Flood monitoring and early warning system:

Flood is one of the biggest natural disasters that occurs frequently around the

world, It can occur without warning and the after effect of it leaves great damage to the

surrounding environment and exposes life threatening to citizen. Therefore, early flood detection

and monitoring system with the implementation of Internet of Things and Global Positioning

System is proposed in order to reduce the risks that may cause flooding. The aim of this project

is to provide the information of a current water level in a drain. When water level increases to a

certain level, the system will send a warning notification to users indicating three categories of

water level, which are safe, warning and critical level. This system contains an ultrasonie sensor

to detect the current water level and at the same time allows users to observe the period of the

water level from their phone so that users are more aware of when flooding ought to happen

Moreover, the system consists of a flooding avoidance method that requires the usage of a solenoid as a shutter valve of the drain and water pump to pump out excessive water flow to a

suitable place for water release purposes

1. Introduction

Flood contributes to significant danger in life and property damage in many areas over the world. In

Malaysia, monsoonal flood and flash flood occur respectively during the northeast monsoon and heavy

rains causing the loss of life and property damages. Flood is one of the most common natural disasters

that Malaysia faced annually. Based on data collected by the Centre for Public Policies Studies, due to

climate change, rainfall in Malaysia is above average especially during monsoons seasons affecting

cities particularly in the eastern states such as Kelantan, Terengganu, and Perak. However, urban cities

with rapid growth like Kuala Lumpur also face this problem due to the inefficiency of the drainage

systems. In 2009, researchers have found that an estimation of the area at risk of flooding is

approximately 29,800km' that is about 9% of the total area in Malaysia affecting almost 4.85 million

people, which is approximately 22% of the total population in this country [1]. Over 28% of citizens supported that undeniably the main cause of the flooding is due to the improper drainage system in

Malaysia (21.

Although flooding was an abnormal phenomenon years ago, it is now considered as a life threatening

natural disaster for the humankind. A study stated that the effects of flooding include damages to homes,

shops, transportation disrupt and industries [3-5]. The research pointed out that, flood victims usually

have problems with the repair cost causing for example, small shops fail to reopen after the disaster.

Other organisations and the government need to spend a lot of money to restore all of the broken

facilities due to flooding while providing a rescue unit to keep all of the victims safe. Not only it will

cost so much money, but it will also need a lot of human force such as nurses, doctors, rescue workers

and others [6-8].

Due to its relative regularity, flood mitigation, forecasting, and warning system efforts have been

Undertaking by various agencies to minimize impacts brought forth by floods [191. Such an event

Scrutinizes Malaysia’s ability to respond to floods in the area of readiness, relief, and rebuilding, Despite

Various preparations, present countermeasures remain insufficient as experienced during December

2014 to January 2015 flood crisis; where close to 250,000 residents were displaced. It is in the general

Interest of all stakeholders to minimize the effects of floods inflicted on Malaysian residents, not only

Due to its disruptiveness to the livelihood of its victims, adverse environment and health effects, and

Various causes to individual victims suffering from the catastrophe, but also due to the massive cost

Involved in the redevelopment of infrastructure. Therefore, minimizing flood occurrences would

Ultimately be more cost efficient for all stakeholders, primarily the taxpayers, especially in areas where

Floods occur on a consistent basis.

If only early flood warning system has been effectively utilized, these issues can be reduced and

Appropriate steps in fighting against the flooding scenario can be taken in the shortest time within the

Available resources [10], Problems like this can be prevented by warning directly to the public, especially

Those living near the drainage [1 1]. Along with advances in computing technology, each community in

Malaysia has been affording to have a smartphone that the usage is in rapid growth in our society. This

Is where Internet of Things (loT) can come in handy. loT is a technology that connected anything and

Everything to the Internet. IoT is the newest technology rapidly widen in its usage. This technology

Brings new products such as disaster monitoring [12]. Since flood disaster is the main concern in

Malaysia because every year there are floods occurring, we can use this technology to do monitoring

Activity that people are not able to do in 24 hours before.

