	1726mL ,	/ 1L	FLOW	rate:	10	.92L/min	Output	Liquid	Quantity:	3766mL	1	3L
Flow	rate:	4.53L/min	Output :	Liquid	Quantity:	1801mL ,	/ 1L	Flow	rate:	10	.92L/min	Output	Liquid	Quantity:	3948mL	1	3L
Flow	rate:	0.13L/min	Output :	Liquid	Quantity:	1803mL ,	/ 1L	Flow	rate:	10	.92L/min	Output	Liquid	Quantity:	4130mL	/	4L
Flow	rate:	0.00L/min	Output :	Liquid	Quantity:	1803mL ,	/ 1L	Flow	rate:	10	.79L/min	Output	Liquid	Quantity:	4309mL	/	4L
Flow	rate:	0.80L/min	Output 3	Liquid	Quantity:	1816mL ,	/ 1L	Flow	rate:	9.	46L/min	Output	Liquid	Quantity:	4466mL	/	4L
Flow	rate:	7.06L/min	Output 3	Liquid	Quantity:	1933mL ,	/ 1L	Flow	rate:	8.	79L/min	Output	Liquid	Quantity:	4612mL	/	4L
Flow	rate:	0.93L/min	Output 3	Liquid	Quantity:	1948mL ,	/ 1L	Flow	rate:	7.	19L/min	Output	Liquid	Quantity:	4731mL	/	4L
Flow	rate:	5.99L/min	Output 3	Liquid	Quantity:	2047mL	/ 2L	Flow	rate:	6.	39L/min	Output	Liquid	Quantity:	4837mL	1	4L
Flow	rate:	5.59L/min	Output 3	Liquid	Quantity:	2140mL ,	/ 2L	Flow	rate:	1.	73L/min	Output	Liquid	Quantity:	4865mL	/	4L

Figure 4.4 Serial Monitor Display Flow Rate Value for Rainfall Intensity Measurement

Table 4.1 Water Level Calibration

Water Level Calibration											
shl.	1.15	<u> </u>									
Actual Measured	System Measured	Emin (am)	C Error								
Level (cm)	Level (cm)	Enor (cm)	70 EIIO								
5.0	4.93	0.07	ELAKA 1.40								
7.0	6.98	0.02	0.29								
8.0	8.03	0.03	0.38								
10.0	9.97	0.03	0.30								
11.0	10.95	0.05	0.45								
13.0	12.96	0.04	0.31								
16.0	15.83	0.17	1.06								
20.0	20.05	0.05	0.25								
25.0	24.49	0.01	0.04								
30.0	29.97	0.03	0.10								
Rainfall Intensity Calibration											
--------------------------------	--------------------------------	------------	---------	--	--	--	--	--	--	--	--
Actual Measured Volume (mL)	System Measured Volume (mL)	Error (mL)	% Error								
250	262	12	4.80								
500	518	18	3.60								
750	764	14	1.87								
1000	1031	31	3.10								
1250	1291	41	3.28								
1500	1475	25	0.09								
1750 MALAI	1726	24	1.37								
2000	2047	47	2.35								

#### Table 4.2 Rainfall Intensity Calibration

Table 4.1 and Table 4.2 shows water level calibration and rainfall intensity calibration, where the percent error (% error) is the difference between the actual measured value and system measured value as a percentage of actual measured value. For the water level calibration, the range of % error is from (0.10 to 1.06) %. While for rainfall intensity calibration, the range of % error is from (0.09 to 4.80) %. This can be concluded that the percent error can be reduced by using the suitable calibration factor for the sensor inside the Arduino IDE program.

### 4.3 **Prototype testing**



Figure 4.5 Prototype testing with different rainfall intensity value

Figure 4.5 represents the prototype testing of the flash flood early triggering system. The water from the pipe flow through the flow rate sensor and control valve 1, and then enter UNIVERSITITEKNIKAL MALAYSIAMELAKA the water tank. The water level value is monitored using ultrasonic sensor. A flow rate sensor manipulated the intensity of the rainfall and classified as in Table 4.3.

