Faculty of Electronics & Computer Technology and Engineering

DEVELOPMENT OF REAL-TIME FLOOD WARNING SYSTEM BY INTEGRATING IOT AND NODEMCU FOR RIVER MONITORING

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DEDICATION

This study wholeheartedly dedicated to my beloved parents Khairiah Binti Mohd Yunos and Ibrahim Bin Jali who have been the source of inspiration and strength to push me forward one step closer toward success and continually provide moral, spiritual, emotional, and financial support.

And next we dedicated this study to the Almighty God Allah S.W.T. for the knowledge and wisdom provided that made this possible.

ABSTRACT

Floods have become a typical yearly occurrence due to the rising frequency of natural catastrophes caused by global warming, particularly during severe rainy seasons when rivers overflow with precipitation that occurs. Since rain cannot be avoided, the creation of a dependable technology capable of predicting flood incidents becomes important. Therefore, this project aims to create a real-time flood warning system for rivers using IoT and NodeMCU. The goal is to provide accurate and timely flood warnings by collecting and transmitting environmental data like water levels and rainfall to a centralized system for processing and analysis. Configuring the hardware components, such as sensors for water level, temperature, ultrasonic, DHT11, and raindrop, as well as constructing a stable power source utilizing a charger module and solar panel, is part of the technique. The program is set up to initialize the sensors, read data, connect to Wi-Fi, and communicate with the web application. Calibration and testing are carried out to guarantee sensor accuracy, confirm decision logic, and validate real-time flood alerts via a web browser. In addition, the research investigates the incorporation of a camera module for visual data collecting. The current results demonstrate effective sensor integration with the ESP8266 Wi-Fi module, laying the groundwork for remote environmental monitoring and automation. Finally, The successful integration of IoT and NodeMCU in the development and deployment of a real-time flood warning system demonstrates the technology's significant potential for improving flood monitoring and emergency response capabilities, including accurate sensor readings, seamless data transfer to MSSQL, and efficient connectivity with web applications to enable timely notifications and valuable flood management insights.

ABSTRAK

Banjir telah menjadi kejadian tahunan yang biasa disebabkan oleh peningkatan frekuensi bencana alam akibat pemanasan global, terutamanya semasa musim hujan yang teruk apabila sungai meluap dengan air hujan yang berlebihan. Oleh kerana hujan tidak dapat dielakkan, penciptaan teknologi yang boleh dipercayai untuk meramalkan kejadian banjir menjadi penting. Oleh itu, projek ini bertujuan untuk mencipta satu sistem amaran banjir secara langsung bagi sungai yang menggunakan IoT dan NodeMCU. Matlamatnya adalah untuk menyampaikan amaran banjir yang tepat dan pantas pada masanya dengan mengumpul dan menghantar data alam sekitar seperti paras air dan jumlah hujan ke sistem pusat untuk pemprosesan dan analisis. Menyusun komponen perkakas seperti sensor paras air, suhu, ultrasonik, DHT11, dan penurunan hujan, serta membina sumber tenaga yang stabil menggunakan modul pengecas dan panel solar, adalah sebahagian daripada kaedah ini. Program ini disusun untuk mengaktifkan sensor, membaca data, menyambung ke Wi-Fi, dan berkomunikasi dengan aplikasi sesawang. Kalibrasi dan ujian dilakukan untuk memastikan ketepatan sensor, mengesahkan logik keputusan, dan mengesahkan amaran banjir secara langsung melalui pelayar web. Selain itu, penyelidikan ini juga mengkaji penggabungan modul kamera untuk pengumpulan data visual. Keputusan semasa menunjukkan keberkesanan pengintegrasian sensor dengan modul Wi-Fi ESP8266, membentuk asas untuk pemantauan alam sekitar jarak jauh dan automasi. Akhirnya, sistem penyepaduan IoT dan NodeMCU yang berjaya dalam pembangunan dan penggunaan sistem amaran banjir masa nyata menunjukkan potensi ketara teknologi untuk meningkatkan pemantauan banjir dan keupayaan tindak balas kecemasan, termasuk bacaan sensor yang tepat, pemindahan data yang lancar ke MSSQL dan ketersambungan yang cekap dengan web aplikasi untuk membolehkan pemberitahuan tepat pada masanya dan pandangan pengurusan banjir yang berharga.

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LIST OF ABBREVIATIONS

V	-	Voltage
IoT	-	Internet of thing
WHO	-	World Health Organisation
Wi-Fi	-	Wireless Fidelity
NaFFWS	-	National Flood Forecasting and Warning System
GPS	-	Global Positioning System
GIS	-	Geographic Information System
MACRES	-	Malaysian Remote Sensing Centre's
SMS	-	Short Message Service
ML	-	Machine learning
GSM	-	Global System for Mobile Communications
AC	-	Alternating Current
DC	-	Direct currect
USB	-	Universal Serial Bus
GND	-	Ground
VGA	-	Video Graphics Array

CHAPTER 1

INTRODUCTION

1.1 Background

Floods are a highly dangerous natural disaster that can occur frequently if proper preventive measures are not taken. A flood occurs when water overflows into normally dry land, inflicting significant damage to infrastructure and private property as well as frequent injuries or fatalities. According to the World Health Organisation (WHO), 75% of flood-related fatalities are caused by drowning, and over the past 20 years, approximately 2 billion people have experienced flood disasters globally. If appropriate safety measures are not taken by the responsible organizations, this situation could worsen in the coming years. Despite the devastating effects that floods have on both people and the environment, it is essential to be knowledgeable about the various types of floods that might happen [1].

The increasing frequency and severity of flooding events around the world have highlighted the need for effective flood warning systems. Integrating IoT and NodeMCU technologies can provide a solution for real-time flood warning systems, which can aid in preventing flooding. The NodeMCU Wi-Fi module can collect and transmit data to a centralized system for processing and analysis by deploying IoT sensors to measure water levels and other relevant environmental data in flood-prone areas. The resulting real-time data can then be used to provide accurate and timely flood warnings, thereby reducing flood damage and loss of life.

1.2 Addressing Global Warming Through Flood Warning System Project

Global warming is becoming a major concern, and it has been linked to an increase in natural disasters such as floods. To lessen the impact of such disasters, effective flood warning systems that can provide timely alerts to those in danger must be implemented. The combination of IoT and NodeMCU technologies can provide a solution for real-time flood warning systems, which can aid in mitigating the effects of global warming. The NodeMCU Wi-Fi module can collect and transmit data to a central system for processing and analysis by deploying IoT sensors in flood-prone areas. This information can be used to issue real-time flood warnings to those in affected areas, allowing for timely evacuation and damage mitigation. Such flood warning systems can help mitigate the effects of global warming while also contributing to the long-term goal of reducing the risk of natural disasters.

1.3 Problem Statement

There is an urgent need for precise and early warning systems due to the tremendous risk that flooding poses to human life and property. The suggested project aims to create a real-time flood warning system using IoT and NodeMCU technologies to meet this demand. However, the deployment of such a system might be expensive, thus it is important to look into cost-effective measures to guarantee the system's affordability and sustainability. The primary problem to be addressed is the lack of a real-time, cost-effective flood warning system that effectively utilizes IoT and NodeMCU technologies. This system should provide timely alerts to populations at risk and minimize the damage caused by flood disasters.

The creation of a real-time flood warning system poses several challenges. These include the necessity of accurate and efficient flood prediction models, as well as the need for dependable data gathering and communication between system components. The system must also demonstrate resilience to power outages or other disruptions that may happen during flooding events is another challenge. Additionally, effective communication channels must be in place to guarantee that warnings are heard and taken seriously right away. The system must also be simple to use and comprehend for the people it serves.

1.4 Project Objective

By addressing the challenges mentioned in the problem statements, the project aims to contribute to the development of a comprehensive flood warning system that meets the urgent need for timely and accurate alerts, while also considering cost-effectiveness, resilience, and user-friendliness. The main aim of this project is to assemble a simple and effective approach for developing the real-time flood warning system that incorporates IoT and NodeMCU technologies to guarantee prompt notifications. Specifically, the objectives are as follows:

- To develop a flood warning system that can deliver accurate and timely flood warnings.
- To develop the system that use IoT sensors to collect and transmit environmental data such as water levels and rainfall to a centralized system for processing and analysis.
- To develop a system capable of alerting users about approaching floods.

1.5 Scope of Project

The goal of this project is to create a comprehensive flood monitoring system by merging NodeMCU, sensors, and a Wi-Fi module to detect water levels, weather, distence and temperature while transmitting the collected data to a cloud-based platform for analysis, generating warnings and notifications. The following is a list of the project's scope.

- NodeMCU, sensors (water level sensor, rain sensor, temperature sensor, ultrasonic sensor), and a Wi-Fi module will be used in the hardware setup.
- The water level sensor will detect the river's water level, while the rain sensor will detect rainfall in the area.
- The sensor will measure the temperature, weather, distence, and water level, which will aid in flood prediction.
- The sensors will transmit data to the microcontroller, which is NodeMCU.
- The NodeMCU will then use Wi-Fi to send this data to the cloud-based platform. To receive and process data from the flood monitoring system, a cloud-based platform will be developed.
- The platform will store and analyse the data in order to generate a warning system. The platform will generate alerts and notifications, which will be distributed to residents of affected areas. The alerts will be distributed via web application.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Floods are a major natural disaster that destroys infrastructure, property, and human life. One of the most difficult challenges in flood management is the ability to provide timely and accurate warnings to communities at risk. With the growing availability and affordability of Internet of Things (IoT) technologies, there is an increased interest in leveraging these technologies to develop more effective and efficient flood warning systems. In this literature review, we will look at how IoT technologies and NodeMCU devices can be used to create real-time flood warning systems. We will go over current research on the design and development of these systems, including the use of sensors to monitor water levels, rainfall, and other critical parameters. We will also look at the system's challenges and limitations, such as data accuracy, network connectivity, and power supply.

2.2 Previous Real-Time Flood Warning System

The previous flood warning system is an effective and cost-effective non-structural solution for mitigating flood damage. The Department of Irrigation and Drainage (DID) in Malaysia provides the public with a flood prediction and warning service known as the National Flood Forecasting and Warning System (NaFFWS). The primary goal of this system is to aid in life-saving operations and to assist relevant agencies in evacuating towns during floods. The flood warning system monitors rainfall and flood flows and analyses the possible impact on the community by evaluating projections. Creating and spreading warning messages comprises presenting information about current and upcoming flood occurrences, expected effects, and recommended measures. These warnings are distributed to all members of the community by numerous channels such as social media, television, radio, and other forms of media. Following a flood incident, the warning system is thoroughly reviewed to improve its efficacy and efficiency.

Malaysia has 140 telemetry stations devoted to monitoring rainfall, 39 water level stations, and 274 combined stations that measure both elements. These telemetry stations are critical for monitoring precipitation and river flow. The country has embraced contemporary technologies, such as GPS, GIS, remote sensing, and sensor technology, to create disaster management applications. However, due to a lack of a suitable platform and system for managing data across organizations, the promise of these technical breakthroughs and available resources has not been fully realized.

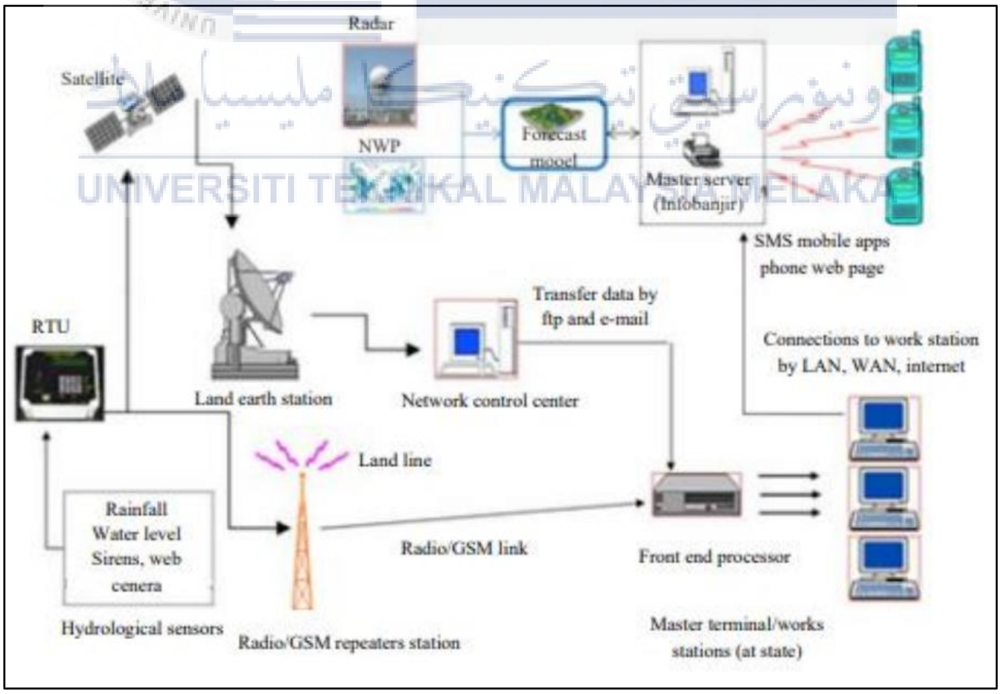


Figure 1: Malaysian system design and architecture for data collecting and distribution.

The system architecture displayed in Figure 1 depicts the Malaysian Remote Sensing Centre's (MACRES) data collecting and distribution infrastructure. MACRES oversees disseminating information produced from remote sensing and comparable technologies, as well as applying early warning detection and monitoring systems [2].

2.3 The Review of The Flood Detection System

The review addresses the flood detection system in detail, highlighting its components, functionality, and performance. This section provides an in-depth look at the system's design and execution, with a focus on its ability to detect water levels, rainfall, and temperature. It differs slightly from the NaFFWS warning system stated above in terms of detection.

2.3.1 Real-Time Flood Detection and Alert System: Methods and Capabilities.

Systems for flood detection have been developed as an immediate response to inform the corresponding authorities before the event happens. It will keep the authorities updated about the current water levels by means of the Arduino sensor network, which will then provide an SMS notification if there is a dangerous situation through the GSM modem. To classify the data, four machine learning methods were used [3].