Moreover, the increase of water level without any controls when flood happens can also troubles drivers

To pass through the road [13]. In most cases, flood water level rises faster and less time is available for

The people to evacuate [14]. The alerts for early flood warning system usually needed for the respective

Organizations and authorities; this is because it will take time for them to reach as water rises quickly in

Most cases [15]. In general, flooding is unavoidable but the early detection and warning system will be

Able to reduce overheads bared by the victims and government

Therefore, the aim of this Flood Detection and Avoidance S ystem with the implementation of loT is to

Be seen as a great approach to help overcome the flooding problems in big cities. This is because, this

System is needed for citizens to be aware of the flooding in their nearby areas by getting the information

From the mobile phone’s application such as the current water level and the flood locations. Further, the

System is needed for prevention of worst dama ges in the country by controlling the excessive water to

Flow to suitable places.

2. System Design

loT is being implemented in the design of this project where it is used as a foundation for data

transmissions between the detection devices to the mobile application. Ultrasonic sensor helps to convert

energy into ultrasound and in this project, a waterproof sensor used to detect and monitor the level of

water from time to time. Global Positioning System (GPS) is being implemented to provide the exact

location of the flood area, The system also consists of a flooding avoidance method that uses a solenoid

valve to control the excess water flowing out so that the water level can be controlled before flooding

occurs. Flood detection and avoidance system not only can create awareness so that citizens can make early preparation after being notified by the mobile phone application, they are also able to monitor

water level at any time of the day. Users can also know the flooding areas that are shown by the GPS

map in the application. An avoidance system is made to slow down the increase of water level so that

users have enough time to make preparation before flood occur. Figure 1 shows the block diagram of

the system where there are two inputs in the system consisting of the ultrasonic sensor and the GPS

module used to receive the data processed in the NodeMCU controller. Meanwhile, the outputs of the

system include the loT platform which are the Blynk app and the solenoid valve. Table 1 summarizes

the function of the components used.

2.1. Working mechanism

The detection system includes three levels where the water is measured at the safe level, warning level

And critical level, Ultrasonic sensors are used to detect the water level and for each level, the depth has

Been decided where for the condition to be at the safe level, the water must be less than 14cm deep while

For warning level, the water has reached a depth between 14cm to 18cm. The critical level is when the

Water is over 18cm deep.

Throughout the three levels, users are able indirectly to monitor the current water level in the drain at a

Specific location that they desire through an app on their phone. During safe level, a shutter that is used

To flow out any excess water will be OFF. This is because there is no triggering danger yet based on the

Current water level. However, as water continues to rise to the warning level, app users will start to

Receive a notification alert on their phone to remind them of the current water level. The same method

Applied when the water level reaches the critical level. App users will once again receive a notification

Alert but this time it will warn users of the critical water level.

During both of these situations, the shutter will finally turn ON and therefore will allow excessive

Floodwater from the drain to flow out to other suitable places. This mechanism of flood avoidance is

Fairly new and never been done by other companies before. In fact, the GPS system that is available in

This project allows users to know the exact location of a place with a rising water level. This in return

Will enable road users to avoid driving through flooded areas and at the same time can avoid heavy

Traffic congestion due to flood. Figure 2 summarizes the working mechanism of the system in a flow

Chart.

Table 1. Function of each components used.

Name	Function
Ultrasonic sensor	To detect and monitor current water level
GPS	Provide exact location of flood area
NodeMCU	Connects system to the Internet when Wi-Fi is available
IoT Platform	Supports Blynk app. Can display water level information, GPS and notification
Solenoid Valve	Allows excess water to flow out to suitable places