Table 4.3 Rainfall Intensity classification during prototype simulation

Rainfall Intensity Classification									
Light	1 – 10 (mm/hour)								
Moderate	11 – 30 (mm/hour)								
Heavy	> 30 (mm/hour)								

When the flow of water from the pipe is slow, the intensity classification of the rainfall is light; nevertheless, if the flow is fast, the intensity category of the rainfall is dangerous. For the condition of the water level, three LEDs (Green, Yellow, and Red) and a buzzer are utilized as alarm signals and alarm sounds. When the water level is Normal, the green LED lights up; when the water level is in Danger, the yellow LED lights up; and when the water level is in Warning, the red LED lights up and a buzzer sounded. The water level classification as in Table 4.4.

Water Level C	Classification	Alarm Signal
Normal	1 – 15 (cm)	LED Green ON
Warning	16 – 20 (cm)	LED Yellow ON
Danger	> 20 (cm)	LED Red and Buzzer ON

Table 4.4 Water level classification and alarm signal during prototype simulation

# 4.4 Blynk Application

The Blynk application is used as a medium to monitor several important parameters in the flash flood early triggering system. The monitored parameters are real time water level, water level condition, rainfall intensity, level increasing rate and estimation time. Due to the integrated Wi-Fi in NodeMCU ESP32, all these parameters were wirelessly transmitted to the Blynk application. These data can be monitored in the Blynk application through the selected virtual pin when setting the flash flood early detection Blynk template and included in the arduino ide program using the Blynk.virtualWrite command. The Blynk display when water level in normal, warning and danger condition is as shown in the Figure 4.6, 4.7 and 4.8 below.



Figure 4.7 Blynk display when water level is Warning 59

	10:53	ul 🗢 🔲
	Flash Flood Early Detection ESP32 Water Level is in DANGER Condition	now
	Normal Warning Dan	ger
	$\bigcirc$ $\bigcirc$	
	Water Level Rainfall Intensity 67.66mm	ı/h
	Water Level WATER LEVEL	
	20	
	10	
	22:40 22:45	22:50
	Live	
	Rainfall Intensity RAINFALL INTENSITY 80	
	60	
	40	
	0 00450-00 00450-45 00450-00	20-52-15
	Live 15M	22:53:15
	Level Increasing Rate Level Indicator	
ALAYSIA	179 <b>cm/min</b>	
Mar 14	23.9	77cm
N	Estimation time	
8	0.4bmin	25
X	>	
F		
5 Figure 4.8 B	ynk display when wate	er level is Danger
·		

Blynk application makes it easier for responsible organizations to monitor the current situation of river or drain water levels and prepare for rescue operations in areas that frequently or are expected to experience flash floods based on the level increasing rate and estimated time.







Figure 4.10 Rainfall intensity reading in real time

The real time water level and rainfall intensity reading inside Blynk application assist the authorities to analyze the pattern of changes of these two parameters for the early detection of flash floods in urban area.

Figure 4.11 Water level increasing rate equation in Arduino IDE

//in cm/min

Level Increasing Rate = WaterLevelDiff/0.3333;

The equation for water level increasing rate is performed by calculating water level difference between current water level and previous water level for every 20 seconds. After that, the water level difference must be divided with 20/60 which gave value of 0.3333 to obtain level increasing rate in cm/min units. The equation for water level increasing rate of the tank is as shown in Figure 4.11.

```
//Calculating Estimation_Time
Estimation_Time = ((25.0 - water_level)/Level_Increasing_Rate); //in minute
```

Figure 4.12 Estimation time equation in Arduino IDE

The equation for calculating estimation time from the current water level to maximum danger level can be derived as in Figure 4.12. The maximum danger level was 25.0 cm, then it must be subtracted with the current water level value and divided by level increasing rate. After that, the value must be divided again with 60 to get estimation time in unit of minutes.



Figure 4.13 Telegram Bot Flash Flood Early Detection ESP32

Apart from monitoring the state of the river level through the Blynk application, Telegram Bot is also utilized to deliver notifications if the current river water level is in a state of warning and danger.



Figure 4.14 Telegram Bot Flash Flood Early Detection ESP32 username

The name of the Telegram bot is Flash Flood Early Detection ESP32 and the username is FFEDESP32\_bot as illustrate in Figure 4.13 and Figure 4.4. However, this telegram bot is set to only be accessed by one authorize user only, for example the authority such as BOMBA and APM.