2.3.2 Reliable Sensors for Flood Detection and Integration into IoT Systems: An Overview.

The operation starts from the data collection in real-time from the various sensors such as the ultrasonic water flow/level sensors, temperature/humidity sensor and rain gauges. All the data is passed to a microcontroller. In the back end, IoT performs data analysis of the real-time data using various software components either using cloud/fog or edge computing. Various data mining algorithms and artificial intelligence/machine learning (ML) techniques help in predicting the possibility of future risks because of floods by comparing them to the pre-programmed values. This information can be broadcasted through social media, other broadcast forms and sending warning messages such as the short message service (SMS) thereby coordinating evacuation and relief efforts. Thus, IoT technologies are used in monitoring, tracking, sensing, controlling, and warning environmental disasters [4].

2.3.3 Exploring Existing IoT-Based Flood Warning Systems: Insights and Lessons Learned.

Building an Intelligent Hydroinformatics Integration Platform for Regional Flood Inundation Warning Systems

provided hydrologists with tools to make management decisions on flood forecasting and flood risk management. Following this track, hydroinformatics has emerged as an essential tool by combining science, technologies, and social considerations into a holistic coherent framework to timely deal with collecting, modeling, visualizing, and sharing flood-related information and to improve the applicability and accuracy of flood warnings. ML methods are efficient tools for extracting the key information from complex highly dimensional input–output patterns and are widely used in various hydrological problems such as flood forecasts in this special issue as well as groundwater and water management issues. Recently, technological advances in social media have improved data gathering and dissemination, especially under the development of world-wide-web technologies. The Internet of Things (IoT) is a system of devices that collect data in real time and transfer it through a wireless network to a communication framework of control centers for analyzing the data and providing suitable countermeasures. Recent studies have indicated that the combination of IoT and machine-learning techniques could be beneficial to flood prediction.

The Internet of Things technology becomes a part of one’s human life. In fact, it can connect the world and allow humans to connect with each other. In some applications, this technology could be lifesaving. As an example, it allows us to save lives of many by disaster management where there is a loss of human life and disruption to a large-scale environment due to natural and man-made disasters. As the IoT permits interconnections of different devices, the IoT enabled disaster management system, for early-warning systems, is used by implementing information analytics and computational tools [5].

2.4 A Software Review for Real-Time Flood Warning Systems for Rivers

This section discusses the software review, which evaluates the capabilities and performance of real-time flood warning systems specifically designed for rivers. It examines the software used in these systems in depth, focusing on its usefulness, accuracy, and effectiveness in detecting and forecasting floods. The purpose of this evaluation is to evaluate the strengths and limits of various software solutions, as well as to highlight critical features and considerations for designing reliable and efficient real-time flood warning systems for river environments.

2.5 IoT (Internet of Things)

The Internet of Things is defined as a "group of infrastructures interconnecting connected objects and allowing their management, data mining, and access to the data they generate” [6]. IoT is one of the "Industry 4.0" enabling technologies. Its goal is to connect humans with machines and intelligent technologies. The Internet of Things (IoT) is a vast interconnected network of computer devices (for example, sensors) that exchange large amounts of data at high speeds [7].

2.5.1 How does IoT work

Simply put, this is the idea of connecting any device with an on/off switch to the Internet (and/or to one another). This includes cellphones, coffee makers, washing machines, headphones, lamps, wearable devices, and nearly anything else you can think of. This also applies to machine components, such as a jet engine in an aeroplane or an oil rig drill. As previously stated, if it has an on/off switch, it is likely to be part of the IoT. According to Gartner, there will be over 26 billion connected devices by 2020... That's a lot of connections (some estimate it to be much higher, more than 100 billion) The Internet of Things (IoT) is a massive network of interconnected "things" (including people). People-people, people-things, and things-things will form relationships. (Morgan, 2014).

2.5.2 Role of IoT in Real-Time Flood Warning System

The Internet of Things (IoT) is critical in the development of real-time flood warning systems since it improves monitoring, data gathering, and communication capacities. In flood-prone locations, IoT devices such as sensors and actuators are used to collect critical data on water levels, rainfall, and meteorological conditions. These devices are often equipped with wireless connectivity, allowing for continuous data transfer to a centralized platform for analysis and decision-making. [9]

Real-time flood warning systems may achieve the following by employing IoT technology:

- Data Collection: IoT sensors installed in rivers, floodplains, and cities collect data on water levels, precipitation, and other environmental aspects continually. This information is critical for understanding flood patterns, determining risk levels, and forecasting possible floods in real-time.

- Remote Monitoring: Internet of Things (IoT) devices allow for remote monitoring of important infrastructure such as dams, levees, and floodgates. These devices' real-time data can assist detect any irregularities or possible breakdowns, allowing for prompt maintenance or intervention.

- Early Warning Systems: When IoT sensors are paired with modern analytics and machine learning algorithms, they may identify unusual changes in water levels, rainfall intensities, and temperature trends, which aids early warning systems. These systems can give timely alerts and messages to authorities and citizens, allowing for proactive flood risk mitigation actions.

- Decision Support: Real-time processing and analysis of IoT data received from numerous sources. This allows stakeholders like emergency response teams and urban planners to make educated decisions based on accurate and up-to-date data. This involves properly directing evacuation routes, managing resources, and organizing rescue operations.

2.6 Hardware Components for River Real-Time Flood Warning Systems

Several hardware components are often utilized in a river real-time flood warning system to gather data and monitor flood conditions. Sensors, communication modules, and microcontrollers are examples of these components [10]. The following are some examples of hardware components that are widely utilized in such systems:

- Water Level Sensors: These sensors monitor the level of water in rivers and streams. They can be ultrasonic, pressure-based, or capacitive sensors that monitor water level accurately and in real time.

- Rainfall Sensors: Rain sensors are used to determine the amount of rainfall in a certain location. They give vital information for flood prediction and monitoring.

- Temperature sensors: Temperature sensors are used to detect the ambient temperature, which aids in understanding weather patterns and their influence on flood risk.

- Communication Modules: These modules, such as Wi-Fi, GSM, or LoRa, allow data from sensors to be sent to a centralized system or cloud-based platform.

- Microcontrollers: Microcontrollers, such as Arduino or NodeMCU, are used to interface with sensors, process data, and control communication modules.

2.6.1 Overview of Hardware Components in Flood Warning Systems

This overview provides an extensive review of the hardware components usually used in flood warning systems. These elements are essential for gathering data, monitoring situations, and providing effective warning and reaction processes. Each hardware component, from water level sensors to communication modules and control systems, contributes to the resilience and dependability of flood warning systems. The section that follows provides an overview of the critical hardware components used in flood warning systems, emphasizing their functions and importance in providing accurate and prompt flood monitoring and response.

2.6.2 Arduino Uno and Its Application in Flood Warning System.

The Arduino Uno is a microcontroller board based on the ATmega328. The Arduino Uno also has 14 digital input/output pins, 6 analogue inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. Arduino Uno can also load everything required to support a microcontroller, easily connect it to a computer with a USB cable, power it with an AC to DC adapter, or start the system with a battery (Nanang Kurniawan, 2018). "Uno" means "one" in Italian, and it was chosen to represent the next output (product) of Arduino 1.0. The Arduino Uno and version 1.0 will be references to future Arduino versions. The Arduino Uno is a reference model for an Arduino board and the final series of the Arduino USB board.

The Arduino microcontroller is linked to a water level sensor, which predicts the flow of water, a temperature sensor, which predicts the humidity level, and a water limit sensor, which determines the minimum raise level of water. When there is a changeover in waterflow or humidity level, the sensors connected to the microcontroller analyses the water level, and if there is any abnormal rise in water level, the water level sensor sends its values to the controller, which is then routed to the application (Nandhini N, Lavanya N, Kowshika V).

2.6.3 NodeMCU and Its Role in Flood Warning Systems

NodeMCU is an open-source electronic platform that includes both hardware and software, including Arduino-compatible firmware. MCU, which stands for Microcontroller Unit, is a device that includes one or more CPUs, as well as programmable input and output devices and memory. NodeMCU has a variety of features, including digital and analogue pins, as well as onboard serial communication (Nandhini N, Lavanya N, Kowshika V) .

2.7 Sensors for Flood Monitoring

This section presents an exploration of sensors used for flood monitoring in comprehensive flood warning systems. Sensors are essential for gathering real-time data on environmental characteristics such as water levels, rainfall, and meteorological conditions. They are critical inputs for flood prediction, risk assessment, and prompt action. Understanding the many types of sensors used in flood monitoring systems, their performance, and their importance in getting correct data is critical for establishing efficient flood mitigation techniques.

2.7.1 Water level sensor

Water level sensors monitor, maintain, and measure the liquid levels in a specific area. These sensors are mostly found in the automotive industry and in a variety of household appliances. There are two types of water level sensors: continuous level sensors, which measure the water level continuously, and point level sensors, which measure the water level when it reaches a specific point. Water level sensors have parallel conductivity lines and an electric current path. If there is an increase in flow, this sensor predicts the water level and sends an analogue value converted to a digital amount to Arduino (Nandhini N, Lavanya N, Kowshika V).

2.7.2 Temperature sensor

The temperature sensor measures the temperature and humidity across the surface. It is one of the simplest methods for measuring temperature. Temperature will be converted to voltage by the temperature sensor connected to the Arduino. This sensor's voltage ranges from 2.7V to 5.5V. This sensor is straightforward and does not require any additional components. These sensors are commonly used in fire alarm systems, power system monitors, and CPU thermal management (Nandhini N, Lavanya N, Kowshika V).

2.7.3 Ultrasonic sensor

The ultrasonic sensor serves as the sensor node's input. The ultrasonic sensor, like sonar and radars, emits ultrasonic waves, which are then converted to electrical signals. This sensor operates by sending a high frequency, short duration ultrasonic pulse into the system. Because the sensor is an electronic component, it must avoid direct contact with water, which can cause damage to the component [12].

2.7.4 Flow rate sensor

The bare minimum of connections required for this flow rate sensor in relation to Node MCU. The flow rate sensor only has three wires: the 3V Vcc (Red wire), the GND (Black wire), and the signal/pulse (Usually Yellow) line. Connect the flow meter's Vcc and GND to the node McUsVcc and GND. The signal/pulse wire is connected to any one of the digital inputs of the Node MCU to display the digital output on the serial monitor (Anandhavalli et al., 2018).

2.7.5 DHT11 Temperature and Humidity Sensor

It detects the temperature of the environment. It has four pins. A 10k resistor should be connected between pins 1 and 2. Pin 1 is linked to the 3.3V supply. GND is connected to Pin 4. Pin 2 is an output pin that provides input to nodemcu pin D4. Pin 3 is left unfilled [14].

2.7.6 Raindrop Sensor

It is employed in the detection of rain. It can also be used to determine the amount of rain falling. It provides both digital and analogue output. This module measures moisture using an analogue output pin and provides a digital output when the moisture threshold is exceeded. Lower output voltage means more water or lower resistance. In contrast, the less water there is, the higher the resistance, i.e., the higher the output voltage on the analogue pin. A completely dry board, for example, will cause the module to output five volts. The module's analogue output is connected to the nodemcu's A0 pin [14].

2.7.7 OV7670 VGA camera module

The OV7670 or VGA camera module is a camera that has small size, low operating voltage, use of the OV7670 CMOS image sensor, and availability of all the features found in a single-chip VGA camera. In order to precisely manage picture quality, data format, and transmission method, the VGA image can move at a maximum speed of 30 frames per second. Programmable image processing features including gamma curves, white balance, saturation, and chroma modifications are made possible via the SCCB interface, which is compatible with the I2C serial communication protocol [15].

As a standardized display format, IBM introduced the Video Graphics Array (VGA) in 1987. VGA colour display panels may display up to 16 colours at once and have a resolution of 640 x 480 pixels. They also have a frame rate of 60 Hz. It can show 256 colours by scaling down the resolution to 320 x 200. Utilising a VGA connection, data is sent from the camera module to the FPGA board and displayed on the screen. The value of VGA is in its capacity to speed up the process of moving images from the handheld camera module to the projected image on the screen [16].

2.8 Commonly Used Programming Languages and Tools for IoT System Development

An IoT system may involve several programs in several different languages. In a basic system, one program controls embedded hardware, and another may provide a user interface, data collection/analysis, or both. More commonly, IoT systems are distributed applications leveraging a variety of web services. On the embedded devices, the choice of programming language depends on the choice of hardware. Therefore, knowing which programming languages the hardware supports is critical. A list of programming languages and supported devices follows [17]:

2.8.1 C++/C

C++/C is supported on Arduino-based devices, like actual Arduinos, ESP8266, Particle's Photon and Electron, as well as the Raspberry Pi and platforms supported by ARM's Mbed, including the micro:bit [17].

2.8.2 Block Based languages

Block Based languages which are particularly convenient for novices or for rapid prototyping, are available for some models of Arduino (See ArduBlock , Snap4Arduino, and Microsoft's TouchDevelop) as well as the micro:bit (Microsoft's Block Editor, and Microsoft's Touch Develop) [17].

2.8.3 Node-RED

Node-RED, a graphical data-flow language is also novice friendly. It is supported on both cloud infrastructures, like IBM's Watson and the Raspberry Pi [17].

2.8.4 LUA

LUA a scripting language, is supported by the ESP8266 processors [17].

2.8.5 Python

Python and its embedded-platform equivalent, MicroPython, are supported on several platforms, including the Raspberry Pi, some models of Arduino, and the micro:bit. In addition, Python can be used in many cloud infrastructure components of IoT systems [17].

2.8.6 Java Script

JavaScript is also a common component of both Raspberry Pi-based IoT systems (often via Node.js) and in either the cloud component of systems or as part of the user interface [17].

2.9 Analysis of Previous Flood Warning System Project

Table 1 shows the comparison of previous projects.