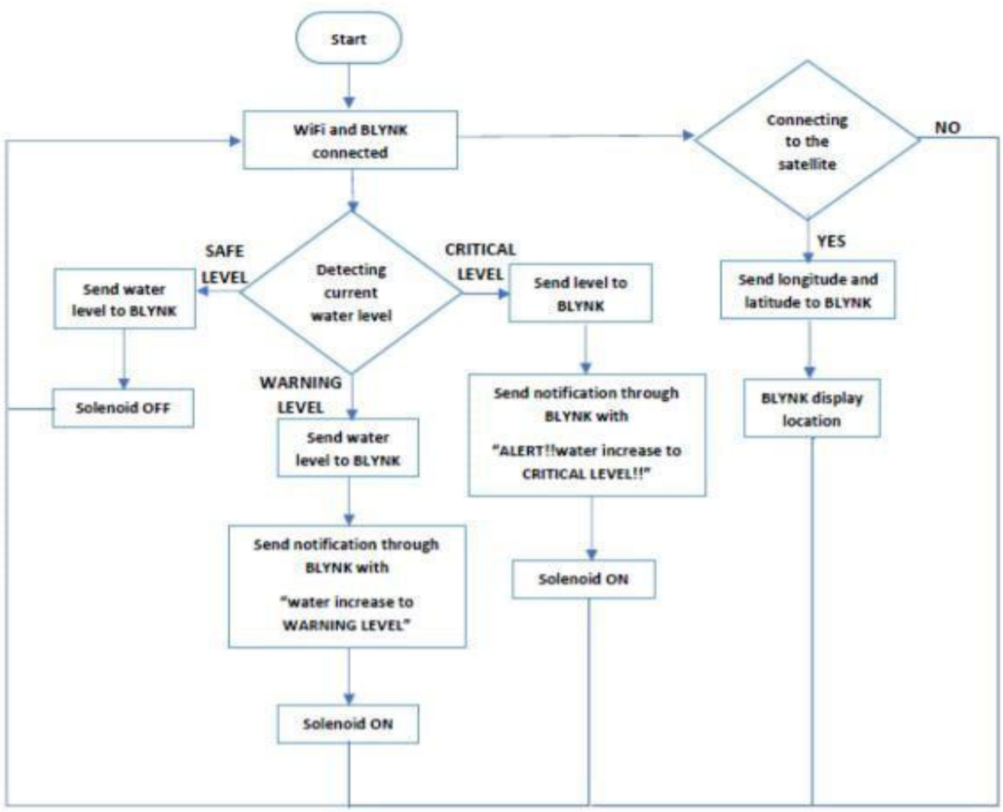

Figure 2. Flowchart of the system.

The integration between the software and hardware is made by using a nodeMCU with ESP8266 Forimport random

Import time

CODING:

```
# Simulated data collection function

Def collect_data():

   # Simulate data from a river gauge and rainfall sensor

   River_level = random.uniform(0.0, 10.0)  # Simulated river level

   Rainfall = random.uniform(0.0, 50.0)  # Simulated rainfall



   Return river_level, rainfall



# Simulated warning generation function

Def generate_warning(river_level, rainfall):
```

```
# Set threshold values (you should determine appropriate values)

River_level_threshold = 8.0

Rainfall_threshold = 30.0



# Check if thresholds are exceeded

If river_level > river_level_threshold and rainfall > rainfall_threshold:

    Return "Flood Warning: River level and rainfall exceed thresholds"

Elif river_level > river_level_threshold:

    Return "Flood Warning: River level exceeds threshold"

Elif rainfall > rainfall_threshold:

    Return "Flood Warning: Rainfall exceeds threshold"

Else:

    Return "No Flood Warning"
```

```
# Main simulation loop

While True:

   River_level, rainfall = collect_data()

   Warning = generate_warning(river_level, rainfall)

   Timestamp = time.strftime("%Y-%m-%d %H:%M:%S")




   Print(f"{timestamp} – {warning}")




   # Simulate data collection interval (e.g., every 15 minutes)

   Time.sleep(900)  # Sleep for 900 seconds (15 minutes)
```

The loT part, nodeMCU has uploaded the sketch of the coding of Blynk mobile phone application, Wifi

ID and WiFi password, this allows nodeMCU to process the WiFi module to connect the WiFi and then

Connect to the Blynk apps, With the connect of Blynk, the nodeMCU proceeds the coding which acts as

He controller to control the flow of the system such as assign ultrasonic sensor as the input data anc

Process the input in the nodeMCU to identify the current water level categories and send data to Blynk.