#### 4.7 Summary

The results and analysis from the simulation of the prototype for flash flood early triggering system based on level increasing rate and rainfall intensity were presented in this chapter. This prototype simulation has proven the concept of the actual implementation of the flood early detection system based on the results shown and the analysis that has been done. Nevertheless, several aspects need to be altered in order for this system to be more accurate.

#### **CHAPTER 5**

#### **CONCLUSION AND RECOMMENDATIONS**

#### 5.1 Conclusion

This thesis presents the development of flash flood early triggering sytem based on rainfall intensity and level increasing rate using NodeMCU ESP32. The prototype developed during the experimental setup is to prove the concept of actual implementation setup of flash flood early triggering system that can be constructed in the main focus area of this project, which is in urban areas. The wireless flash flood triggering and alert system is crutial because this disaster occur every year in Malaysia, particularly in Kuala Lumpur and Selangor. The system makes a significant impact in making residents aware of the potential disaster. Flood information would be acquired in real time, without delay, and actions such as relocating residents and their goods could be prepared early on. In comparison to existing solutions, this initiative can assist authorities in controlling the flood situation throughout Malaysia by utilising high-precision sensors and a wireless network to deliver notifications through Blynk application and Telegram.

#### 5.2 Future Works

For future improvements, accuracy of the rainfall intensity measurement, water level measurement and estimation time could be enhanced as follows:

- Consider using high-precision ultrasonic sensor and rain gauge to get accurate value of water level and rainfall intensity.
- Consider using GPS module to make it easier for the authorities to track the location of flash flood occurs.

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### APPENDICES

## Appendix A Gantt Chart PSM 1

DCM 1		MAC					AP	RIL			N	JUNE			
Project Title: DEVELOPMENT OF FLASH FLOOD EARLY TRIGGERING SYTEM BASED ON RAINFALL INTENSITY AND LEVEL INCREASING RATE USING NODEMCU ESP32 Supervisor: Ts. Shahrizal Bin Saat	Status	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
1. Project title research	plan														
2. Proposal writing	plan actual														
3. Proposal submission	plan actual														
4. Abstract preparation	plan actual						_								
5. Literature Review	plan actual										7				
6. Progress Week 6	Pplan actual					7					1				
7. Component purchasing	plan actual										-				
8. Sensor calibration	plan actual														
9. Methodology preparation	plan actual	a		_	-				ω, ,	- 10					
10. Preliminary results	plan actual						2	A.	V	-	~				
11. Draft report submission to SVRSITI TE	plan actual	(A		M/	L	٩Y	SL	A I	ИЕ	Ľ	<mark>\K</mark>	۱.			
12. Progress Week 12	plan actual														
13. Slide preparation	plan actual														
14. Presentation and Report PSM1 submission	plan actual														

## Appendix B Gantt Chart PSM 2

DCM 2		OCTOBER			N	IOVE	MBE	R	DECEMBER				JANUARY		
Project Title: DEVELOPMENT OF FLASH FLOOD EARLY TRIGGERING SYTEM BASED ON RAINFALL INTENSITY AND LEVEL INCREASING RATE USING NODEMCU ESP32 Supervisor: Ts. Ahmad Nizam Bin Mohd Jahari @ Mohd Johari	Status	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
1. Hardware improvement	plan actual														
2. Rainfall intensity coding	plan														
3. Increasing rate coding	plan														
4. Estimation time coding	plan														
5. Blynk app interface	plan														
6. Progress Week 6	plan														
7. Telegram bot setting	plan														
8. Simulation hardware with Blynk and Telegram	plan					4									
9. Blynk + Telegram interface	plan actual	_								4					
10. PSM2 report writing	plan						-								
11. Results and analysis	plan		1		-					•					
12. Progress Week 12 and Draft Report Submission	plan	-				C.	2		1	<i>7</i> ,	2				
13. Poster preparation NIVERSITI TEK	plan	L.	M	AL	A	YS	IA	M	EL	A.	KA				
14. PSM2 Demonstration and Report Submission	plan														