Table 1 Comparison of previous projects

NO.	TITLE	COMPONENT	ADVANTAGES	DISADVANTAGE
1	Internet of Things in Flood Warning System: An Overview on the Hardware Implementation [18]	• Raspberry Pi • NodeMCU ESP8266 • Ultrasonic sensors • Water flow	• The use of numerous sensors allows for the collection of a wide variety of flood-related data, including water level, temperature, rain, pressure, humidity, water velocity, and GPS position. • System on chip (SoC) devices like as the Raspberry Pi and NodeMCU ESP8266 offer low-cost, high-performance computing capabilities that	• While ultrasonic sensors are highlighted, the advantages and disadvantages of other sensor alternatives are not adequately addressed, resulting in an insufficient knowledge of their appropriateness. • The statement lacks precise information on data transmission protocols and probable constraints of wireless communication techniques, missing

			are coupled with wireless communication modules, making them ideal for IoT applications.	crucial factors for efficient and reliable data transfer.
2	Automated Alert System for River Water Level and Water Quality Assessment using Telegram Bot API [19]	• Ultrasonic sensor • pH sensor	• Compared to human measurements, the ultrasonic sensor gave more precise measurements of water level height. This demonstrates the sensor's dependability in precisely detecting the water level. • The pH sensor enables quick and exact measurement of various liquids, demonstrating its use in checking water quality.	• The system's demonstration was limited to video demos provided to respondents, which may not properly show the system's performance, usability, and dependability when compared to actual testing and user input. • Because of the COVID-19 pandemic, the prototype system was not thoroughly tested in a real-world setting or with the general population. This limitation prohibits an accurate assessment of the

				system's performance and effectiveness in real-world settings.
3	IoT based Flood Monitoring and Alerting System (Sulaimaan et al., 2023).	• Ultrasonic sensor • Node MCU / Wi-Fi module • SIM800 GSM Module	• The device continually reads sensor information, analyses water levels and flow, and delivers real-time updates. This allows for early warnings and rapid action, possibly saving lives and protecting communities. • The project includes a variety of alerting techniques, including online or internet apps, SMS alerts, and email alerts, to ensure timely warnings to authorities and citizens.	• Does not mention of power management, which is critical for IoT equipment, particularly those in distant or outdoor locations. • Does not mention of any validation or testing performed on the system, making assessing its dependability and performance in real-world settings difficult.

4	water quality monitoring system using iot [21]	• Temperature sensor • Ph sensor • Arduino UNO • Humidity sensor • Buzzer	• Sensors in the hardware offer real-time readings of water parameters. This enables accurate monitoring of water conditions. • The system contains an Android app that can display real-time information and enable remote access to the monitoring system at any time. This provides users with ease and accessibility.	• Although the IoT application is outlined, no detailed information regarding its capabilities or operation is provided. This limits information on the system's capabilities and usage. • The statement does not mention of the system's scalability, such as its capacity to accommodate numerous sensors or extend to cover bigger regions. This could limit the system's use in larger applications.
5	Solar Powered IoT Flood Detector	• Arduino UNO • Node MCU (ESP8266 Wi-	• The system's ultrasonic sensor was able to detect changes in water level and imitate water movement, which is an	• Users can only access the uploaded data in real-time via the LCD screen on the receiver circuit due to a problem with the

	[22]	Fi module) • Ultrasonic sensor • LoRa SX1278 transmitter	important part of flood detection. • The LoRa transceivers were able to connect with one another, effectively transferring the sensor data to the receiving circuit. This signifies that wireless data transfer was accomplished. • The received data is correctly processed by the Arduino Uno microcontroller, and clear measurements are displayed on the LCD display. This enables consumers to quickly obtain and comprehend data.	Blynk application. This reduces data availability and may limit the system's use for remote monitoring or analysis. • The statement cites a flaw in the IoT Blynk application. The server was shut down, causing data readings to be interrupted and limiting access to real-time data. This decreases the system's usefulness and convenience for users who rely on the Blynk application.

6	Flood monitoring and alerting system. [23]	• Ultrasonic sensor • Arduino UNO • Water pump • LCD • Buzzer • LED	• The water pump's purpose is to move water from one location to another. Its manual control function makes it simple to use and alter as needed. • The Arduino UNO, which is based on the ATmega328P microcontroller, is a flexible platform for creating electrical projects. Its wide range of input/output capabilities makes it suitable for a wide range of sensor and robot applications. • Based on the ESP8266 Wi-Fi chip, NodeMCU provides an open-source IoT platform. It allows for the creation of IoT applications by offering connection	• The statement doesn't go into detail on how data from the water level sensor or other sensors is transferred or analysed. This data is important for understanding the system's ability to deliver flood warning and monitoring functions. • The statement highlights the need for a flood warning and monitoring system for cars parked in flash flood-prone locations. The advantages and disadvantages presented may not cover all elements or concerns for additional flood monitoring scenarios or applications.

			and communication capabilities.	
7	An IoT Based Real-Time Environmental Monitoring System Using Arduino and Cloud Service [24]	• Arduino UNO board. • DHT11 sensor. • ESP8266 Wi-Fi module.	• The method presented in the study is affordable, making it accessible to a broader variety of users with limited financial resources. The utilization of low-cost components such as Arduino and the ESP8266 Wi-Fi module helps to reduce total implementation costs. • Sensor integration, wireless connection, cloud storage, and mobile application development are all covered by the system. It offers a comprehensive understanding of how these components might be combined to form a practical	• The DHT11 sensor is used to detect temperature and humidity in the system. While it may be suitable for simple environmental monitoring applications, it may lack the precision or range of readings necessary for more complex or specialized use cases. • For data processing and storage, the system largely relies on cloud storage and the IoT API provider ThingSpeak. This reliance on external services provides a possible point of failure and might cause problems if the cloud infrastructure is

			IoT-based environmental monitoring system.	disrupted or the API service changes.
8	IoT Prototype System of Flood Detection at Housing Pondok Gede [25]	• NodeMCU ESP8266 • Transistors • Flow meter • LED • Buzzer	• The creation of an independent flood warning system based on IoT technology solves the unique issue of flooding in the Pondok Gede Permai residential neighborhood. This technology takes a proactive approach to monitoring water levels and identifying future flooding situations, allowing households to take appropriate actions. • Transistors, flow metre sensors, LEDs, LCDs, and a buzzer are among the	• The study does not go into depth on the data transmission technique used by the NodeMCU ESP8266 or any potential connectivity difficulties that could emerge. These variables can have an important impact on the system's stability and real-time performance, especially in places with temporary or poor network coverage. • The system is given as a prototype in the article, meaning that it does not have significant field testing or has been

			components used in the system. These integrated sensors aid in the precise detection of water levels, the tracking of water flow, and the provision of visual and audible alerts to residents in the event of rising water levels.	deployed on a wider scale. To assure the system's efficacy and adaptation to different flood-prone locations, more validation and scaling considerations will be required.
9	Development a prototype of river water level monitoring system using ESP32 based on internet of things for flood mitigation.	• Ultrasonic sensor • Blynk (software) • Thingspeak (software) • ESP32 microcontroller.	• The creation of a river water level monitoring system utilizing the ESP32 microcontroller and IoT technologies enables the early identification and monitoring of river water levels. This technology allows for preventative flood mitigation measures to be implemented, lowering the severity of flood disasters.	• The study makes no mention of potential connection challenges that might appear when transferring data from the ESP32 microcontroller to platforms such as Blynk and Thingspeak. Unreliable or intermittent communication may impede real-time monitoring and access to water level data, reducing the system's dependability and effectiveness.

	[26]		• The system's use of an ultrasonic sensor enables precise detection of water levels. This kind of precision enables for more exact flood monitoring and evaluation, allowing authorities to make educated judgments and take necessary action.	• The study does not mention the system's scalability. It is critical to evaluate how the system may be scaled up to monitor several rivers or wider regions, as well as the practicality and cost-effectiveness of putting the system in place on a larger scale.
10	Prototype Flood Detection Water Level Monitoring IoT Web Based with Ultrasonic Sensor HC-SR04 [27]	• Ultrasonic sensor HC-SR04 • NodeMCU ESP8266	• The development of an IoT-based flood management system intends to forecast and respond to flood disasters in flood-prone locations. The system provides a unique approach to flood protection and control by merging smart home principles with automation.	• The testing results show that the ultrasonic sensor's accuracy reduces when it is too close to things or when items are present on the water's surface. These limitations could lead to mistakes in water level measurements, threatening the system's dependability and effectiveness in flood management.

			• The system allows for both passive data exchange (notifications) and active information gathering (information requests). This dual communication feature improves the user experience and guarantees that flood-related information is delivered on time.	• The article discusses the issues encountered when creating and integrating the website with the microcontroller using Visual Studio and MySQL. These difficulties may cause delays or problems in obtaining and processing data from the flood control system, affecting its overall performance and user experience.

Table 2.1 show that River real-time flood warning systems offer characteristics that make them useful for preventing flood-related problems. According to the comparison, the most relevant comparative project is the use of low-cost components in an IoT-based real-time environmental monitoring system utilizing Arduino and a cloud service. This technique makes technology more affordable and accessible to a larger variety of consumers with limited financial means. The entire implementation expenses are greatly lowered by using low-cost components such as the Arduino UNO and the ESP8266 Wi-Fi module. The system also integrates sensors, wireless networking, cloud storage, and mobile application development, making it a feasible option for IoT-based environmental monitoring. It is worth mentioning, however, that the DHT11 sensor used for temperature and humidity monitoring may lack the precision or range of values required for more complicated or specialized applications. Furthermore, depending on external cloud storage and IoT API services such as ThingSpeak presents a possible point of   failure as well as reliance on the availability and reliability of those services.

2.10 Summary

The literature review investigates how an IoT, ESP32-CAM, and NodeMCU-based real-time flood warning system for rivers monitoring might be developed. The major goal of the system is to keep an eye on water levels and issue prompt alerts to stop flood damage. By utilizing sound waves and timing computations, ultrasonic sensors are essential for precisely sensing water levels. Data processing and wireless connection are made possible by the Wi-Fi-enabled microcontrollers ESP32-CAM and NodeMCU. Microsoft SQL Server is a suggested IoT platform because of its simple installation process and adaptable user interfaces. The assessment does list the advantages and disadvantages of earlier programs, like precise measurements, robust data processing, and customizable user interfaces.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This section describes the methodology used to develop a real-time flood warning system using IoT and NodeMCU. We describe the steps involved in the system's design, implementation, and testing, including the selection of appropriate sensors, microcontroller configuration, and communication protocol integration. The methodology is founded on a blend of theoretical and practical approaches, drawing on existing literature on IoT and flood warning systems, as well as hands-on experimentation with hardware and software components. The tools and technologies used to implement the system, such as the Arduino Integrated Development Environment (IDE), NodeMCU firmware, and various sensors and communication modules, are also described.

3.2 Flowchart and Block diagram

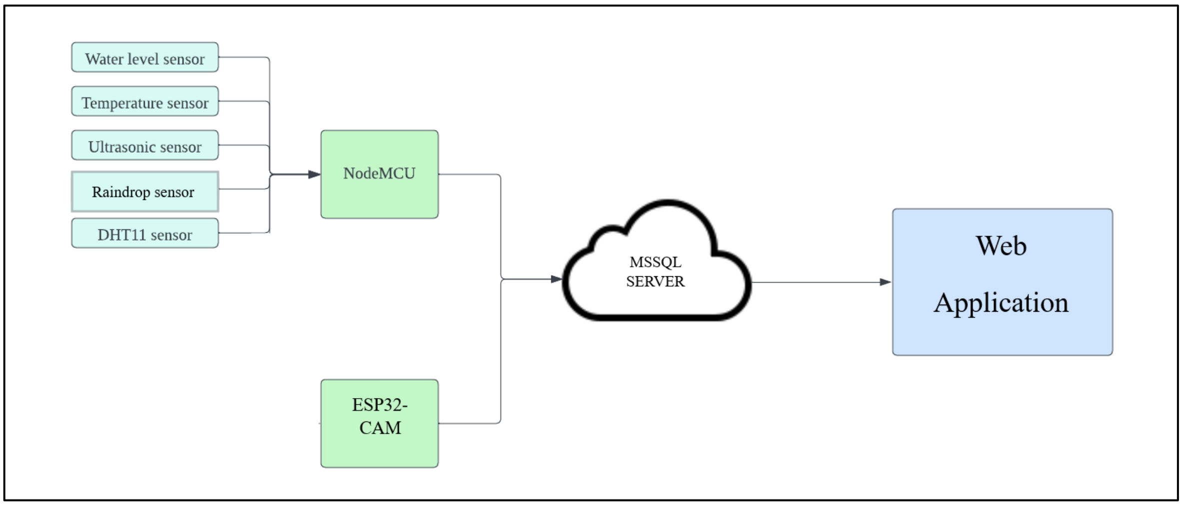


Figure 2: Block Diagram

Figure 2 may display the block diagram for an ESP32-CAM and nodeMCU based system for real-time flood warning system for river monotoring. A NodeMCU microcontroller is shown as being linked to a variety of sensors in the block diagram, including those for water level, ultrasonic, DHT11, and raindrops. As a central hub, the NodeMCU gathers data from all the sensors. Furthermore, an ESP32-CAM is linked to a camera with model number 0V2640. The NodeMCU and ESP32-CAM both submit their gathered data to MSSQL server, a platform that assists in gathering, processing, and displaying the data via a web browser. Additionally, the captured camera photos and sensor data may be posted on the web application. More individuals will be able to get the knowledge immediately and spread it around.