When the input data from the ultrasonic is matched to the warning level value which is set inside the

Coding of the nodeMCU, the nodeMCU will process the part of the warning level process to send

Warning level's notification ("water increase to WARNING LEVEL") and activate solenoid and water

Pump.

Meanwhile, for critical value, nodeMCU still activates the solenoid and water pump and sends critical

Evel's notification ("ALERT!! Water increase to CRITICAL LEVEL!") to the Blynk app. For the GPS

Part, the activated GPS coding is uploaded inside the nodeMCU and nodeMCU activates GPS antenna

To have the connection with the satellite and if the satellite connected, the longitude and latitude values

Are received inside the nodeMCU and then the data is sent to the BL YNK to show the location. Figure

3 shows the schematic diagram of the system and Figure 4 shows the overall circuit setup.

Table 2. Condition for each water level.

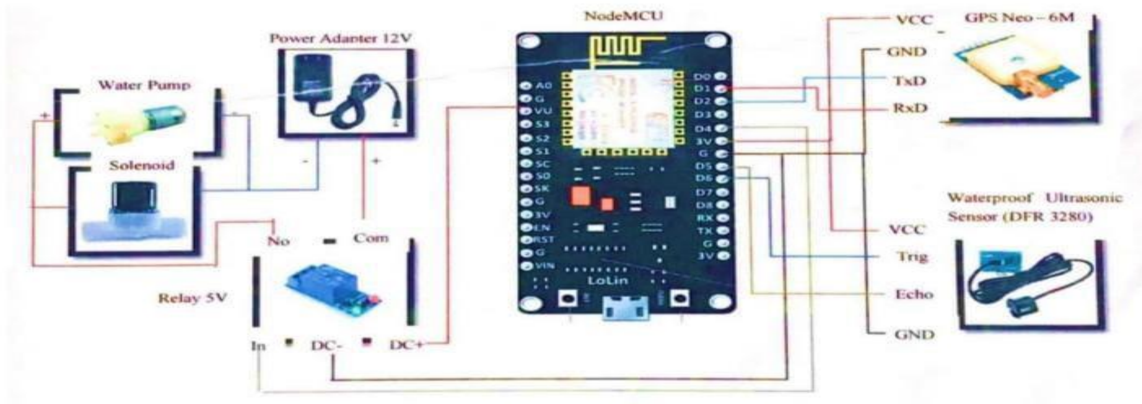

Figure 3. Schematic diagram of the system.

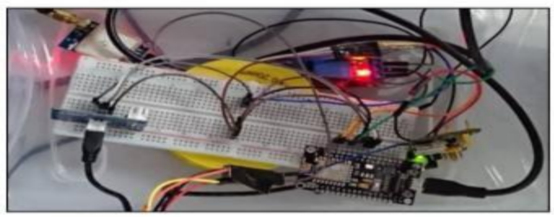

Figure 4. Overall circuit setup.

Figure 5. Prototype setup.

3. Result and discussion

The main results of this project are divided into two categories, which are the function of the prototype

And the data collecting results. The protot ype was shown in Figure 5 below where the design was made

According to the sittation. The categories of the water level in the drainage designed together with the

Prototype is measured based on the depth of the water that has been set such as in Table 2.

3.1. Testing on safe tevel

Figure 6 shows that the water level is at a safe level where from inside the drainage, it can be seen that

The water level is lower than 14cm. In this stage, the solenoid and water pump are inactive. Figure 7

Shows the water level graph that can be monitored in the Blynk app. It shows there are some inaccurate

Current water level, data happens frequently; this is because of the limitation of the ultrasonic sensor due

To the affect from temperature, wind rate, noise and humidity.

3.2. Testing on warning tevel

Figure shows the water level inside the drainage of the prototype showing that it is at a warning level

Where the water level is below critical level and higher than safe level, roughly between 14cm and 18cm.