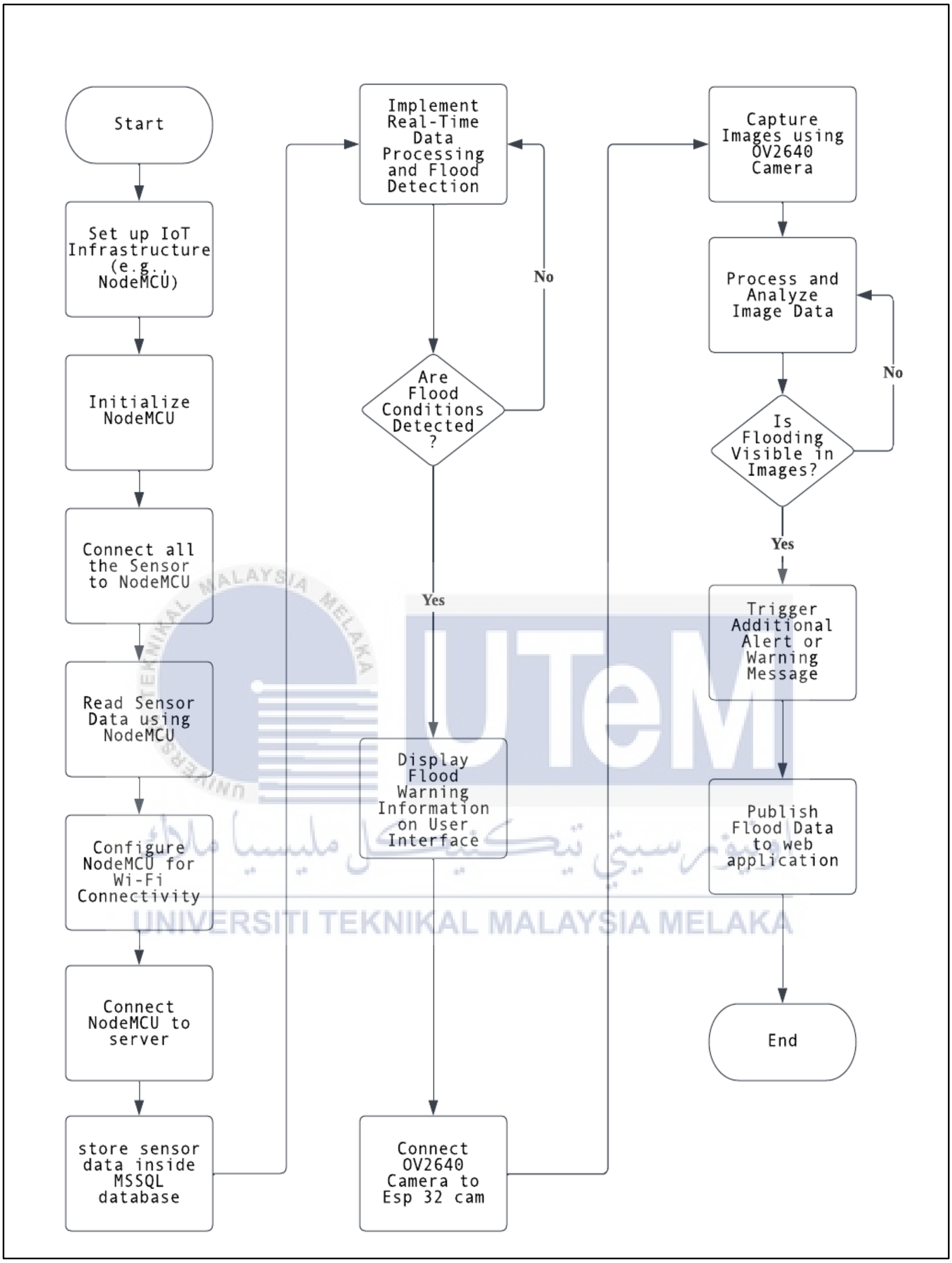


Figure 3: Flow Chart

Figure 3 displays the flow chart of integrating ioT, ESP32-CAM, and nodeMCU for real-time flood warning system for river monitoring. The flowchart shows how IoT, ESP32-CAM, and NodeMCU are used to create a real-time flood warning system. Setting up an IoT infrastructure, such as NodeMCU, to manage the data is the first step in the procedure. The system is launched by initializing the NodeMCU board. Several sensors are directly attached to the NodeMCU board, including the water level sensor, ultrasonic sensor, DHT11 sensor, and raindrop sensor. To gather data regarding flood conditions, the NodeMCU reads data from these sensors. It is set up to use Wi-Fi to connect to the internet. To share the sensor data, the NodeMCU connects to an IoT infrastructure like Microsoft SQL Server. To identify flood conditions, the data is analyzed immediately. When flood conditions are found, an alert or warning message is sent, and all relevant individuals are informed. A "Yes" is displayed on the user interface to denote the existence of a flood. If no flood conditions are found, on the other hand, the system will revert to its implementation of the real-time data processing and flood detection process.

The flowchart includes an OV2640 camera linked to ESP32-CAM in addition to the flood sensors. The camera captures images, which are then processed and examined separately from the NodeMCU. An extra alert or warning message is sent out if the photos show evidence of flooding. Using Microsoft SQL Server, the flood data may also be shared on web application. The system's functioning ended at the flowchart's conclusion.

3.3 Circuit Diagram

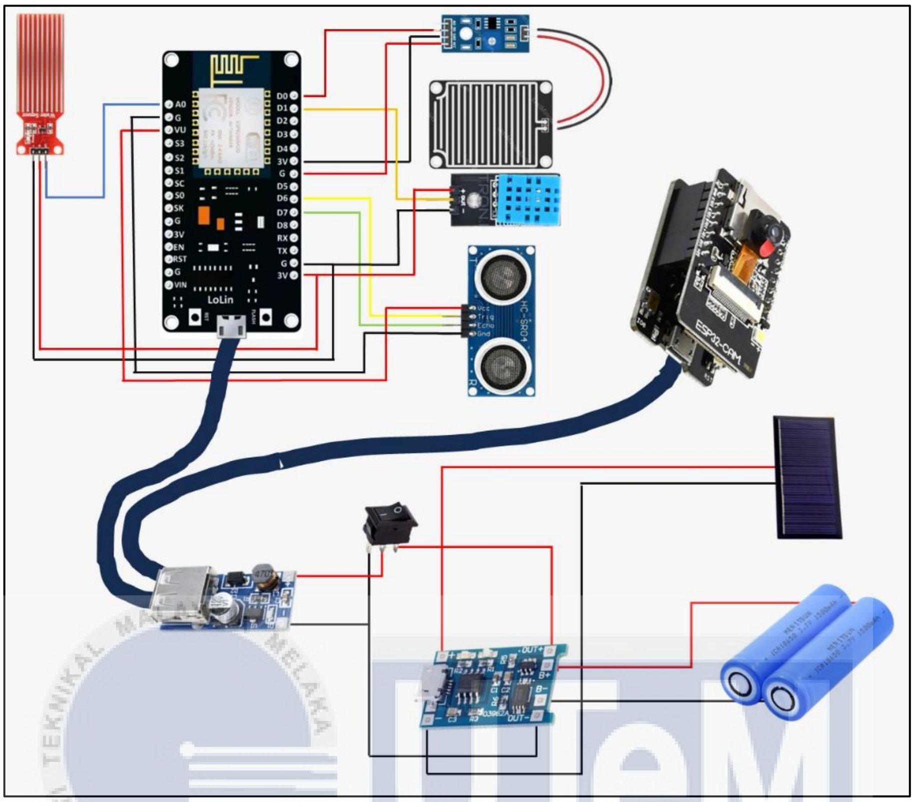


Figure 4: Circuit Diagram

Figure 4 shows how all the components are connected in one circuit. The ultrasonic sensor, rain sensor, DHT11, and water level sensor are all connected to the NodeMCU. The solar panel charges the battery via a charger module. The charger module's output is connected to a USB boost converter via a switch in between. The USB boost converter then powers both the NodeMCU and the ESP-32 Camera. This configuration ensures that everything is correctly connected and receives the necessary electricity.

3.4 Promoting Sustainable Development in IoT Integration for Real-Time Flood Warning Systems and Social Media Connectivity.

Sustainable development may be achieved by integrating IoT, Microsoft SQL Server, and NodeMCU for a real-time flood warning system. A water level sensor, temperature sensor, ultrasonic sensor, flow rate sensor, DHT11 sensor, and raindrop sensor are just a few of the sensors used in this project. There is no need for an Arduino UNO because the sensors link directly to the NodeMCU. The ESP32-CAM is additionally connected to an OV2640 camera. Data is generated by the system and distributed via web application using Microsoft SQL Server.

This sustainable development offers various advantages. For starters, it helps in environmental protection by delivering timely flood warnings, minimizing environmental damage, and reducing pollution. Second, utilizing IoT technology and directly connecting sensors to the NodeMCU, increases resource efficiency by lowering energy use and material waste. Third, by collecting and analyzing data from many sensors, the initiative allows data-driven decision-making, improving flood management methods and resource allocation.

The concept makes it easier for individuals to keep informed about floods and take required steps by integrating website channels like web application with Microsoft SQL Server. It allows real-time communication of flood alerts and updates, helping people and communities in making informed choices to protect themselves. The use of social media encourages collaboration and knowledge exchange among all users, encouraging everyone to take responsibility for properly managing floods.

3.5 Technical specifications of the hardware

To get the intended result, The real-time flood warning system is made up of basic hardware components that interact with one another. The NodeMCU board serves as the primary control unit, connecting wirelessly and managing everything. Water level, ultrasonic, DHT11, and raindrop sensors are among the sensors available. Images are captured with an ESP32-CAM device and an OV2640 camera. Microsoft SQL Server is an Internet of Things (IoT) platform for data management and web applications. This configuration allows for effective and dependable flood monitoring and warning.

3.5.1 ESP32-CAM

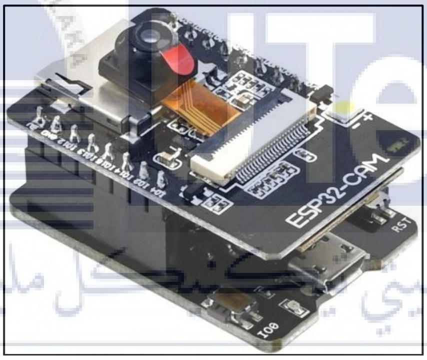


Figure 5: ESP32-CAM

Figure 5 shows the ESP32-CAM, a microcontroller board designed specifically for camera operations. It, like the Arduino UNO, employs pins to connect components like sensors and lights. The ESP32-CAM can operate equipment, collect sensor data, and interact with the actual environment by being programmed with a computer. It is a flexible tool for studying electronics and creating unique products. Notably, it has the OV2640 camera sensor, which provides high-resolution image capabilities of up to 2 megapixels. This makes the ESP32-CAM appropriate for tasks needing vision-based functionality.

3.5.2 ESP8266 Wi-Fi Module

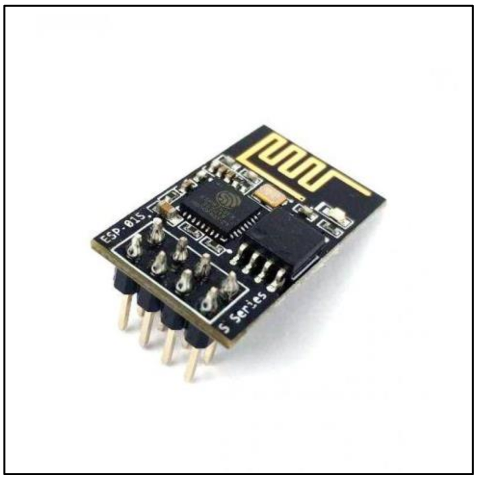


Figure 6: ESP8266 Wi-Fi Module

Figure 6 shows the ESP8266 Wi-Fi Module. The ESP8266 Wi-Fi module is a small and reasonably priced gadget that gives electrical projects Wi-Fi functionality. With its integrated Wi-Fi radio and microprocessor, devices may access the internet wirelessly. It may be programmed in a variety of languages, including Micro Python and Arduino. To connect sensors and operate other devices, it contains pins. For remote monitoring and home automation, Wi-Fi allows it to send and receive data over the Internet. The ESP8266 module is popular since it's simple to use and has a large following among makers. It's an excellent option for incorporating wireless connections into projects without adding a lot of complexity or expense.

3.5.3 Ultrasonic sensor

Figure 7: Ultrasonic sensor

Figure 7 shows the Ultrasonic sensor. An ultrasonic sensor is a tool for measuring distances and detecting things using sound waves. It has a transmitter that emits sound waves and a receiver that detects the echo of those waves as they reflect off of things. The sensor can estimate an object's distance by measuring how long it takes for the sound waves to return. To detect things and measure distances without actually touching them, it is frequently employed in robotics and automation.

3.5.4 Water level sensor

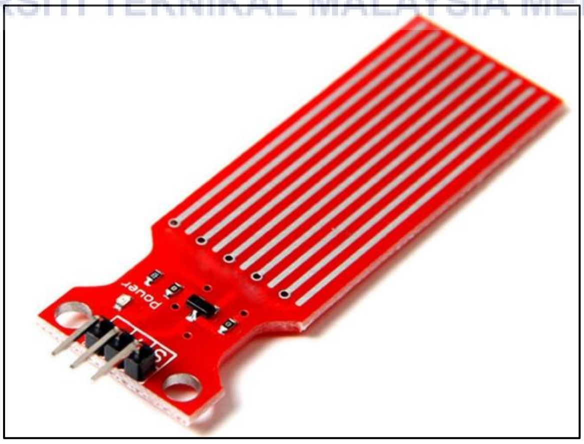


Figure 8: Water level sensor

Figure 8 shows the water level sensor. A water level sensor measures the amount of water in a container or area. The water level is measured using a variety of techniques, including floats and pressure. It helps in monitoring the water levels in reservoirs, wells, and other water systems. The sensor helps with water management and guards against issues like overflowing or running out of water.

3.5.5 DHT11 Temperature and Humidity Sensor

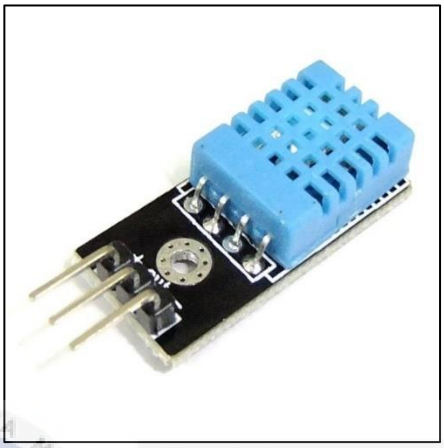


Figure 9: DHT11 Temperature and Humidity Sensor

Figure 9 shows the DHT11 temperature and humidity sensor. The DHT11 sensor is a small and low-cost device that can monitor both temperature and humidity. It is frequently used in projects to monitor and regulate the environment. The sensor is simple to use and delivers reliable temperature and humidity measurements. It's a popular choice for weather monitoring, home automation, and interior climate management.

3.5.6 Raindrop Sensor

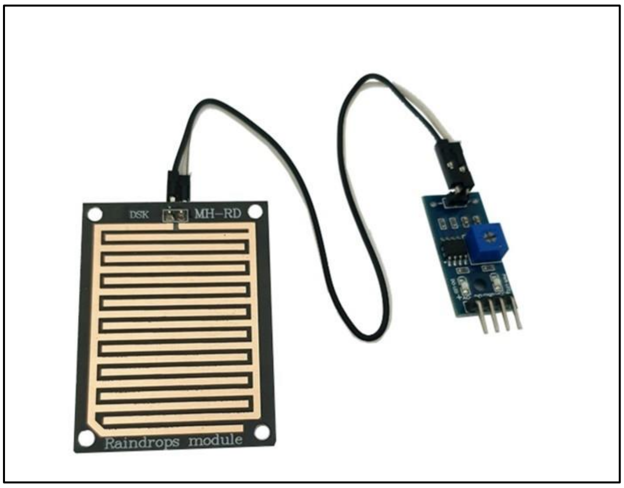


Figure 10: Raindrop Sensor

Figure 10 shows the raindrop sensor. A raindrop sensor detects the presence of raindrops or water droplets. It detects variations in moisture levels. When water droplets come into touch with the sensor, a signal indicating the presence of rain is sent. This data can be used to trigger alerts, control automated systems, or track weather patterns. Raindrop sensors are frequently employed in applications such as weather monitoring, irrigation systems, and automobile rain detection. They give a simple and effective method for detecting rain and responding appropriately.

3.5.7 USB Boost Converter

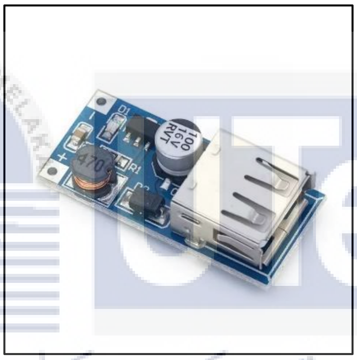


Figure 11: USB Boost Converter

Figure 11 shows the USB Boost Converter. DC-DC 0.9V-5V to 5V 600MA Charger Step-Up Boost Converter Supply Voltage Module is the USB Boost Converter. This small module efficiently converts voltages ranging from 0.9V to 5V into a steady 5V output with a charging capability of 600mA. It's simple to connect to microcontrollers or development boards, making it useful for a wide range of applications. This module is commonly used in projects that require a simple and cost-effective solution for raising voltage levels, which is notably useful for powering USB-enabled devices. It is critical in projects involving power management and portable electronics.

3.5.8 Mini Solar panel

Figure 12: Mini Solar panel

Figure 12 shows the mini solar panel. A mini solar panel is a small device that converts sunlight into electricity. It's small, light, and simple to set up. These panels are commonly used to power tiny electrical gadgets or as a portable energy source for outdoor activities. They are meant to catch sunlight and transform it into usable electrical energy. Mini solar panels are a simple and eco-friendly solution to harvest solar electricity in a small package.

3.5.9 Charger Module (TP4056)

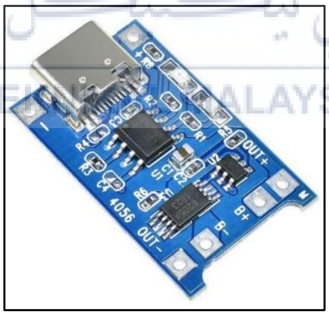


Figure 13: Charger Module (TP4056)

Figure 13 shows the charger module (TP4056). The Charger Module (TP4056) is a tiny circuit board that is used to charge lithium-ion or lithium-polymer batteries. It features built-in protection against overcharging and short circuits, assuring the module's and the battery's safety. The TP4056 module is widely utilized in mobile devices such as smartphones and tablets to provide a dependable and efficient charging solution.

3.5.10 Lithium Battery (18650)

Figure 14: Lithium Battery (18650)

Figure 14 shows the Lithium Battery (18650). The Lithium Battery (18650) is a well-known rechargeable battery that is noted for its small size, high energy density, and versatility in products like laptops, power tools, and portable gadgets. It produces consistent power, has a long lifespan, and runs at 3.6-3.7 volts. However, owing to possible risks, it must be handled with caution. Overall, it is a popular and dependable battery alternative.

3.5.11 Toggle Switches

Figure 15: Toggle Switches

Figure 15 shows the Toggle Switches or know as Boat Toggle Switches SPDT 3 Positions on Off on Rocker Switch. With three positions: On, Off, and On, this switch is frequently used for regulating electrical circuits. It has a traditional rocker style and can handle AC 125V/12A and 250V/10A. The black color lends a sleek appeal, making it appropriate for a variety of situations. While simple to use, care should be taken during installation to ensure appropriate performance.

3.6 Project implementation

Begin with configuring the hardware components for the real-time flood warning system. Connect the NodeMCU board's water level sensor, ultrasonic sensor, DHT11 sensor, and raindrop sensor to the proper pins. Using a charger module such as the TP4056, ensure a reliable power supply for the NodeMCU board. Include a tiny solar panel as well to give a green energy source for the system.

After that, configure the system's software. Install the libraries and tools needed to programme the NodeMCU board. Write the code to initialize the sensors, read data from them, and connect to the Microsoft SQL Server platform over Wi-Fi. Develop decision logic based on sensor data to evaluate flood conditions and initiate relevant responses. The Microsoft SQL Server can be configured to communicate sensor data and provide real-time flood alerts. To communicate flood warning information, integrate web application with Microsoft SQL Server.

After the software is configured, proceed on to testing and calibration. Start the system and check that the NodeMCU board has successfully established a Wi-Fi connection. Check the sensor values for accuracy and dependability. Simulate various flood situations to validate the decision logic and ensure that the system takes the appropriate measures. Validate data transfer to Microsoft SQL Server and ensure that real-time flood alerts are created and distributed via web application.

Connect the OV2640 camera module to the ESP32-CAM board to integrate it. Use the camera module to write programs to capture photographs or video. Create communication protocols to send visual data to the web application for processing or storage. Deploy the system at the specified area once testing and calibration are completed. For accurate readings, ensure that the sensors are properly positioned. Monitor the system's performance on a regular basis and guarantee a reliable Wi-Fi connection. Perform routine maintenance, such as cleaning the sensors and inspecting them for physical damage or connection concerns.

3.7 Software configuration

This section explains the software setup required for the development of a real-time environmental monitoring system utilizing Arduino IDE and a cloud service. The significance of software configuration in assuring the flawless integration and operation of system components such as sensor data collecting, wireless connection, cloud storage, and data visualization is critical. Understanding software configuration features is critical for setting up and optimizing system performance, allowing for proper data gathering, analysis, and accessibility. The next section goes into the software set-up stages and concerns involved in putting this IoT-based environmental monitoring system in place.

3.7.1 Arduino IDE

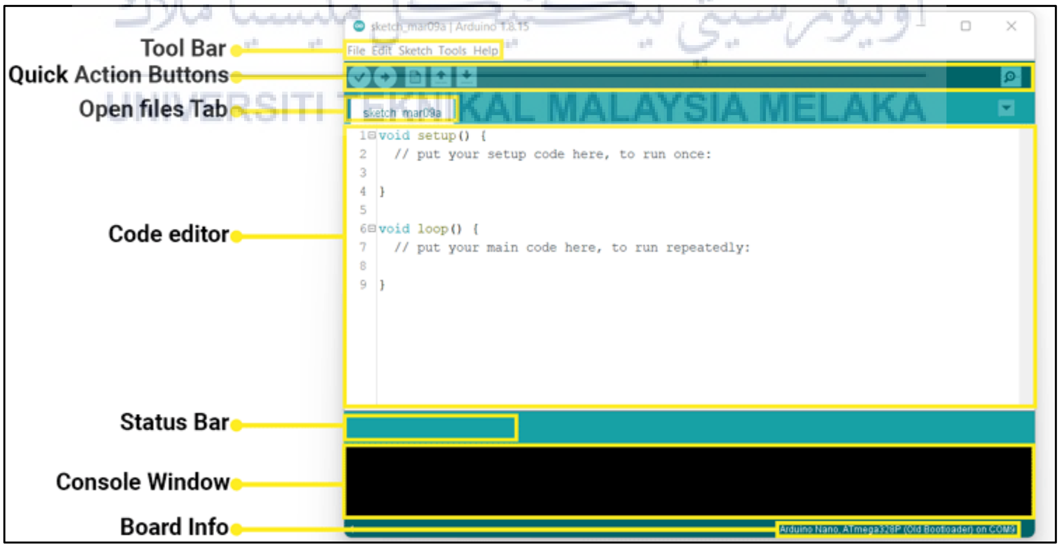


Figure 16: Arduino IDE program

Figure 16 show tha arduino IDE program. The Arduino IDE (Integrated Development Environment) is a programming software tool for Arduino boards. It has a user-friendly interface that makes authoring, building, and uploading code to the Arduino microcontroller easier. The Arduino IDE works with a variety of operating systems, including Windows, macOS, and Linux.

Users are able to generate code in the Arduino programming language, which is based on C and C++, using the Arduino IDE. The IDE includes a code editor with features like syntax highlighting, auto-completion, and code recommendations to make writing and editing code simpler. Once the code has been written, the user can compile it within the IDE. The compiler examines the code for faults and transforms it into Arduino-readable instructions. If any issues occur, the IDE shows error warnings to assist the user in identifying and correcting them.

After successful compilation, use a USB connection to upload the produced code to the Arduino board. The IDE manages the connection between the PC and the board, allowing users to simply upload and run their code on the Arduino. Furthermore, the Arduino IDE includes a Serial observation tool that allows users to interface with the Arduino board and observe the output created by the code themselves. It shows data from the board sent over the Serial connection interface, which is useful for troubleshooting and testing.

3.7.2 Microsoft SQL Server

Figure 17: Microsoft SQL Server

Figure 17 show the Microsoft SQL Server, a powerful and adaptable database management system. SQL Server is a comprehensive solution for applications that require organized and accessible data. It is designed for effective data storage, retrieval, and administration. Its integration capabilities span many computer languages, guaranteeing usability and scalability from small projects to huge companies.

SQL Server provides safe and transactional processing, with a focus on data integrity. SQL Server Management Studio (SSMS) simplifies database administration operations by allowing users to write queries, define schemas, and manage security settings all in one place.

SQL Server interfaces with Microsoft services and tools, allowing the development of complete solutions, including cloud-based applications via Azure services. In summary, Microsoft SQL Server emerges as a robust, dependable, and adaptable database management system with broad data processing and analysis capabilities in a wide range of applications.

3.7.3 Bootstrap Studio

Figure 18: Bootstrap Studio

Figure 18 shows the Bootstrap Studio logo, which is a user-friendly web design platform. It uses a drag-and-drop interface to simplify the process of developing responsive and visually appealing websites, making web design accessible to users of all skill levels. Bootstrap Studio is an extension of the Bootstrap framework that allows for quick customization of components and layouts without requiring considerable code. The real-time preview tool allows users to see their ideas as they are being built. The program also allows for collaboration and outputs clean HTML, CSS, and JavaScript code for connectivity with different web browsers. In conclusion, Bootstrap Studio is a useful tool for simplifying web design and making it efficient and accessible to designers of various levels of competence.

3.7.4 Microsoft Visual Studio

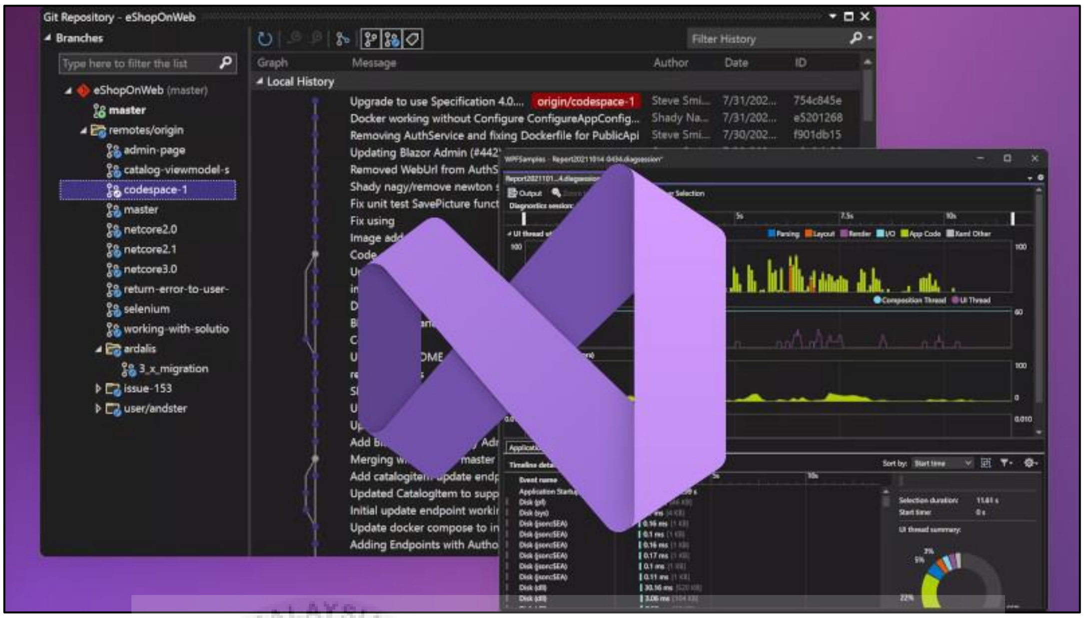


Figure 19: Microsoft Visual Studio

Figure 19 shows the Microsoft Visual Studio. Microsoft Visual Studio is an advanced integrated development environment (IDE) for software development. It is user-friendly and appropriate for developers of all skill levels. The platform provides a variety of tools and features to make application creation easier. Its straightforward interface, drag-and-drop capability, and built-in templates make it easier to create a variety of software applications. Visual Studio supports a variety of programming languages, including C#, C++, and Python, making it adaptable. It supports real-time debugging, testing, and collaboration functions. The resulting code is clean and optimised for interoperability with various operating systems and devices. To summarise, Microsoft Visual Studio is a useful and easily accessible software development tool.