At this stage, the solenoid valve and water pump are activated where the solenoid opens the valve and

The excessive water is flown out of the drainage by the water pump. The users can also monitor the water

Level through the monitoring graph that was built-in the app where the graph, such as in Figure 9 shows

That the water level is above 14cm. When this condition oceurs, a warning message is sent to the users

Of the mobile application to alert them about the water level rising. Figure 10 shows the demonstration

Of the pop-up warning message that the users will receive via the Blynk app.

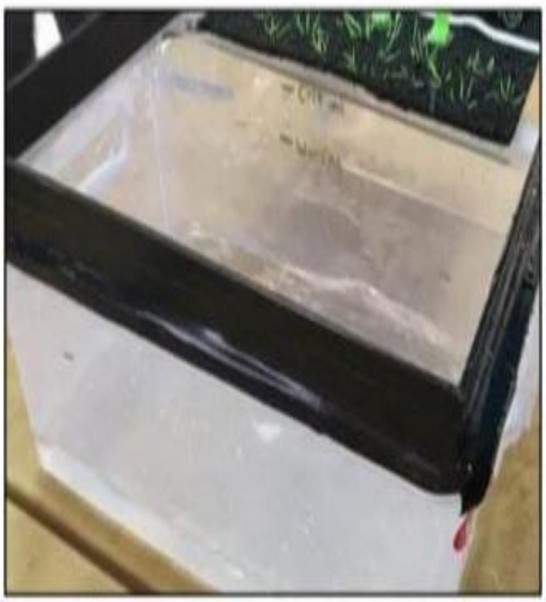

Figure 6. Prototype at safe level.

Figure 7. Blynk app interface of the water level graph at safe level.

Figure 8. Prototype at warning level.

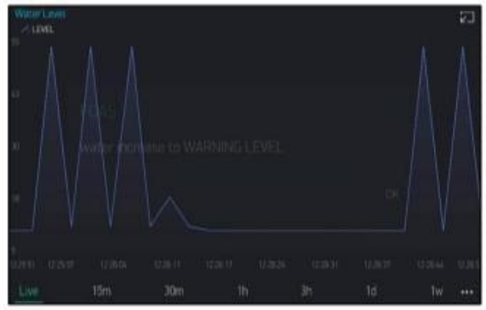

Figure 9. Blynk app interface of the water level graph at warning level.

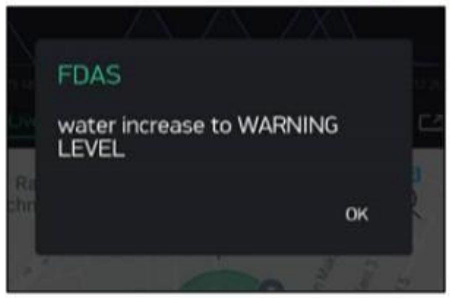

Figure 10. Warning level alert message.

Figure 11. Prototype at critical level.

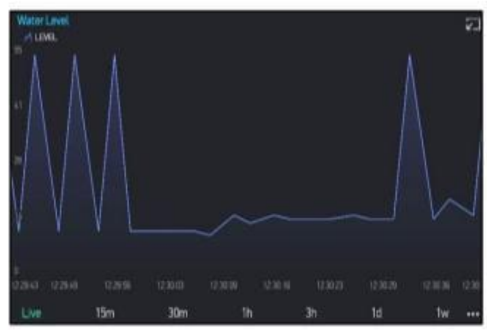

Figure 12. Blynk app interface of the water level graph at critical level.

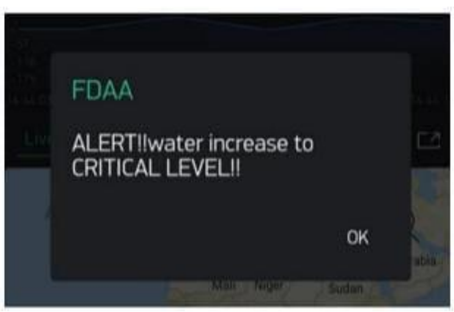

Figure 13. Critical level alert message.

Figure 14. GPS tracker on the Blynk app interface message.