3.8 Casing

Figure 20: Casing part

Figure 21: Finished looks

All the components are placed in a casing. This casing was first designed using a wood case and Polyplast PP Corrugated Board. Each part is then attached using a hot glue gun. As the device will be placed outdoors, the material is made of plastic because it does not rust, is waterproof and easy to work with. As in the Figure below, there are 6 parts which are the top, bottom, left, right, rear, front, and the supporting piece. Only the cylinder part is not designed. The supporting piece will be attached on the top part to act as a base for the solar panel and the rain sensor. These two components will be placed in an angle to prevent rainwater from accumulating on the surface and disrupt the function. The cylinder part is used as the stilling well.

3.9 System structure

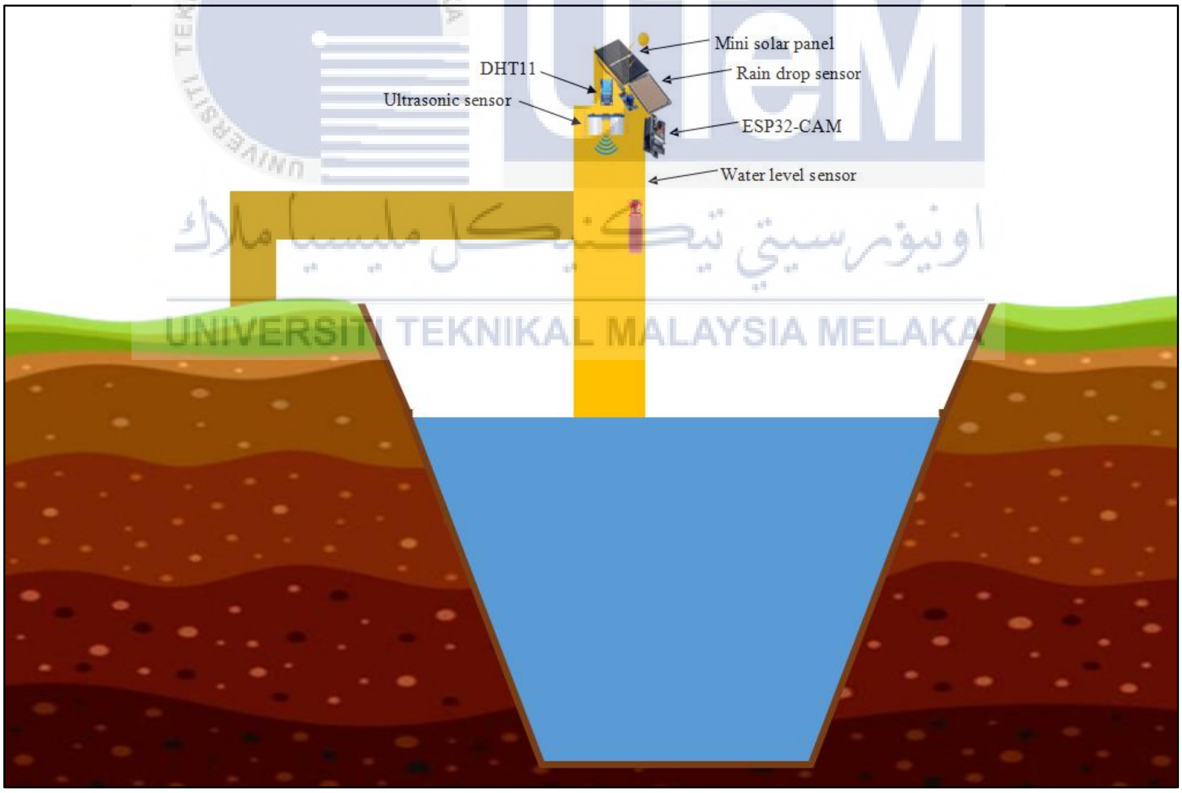


Figure 22: Planned structure

This system is planned to be placed at the river with DHT11 and raindrop sensors installed outside to immediately track the weather. An ESP32 camera is also installed to provide real-time visual monitoring of the surroundings. An ultrasonic sensor and a water level sensor are contained in a cylindrical construction to provide exact water level readings, similar to the function of a stilling well. This arrangement not only stabilizes the water surface, improving measurement accuracy, but it also serves as a protective barrier against debris that may interfere with sensor data. This integrated sensor network gives comprehensive data on the riverside environment, allowing for more informed decision-making and resource management. This method is reference from a research of Fondriest environmental learning center [28].

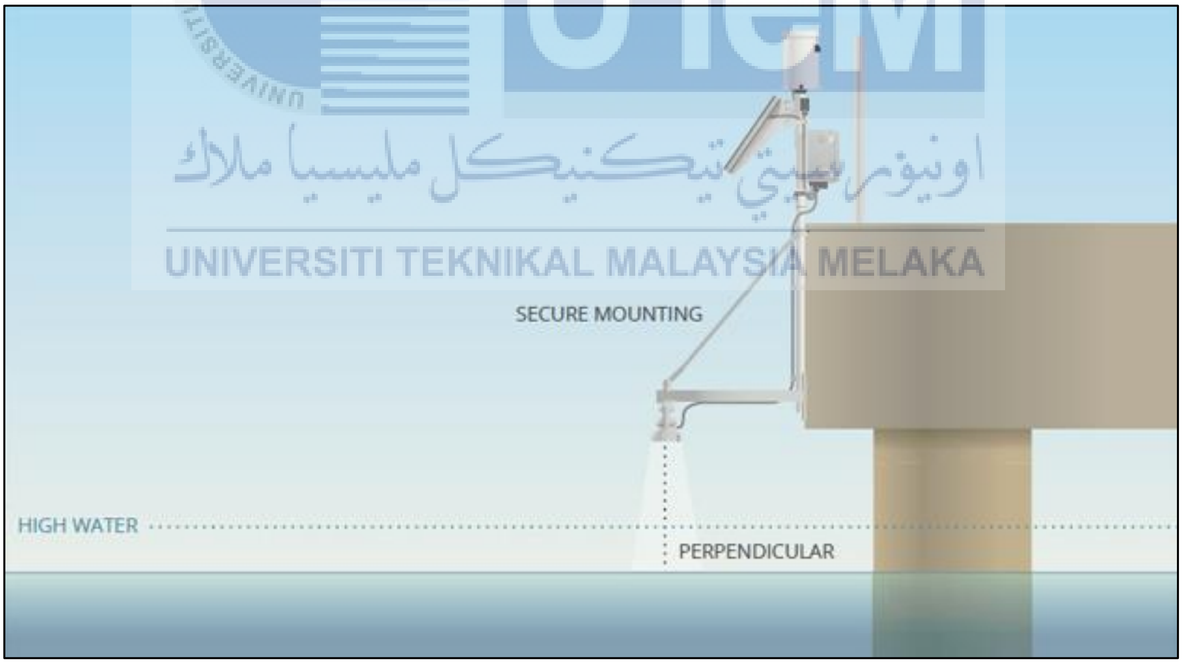


Figure 23: Reference structure

3.10 Limitation of proposed methodology

This project aims to develop a prototype to demonstrate the system's functionality on a small scale using IoT concepts. However, the proposed components may not be suitable for longterm measurement. The limitations are as follows:

- **DHT 11 Temperature and Humidity sensor:** While the DHT11 sensor is competent in measuring ambient temperature and humidity, it may have limits in harsh environments. It may not be ideal for applications requiring accurate temperature and humidity measurements, and further calibration may be necessary for maximum accuracy.
- **Water level sensor:** The water level sensor used in this prototype may have difficulty correctly monitoring water levels in turbulent or fast-moving rivers. Debris, sedimentation, or uneven riverbeds might all have an impact on the sensor's function, perhaps resulting in inaccurate water level measurements.
- **ESP32-CAM module:** The ESP32-CAM module, while providing a low-cost solution for image capturing in the prototype, may have limitations in real-world settings. Power consumption, picture quality, and limited onboard storage may be issues that must be solved in order to provide more thorough and prolonged monitoring in real applications.
- **Ultrasonic sensor (HC-SR04):** The chosen ultrasonic sensor model, the HC-SR04, has a detection range of 4-5 metres. In real life, this means that the project may not work properly in rivers with water levels beyond this threshold. Furthermore, the diameter of the stilling well may interfere with the detection range since the wave generated by the ultrasonic sensor might strike and detect the well's wall.

- **Wi-Fi module as data transmitter:** The use of a Wi-Fi module for data transmission requires proximity to a Wi-Fi network. This constraint is a barrier in a real river setting, as Wi-Fi units normally work across short distances. As a result, for extensive river monitoring, different communication technologies with long-range capability may be considered.
- **Rain sensor:** The rain sensor's sensitivity may make it difficult to correctly distinguish between light and heavy rain. Its inability to accurately detect the intensity of rain, even when little volumes of water hit the sensor, restricts its capacity to provide thorough and dependable rainfall data.

3.11 Summary

In conclusion, the Real-Time Flood Warning System for the River Project Using IoT and NodeMCU may be successfully constructed by verifying all hardware and software components are correctly linked and satisfy the essential criteria. Any possible faults or difficulties identified during the project will be rectified to ensure that the project objectives are met. The data gathering and analysis techniques for the system will be explained in Chapter 4, offering an understanding of the process.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

The findings and outcomes of Integrating IoT and NodeMCU for a Real-Time Flood Warning System for Rivers monitoring will be presented and discussed in this section. This chapter summarizes the project's decisive findings and analysis. Consistent measurements confirm the accuracy of the results, and the sensor data is carefully compared to real-world measurements to validate.

4.2 Final product design

Explore the final product design of the Real-Time Flood Warning System, which combines components such as NodeMCU, sensors, a power source, and a camera to monitor and respond to floods in real time. Combining these aspects results in a powerful and responsive solution capable of quickly addressing flood detection issues. The addition of a camera enhances its capabilities, increasing the accuracy and efficiency of flood monitoring. Overall, this final product design represents a meaningful step forward in employing technology to protect communities from flooding.

Figure 24: Final product diagram

Figure 24 shows the comprehensive final product diagram for the Real-Time Flood Warning System. It shows all of the components operating together, such as the NodeMCU, sensors, and power supply. It even installed a camera to improve its flood detection capabilities. Looking at this figure helps show how the system monitors flooding and responds promptly.

4.3 Performance testing setup

For the results, the project wasn't done in a real river setting. It was tested in a controlled environment to make sure the system works. The thought is, if it works in a small test, it should work in a river too.

Figure 25: Project Prototype Setup

Figure 25 shows the built-up scene to resemble a river. The bucket represents the river, and the sensor monitors the situation as we pour water into it. This allows us to gather vital information to determine how well the system will perform in a real river.

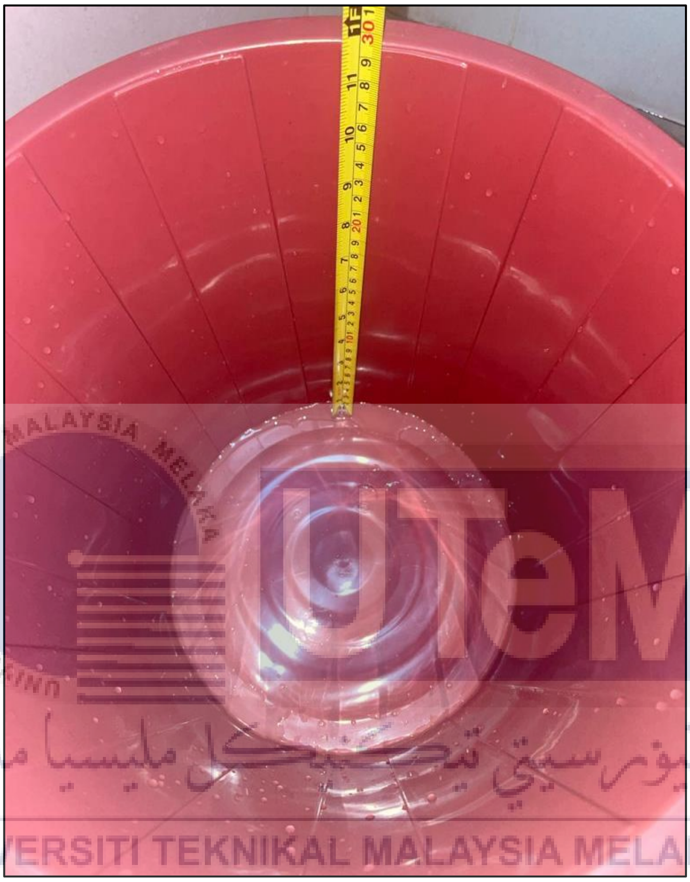


Figure 26: Measuring Method

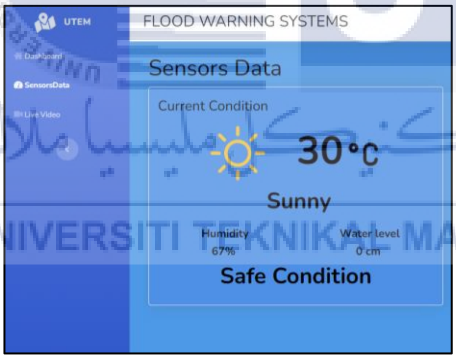
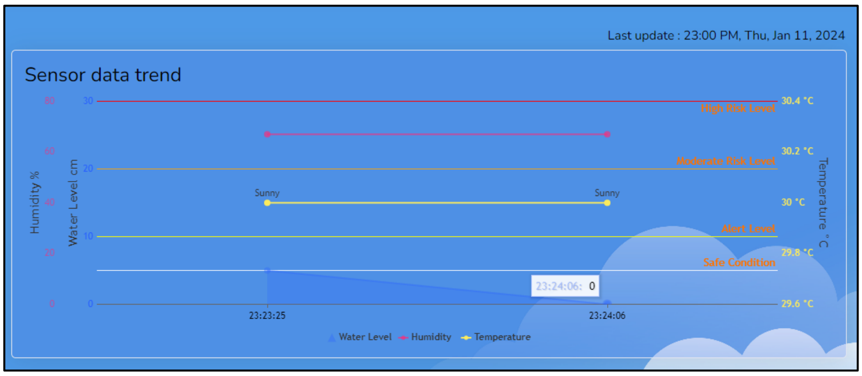
Figure 26 shows the sensor's measurement will be measured on a measuring tape. In this configuration, the bucket is built to hold exactly 30cm of water before reaching its maximum and spilling. This information serves as a standard for determining the accuracy of sensor readings.

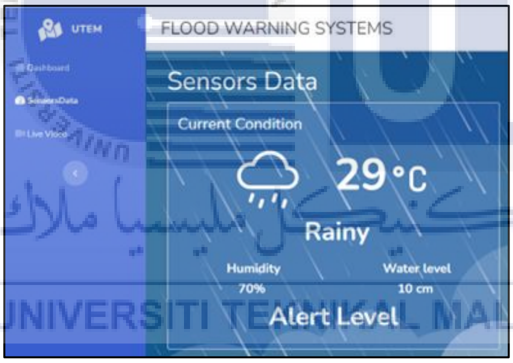
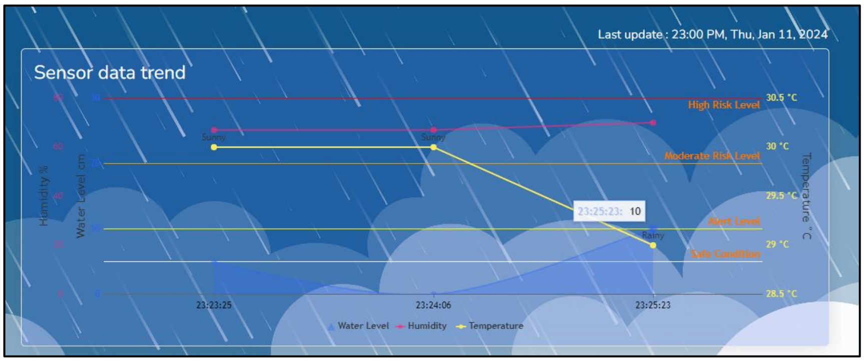
4.4 Results and Analysis

This part focuses on understanding the operation of the project's sensors, which are critical components of our real-time flood warning system. Data was gathered methodically using various devices such as ultrasonic, DHT11, water level, rain sensor, and ESP32-CAM. The following study seeks to reveal the information gained from these sensors and deliver insight into their coordinated operation. This analysis, similar to detectives revealing an equation, entails examining the evidence found by the sensors to determine the system's capability in detecting and responding to flood situations.

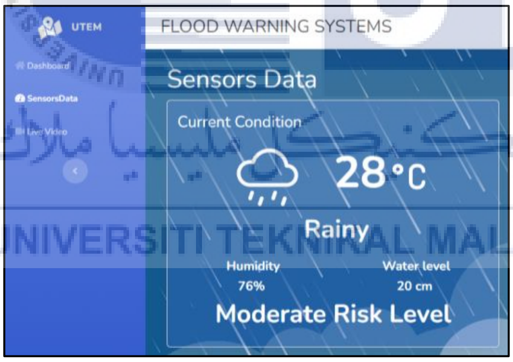
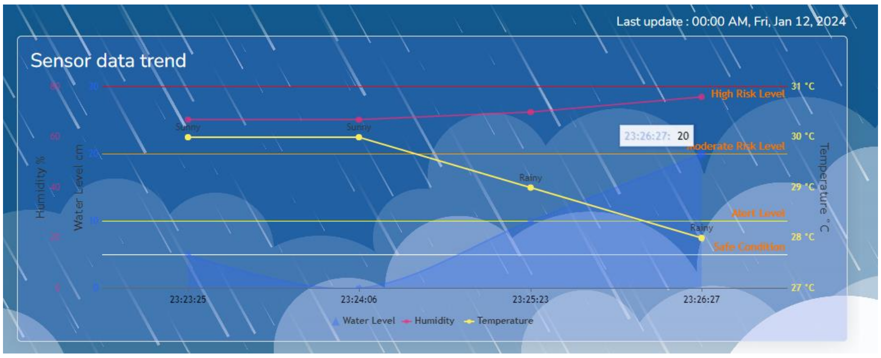
4.4.1 Sensor Measuring (Ultrasonic, DHT11, and Water Level)

Table 2: Sensor measuring result

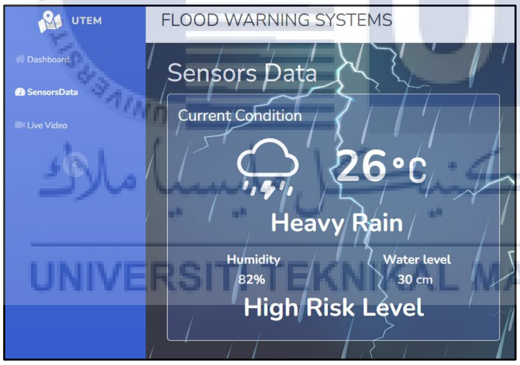
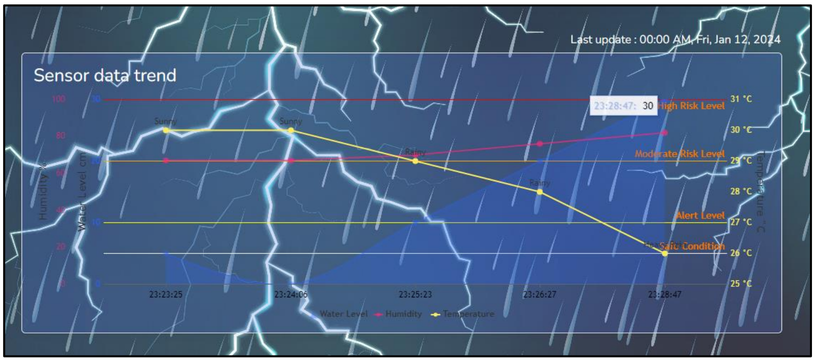
Result (Measuring 0 cm water level)	Details
  	Web application display (microsoft visual studio)- ➢ Ultrasonic sensor reading: 0 cm ➢ DHT 11 sensor reading: Temperature = 30°C Humidity = 67% ➢ Water level = safe condition

	No water inside the bucket
Result (Measuring 10 cm water level)	Details
 	Web application display (microsoft visual studio)- ➢ Ultrasonic sensor reading: 10 cm ➢ DHT 11 sensor reading: Temperature = 29°C Humidity = 70% ➢ Water level = Alert level

	Water level – 10 cm of water in the bucket

Result (Measuring 20 cm water level)	Details
 	Web application display (microsoft visual studio)- ➢ Ultrasonic sensor reading: 20 cm ➢ DHT 11 sensor reading: Temperature = 28°C Humidity = 76% ➢ Water level = Moderate Risk Level

	Water level – 20 cm of water in the bucket

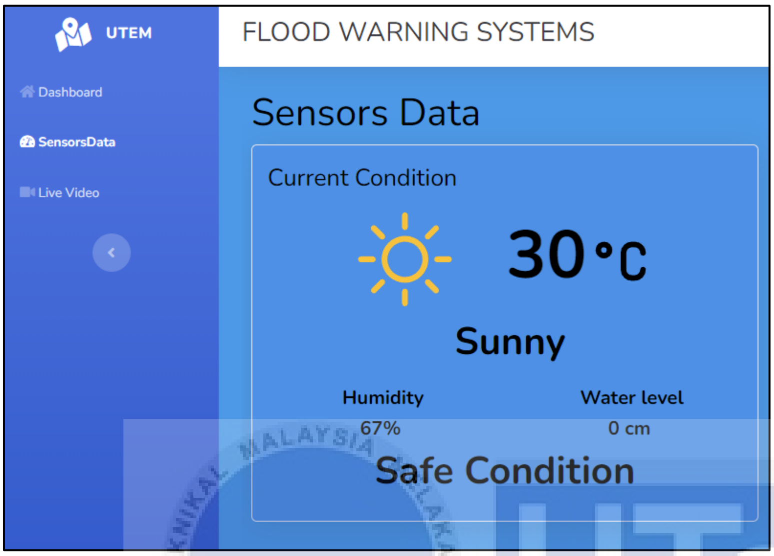
Result (Measuring 30 cm water level)	Details
 	Web application display (microsoft visual studio)- ➢ Ultrasonic sensor reading: 30 cm ➢ DHT 11 sensor reading: Temperature = 26°C Humidity = 82% ➢ Water level = High Risk Level

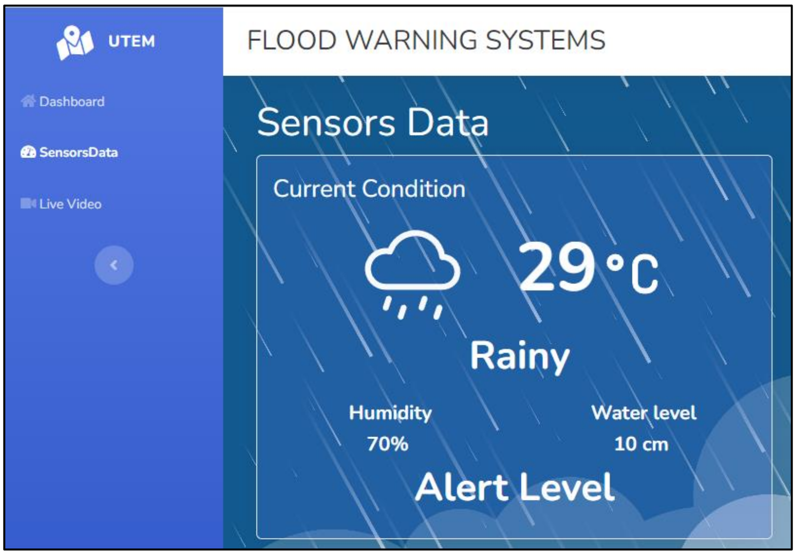
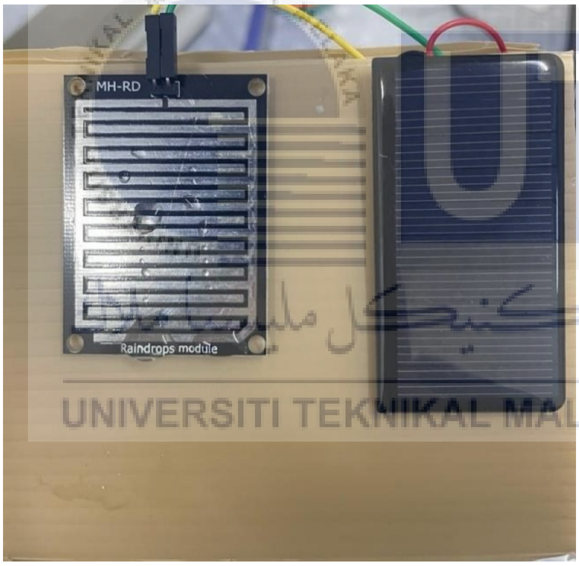
	Water level – 30 cm of water in the bucket

Table 2 summarize the sensor measurements for various water levels in the real-time flood warning system. At a water level of 0 cm, there is no water in the bucket, and the measurements reveal a temperature of 30°C and humidity of 67%. As the water level rises to 10 cm, the ultrasonic sensor reads 10 cm, and the DHT 11 sensor registers a temperature of 29°C and humidity of 70%, resulting in an alert. The ultrasonic sensor detects 20 cm of water, and the DHT 11 sensor registers a temperature of 28°C and humidity of 76%, indicating a moderate risk level. When the water level exceeds 30 cm, the ultrasonic sensor reads 30 cm, while the DHT 11 sensor shows a temperature of 26°C and humidity of 82%, indicating a high risk level. This data, provided in the web application built with Microsoft Visual Studio, is critical for evaluating various flood risk scenarios.

4.4.2 Rain sensor

Table 3: Rain sensor result

Result (Detecting no water droplets)	Details
	Web application display (microsoft visual studio)- ➢ Rain drop sensor reading: Sunny
	Sensor condition – No water on the rain sensor surface

Result (Detecting 2-3 water droplets)	Details
	Web application display (microsoft visual studio)- ➢ Rain drop sensor reading: Rainy
	Sensor condition – 2-3 droplets of water are poured on the rain sensor surface

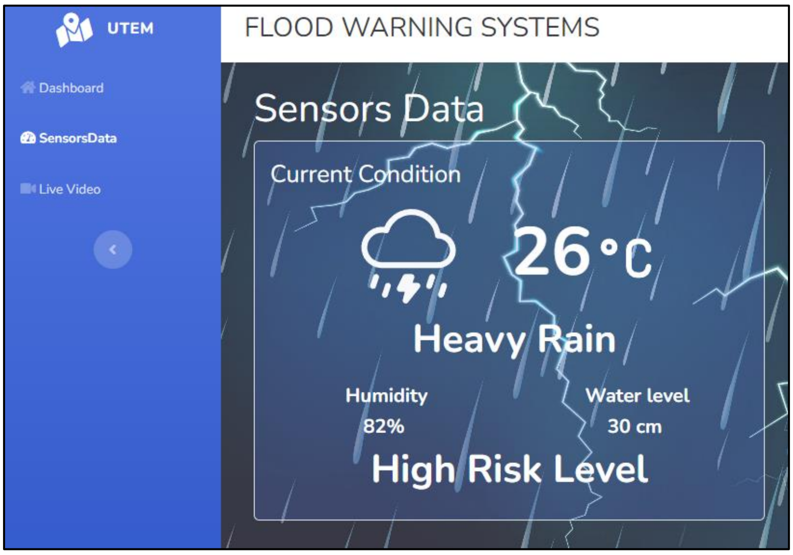
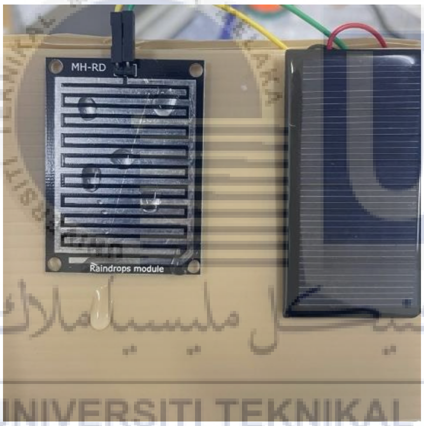
Result (Detecting more than 5 water droplets)	Details
	Web application display (microsoft visual studio)- ➢ Rain drop sensor reading: Heavy rain
	Sensor condition – more than 5 droplets of water is poured on the rain sensor surface

Table 3 summarises the results of the rain sensor in the real-time flood warning system. When no water droplets are detected, the web application, written with Microsoft Visual Studio, presents a sunny state with the raindrop sensor reading showing no water on the sensor's surface. In the case of detecting 2-3 water droplets, the programme displays a rainy state, and the sensor reading indicates the existence of 2-3 droplets on the sensor. When more than 5 water droplets are detected, the web application shows heavy rain, with the raindrop sensor reading indicating the presence of more than 5 droplets on the sensor surface. This data, as provided via the web application, is critical for interpreting and categorising rainfall intensity levels in the monitored region.

4.4.3 ESP32-CAM

Table 4: ESP32-CAM result

Result (facing infront)	Details
	Web application display (microsoft visual studio)- ➢ ESP32-CAM link website: http://192.168.0.7
	ESP32-CAM condition – Facing infront view

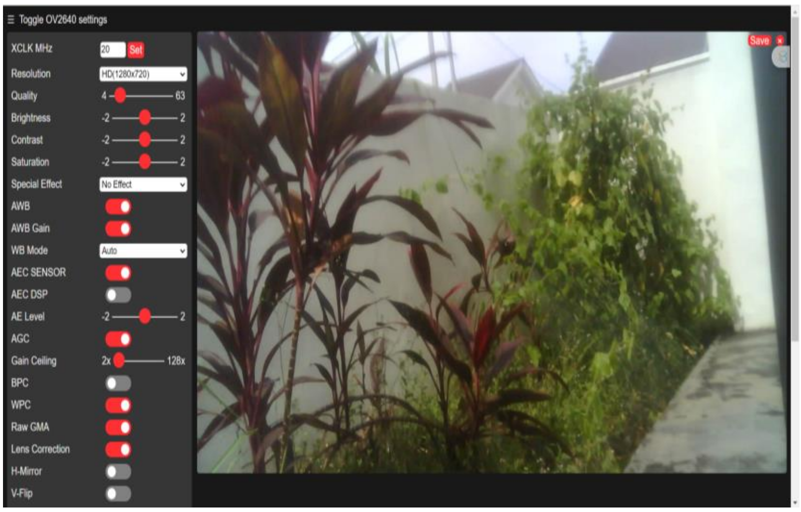
Result (facing the side)	Details
	Web application display (microsoft visual studio)- ➢ ESP32-CAM link website: http://192.168.0.7
	ESP32-CAM condition – Facing side view

Table 4 shows the findings of the ESP32-CAM in our flood warning system. When the ESP32-CAM is facing forward, the web application written with Microsoft Visual Studio shows a link to the URL http://192.168.0.7, indicating that the ESP32-CAM is in the front view. Similarly, when the ESP32-CAM is facing the side, the web application displays the same link, and the ESP32-CAM is identified as facing the side view. This information, which can be accessed via the given connection, aids in real-time monitoring and confirmation of the orientation of the ESP32-CAM camera, making it an invaluable tool for visual inspection in the flood warning system.

4.4.4 Data storage

The MSSQL securely stores all information acquired in its cloud database. It can archive data since the channel's creation. The data collected from various sensors is saved in a user-friendly .mdf format, allowing for easy visualization and retrieval using MSSQL.

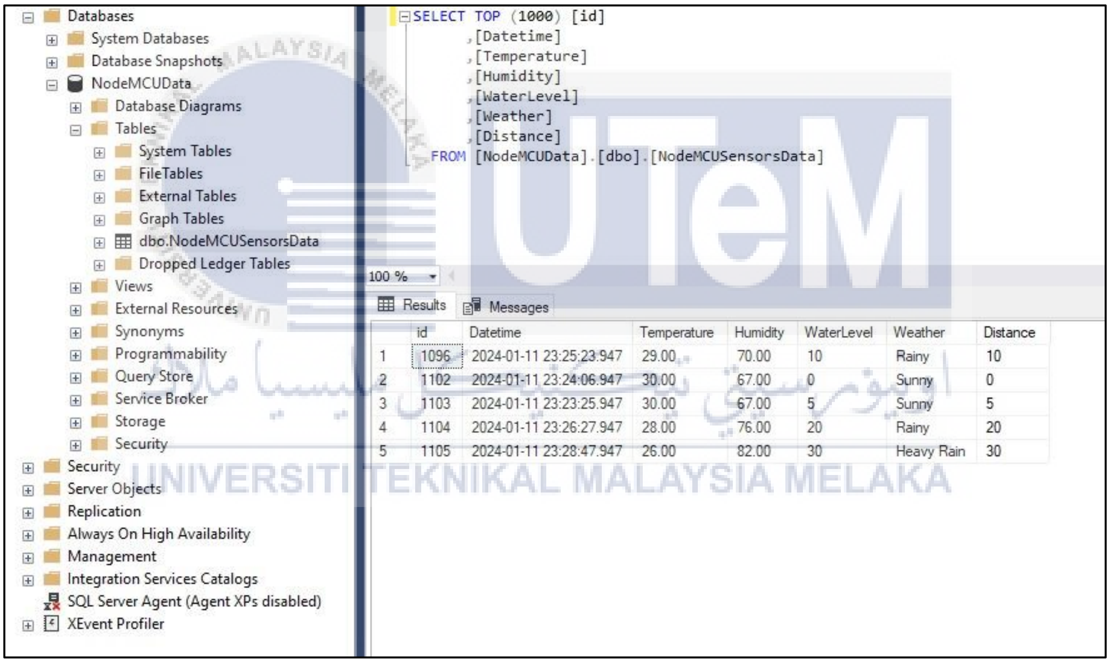


Figure 27: Data stored in cloud

Based on the figure above, the data can be seen received in a 10-second interval. This is because all data is received at the same time. Data from each sensor are stored every 10 seconds for analysis.

4.5 Discussion

The integration of IoT and NodeMCU in the creation of a real-time flood warning system for rivers monitoring has various benefits. It allows for accurate and fast flood alerts, is cost-effective, and collects complete data. Because of the system's low cost, it is accessible to a wide spectrum of consumers. However, sensor limitations and backup techniques should be considered to assure reliability and performance in real-world circumstances. This method has the potential to improve flood monitoring and responses to emergencies in general.

4.6 Summary

The result shows that an ultrasonic sensor, water level sensor, rain drop sensor and a DHT11 sensor were successfully integrated with the ESP8266 Wi-Fi module. These sensors were attached to certain pins on the ESP8266, allowing distance, weather, water level, temperature, and humidity to be measured. The goal of the integration was to create a complete data-gathering system for environmental monitoring and automation was successful. This accomplishment establishes the groundwork for future growth and integration within the IoT ecosystem, allowing for remote monitoring and data-driven decision-making processes.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In conclusion the Integrating IoT and NodeMCU for Real-Time Flood Warning System for river monotoring was configured, tested, and deployed successfully. For accurate measurements, the hardware components, including the NodeMCU board, sensors, and power supply, were connected and calibrated. The software was designed to gather sensor data, connect to Wi-Fi, and communicate with MSSQL and web application sites. Testing validated the system's dependability, sensor accuracy, and decision-making effectiveness. The addition of a camera module increased the system's capability. Once in place, the system proved its capacity to monitor floods, provide timely alarms, and give important flood control information. Overall, this system has a lot of promises for flood monitoring and response.

Finally, the real-time flood warning system effectively integrated hardware and software components to provide a dependable and efficient solution. Accurate sensor readings, data transfer to MSSQL and connectivity with web application platforms allow for timely flood notifications and significant flood management insights. The introduction of this technology demonstrates its potential for improving flood monitoring and emergency response activities.

5.2 Future Works

A few improvements and upgrades can be made in the future to overcome the limitations of this project. Component improvements are required for the project to function properly. Also below are suggestions for future improvements to this project:

- Integrate artificial intelligence algorithms to increase adaptive learning and flood alert generating.
- Allow system administrators to access and administer the flood warning system from anywhere by enabling remote monitoring and control capabilities. This feature can help with remote diagnostics, troubleshooting, and upgrades in order to increase system performance and efficiency.
- Include additional sensors, such as soil moisture sensors, wind speed sensors, or barometric pressure sensors, to collect more extensive environmental data. This extended sensor network can give a more comprehensive picture of flood conditions.

5.3 Project potential

The successful development and deployment of the Real-Time Flood Warning System, which includes precise hardware integration, comprehensive software design, and enhanced flood monitoring capabilities, not only addresses critical community needs but also demonstrates promising commercialization potential in industries that require dependable, efficient, and innovative solutions for river monitoring and emergency response.

- **IoT Integration for River Monitoring:** The Real-Time Flood Warning System's successful design, testing, and deployment prove the commercial potential for river monitoring projects.

- **Accurate Measurements and Calibration:** The hardware components, including the NodeMCU board, sensors, and power supply, were successfully connected and calibrated for exact measurements. This dependability satisfies the demand for accurate information in a variety of applications.

- **Testing and Validation:** thorough testing demonstrated the system's reliability, sensor accuracy, and decision-making capability. This dependability is an important consideration for possible commercialization in areas where accuracy is essential.

- **Enhanced Capability with Camera Module:** The addition of a camera module dramatically expanded the system's capability, allowing for visual monitoring and assessment. This feature expands the system's usefulness in situations when visual data is important.

- **Community demand for enhanced Flood control:** The introduction of this technology addresses a critical community demand for enhanced flood control solutions. Its practical application in improving flood monitoring capacities is consistent with the growing desire for novel techniques to address climate-related concerns.

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APPENDICES A

GANTT CHART

BDP 1 Gantt chart

Task name	Stard date	End date	Progress	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK 8	WEEK 9	WEEK 10	WEEK 11	WEEK 12	WEEK 13	WEEK 14
PROJECT TITLE SELECTION	22/3/2023	28/3/2023	**100%**														
PROJECT RESEARCH (JOURNAL/ARTICLE)	29/4/2023	4/4/2023	**50%**														
STUDY ABOUT COMPONENT & BLOCK DIAGRAM	5/4/2023	12/4/2023	**70%**														
SELECTION OF COMPONENT	13/4/2023	21/4/2023	**80%**														
REPORT WRITING: CHAPTER 1 AND DRAFT REPORT FOR CHAPTER 2 & 3	22/4/2023	3/5/2023	**70%**														
SUBMITTING PROGRESS 1 (WEEK 6)	4/5/2023	9/5/2023	**100%**														
MAKE A CORRECTIONS FOR CHAPTER 1, 2, AND 3	10/5/2023	16/5/2023	**50%**														
ADD MORE LECTURER REVIEW ON CHAPTER 2	17/5/2023	23/5/2023	**50%**														
MEETING WITH SUPERVISOR FOR APPROVAL FOR CHAPTER 1, 2, AND 3	24/5/2023	30/5/2023	**60%**														
MAKE A FLOW CHART AND BLOCK DIAGRAM FOR CHAPTER 3	31/5/2023	7/6/2023	**100%**														
DO A CORRECTIONS AND ADDING INFORMATION IN CHAPTER 2 AND 3	8/6/2023	15/6/2023	**80%**														
SUBMITTING PROGRESS 2 (WEEK 12)	16/6/2023	22/6/2023	**100%**														
PRESENTATION PSM 1 AND SUBMISSION REPORT PSM 1	23/6/2023	25/6/2023	**100%**														

BDP 2 Gantt chart

Task name	Stard date	End date	Progress	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK 8	WEEK 9	WEEK 10	WEEK 11	WEEK 12	WEEK 13	WEEK 14
MEETING AND BRIEFING ABOUT BDP 2	22/3/2023	28/3/2023	**100%**														
MAKING WEBSITE USING BOOTSTRAP	29/4/2023	4/4/2023	**40%**														
CONTINUE PSM 2 BY MAKING WEBSITE USING BOOTSTRAP	5/4/2023	12/4/2023	**70%**														
ENHANCING AND REFINING FINAL YEAR PROJECT WITH SUPERVISOR GUIDANCE	13/4/2023	21/4/2023	**80%**														
SOURCING COMPONENTS FOR A CUTTING-EDGE FINAL YEAR PROJECT	22/4/2023	3/5/2023	**70%**														
ACCOMPLISHED CONNECTIONS AND READINGS WITH NODEMCU ESP8266	4/5/2023	9/5/2023	**100%**														
HARDWARE AND CODING SETUP	22/11/2023	21/11/2023	**50%**														
WINDOWS TERMINAL INTEGRATION	29/11/2023	30/11/2023	**50%**														
MSSQL DATABASE CONFIGURATION.	6/12/2023	19/12/2023	**60%**														
MVC WEB DEVELOPMENT COMPLETION	20/12/2023	26/12/2023	**100%**														
SYSTEM TESTING AND VALIDATION	27/12/2023	3/1/2024	**80%**														
FINALIZATION AND CONCLUSION	4/1/2024	13/1/2024	**100%**														
PRESENTATION PSM 2 AND SUBMISSION REPORT PSM 2	14/1/2024	17/1/2024	**100%**														