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Smart Flood Alerting System using Embedded Systems

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Abstract — One natural disaster that commonly brings about tremendous economic loss as well as lots of casualties is flooding. For purposes of mitigation, an IoT-based flood monitoring and warning system has been devised. The system relies on the utilization of an Arduino UNO, an LCD display, a buzzer, and a water level sensor. The system aims at monitoring water levels on a constant basis and provides real-time alert to an online server, and also provide flood warnings via SMS to approved phones. When a certain level is sensed by the water level sensor, an SMS warning is notified to approved mobile devices. Real-time visual indication of water levels on the LCD display is also present in the system and activates a buzzer for local immediate notifications. The water level is also transmitted to a cloud server where it can store remotely and accessed to enable further analysis and decision-making. Instant communication is facilitated by IoT technology that allows disaster management personnel and emergency services in order to be able to respond quickly and take protective measures prior to the flood reaches its critical points. timely warning and information which help in minimizing loss and damage and local and remote user alerts, the system provides an economical and efficient solution for flood sensing. Through the use of Arduino, IoT, a buzzer, and an LCD display, the project greatly improves flood response and readiness functionality.

Keywords: Arduino uno, automated flood water level sensor, GSM module, SMS, Wi-Fi module, early warning system**,** LCD screen**,** Buzzer.

1.Introduction

Flooding is one of the most devastating natural calamities, causing widespread destruction and disruption to people, property, and the economy globally. A number of factors, such as excessive rainfall, snowmelt, the storm surges, and river overflow, can result in flooding [1]. Rainfall that is excessive can overwhelm drainage systems and cause surface runoff that floods low-lying areas and urban communities. Rapid springtime snowmelt can cause rivers to overflow by raising water levels. Rivers can flood when sustained rainfall upstream raises water levels above the riverbanks, and coastal areas are especially susceptible to storm surges caused by hurricanes or tropical storms [2].
To minimize the impacts of floods so that the emergency teams can take preventive measures before the situation goes beyond control, early identification and detection is essential. Methods of flood detection till date are not real-time in nature [3]. Here, an Internet of Things based flood detection and alarm system which uses a water level sensor, a SIM module, a Wi-Fi module, an LCD display and a buzzer is proposed in order to address the problem. It consists of continuously monitoring of water level and sending the alerts to mobile using SMS and updates the server [4] using Wi-Fi module. This also gives buzzer and local alerts and shows the water level on LCD panel. The water level information is sent to a cloud server through the Wi-Fi module in this system. Remote access allows for additional actions and evaluations [5]. The system is a low-cost scalable solution, which minimizes the harm to the people, minimizes reaction time, and ultimately saves lives through continuous monitoring using the sensors and real time data transfers to the users [6].

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2. Literature Review

In the past, numerous studies of flood detection methods have been carried out, frequently as a component of technical reports and research publications that covered different geographic areas.

Ankesh Suresh Patil et al [7] used Arduino to create a flood monitoring system. Water float sensors, an Arduino Uno, buzzer, liquid crystal display, GSM module, LED, and ultrasonic sensor were some of the hardware tools used. Based on float sensors and ultrasonic sensors, the system detected the water levels on highways. An Arduino processed and put the data on the LCD screen. The individuals were alerted through SMS using the GSM module in case of flooding until the water levels became normal. Owing to their limited measurement range and possible errors, the ZP2058 float switch sensor and ultrasonic sensor used for measuring the water level had some limitations

Muhammad Ahmad Baballe et al [8] made comparative analysis of flood detection systems using an Arduino Uno, an ultrasonic sensor, a GSM module, an LCD, and a buzzer. The microcontroller prompted the GSM module to send SMS alerts to affected area authorities and residents as soon as the water level crossed the level set by the ultrasonic sensor. Using an ultrasonic sensor with a short distance and not accurate for the measurement of the water level was another drawback of the study.

Vijaya Lakshmi et al [9] used an Arduino Uno, an ultrasonic sensor, a float sensor, a flow sensor, and a humidity sensor in the development of an Internet of Things-based early flood warning and alarm system. These sensors were paired with an Arduino Uno to predict flood events. IoT notified the authorities and surrounding villages through a Wi-Fi module in case of a possible flood. Since the application of the ultrasonic sensor to detect water level was stated as the cause of the limitation because of the limited range of measurement and sensitivity to errors because of obstructions, its application was restricted.

In East Africa, Ange Josiane Uwayisenga et al [10] developed an Internet of Things-based early floodwater warning and detection system. The system consisted of an ultrasonic sensor, Arduino Uno microcontroller, GSM module, LCD, buzzer, and DHT22 temperature and humidity sensor. Temperature and humidity were sensed by the DHT22 sensor, and the water surface distance was sensed by the ultrasonic sensor. An alarm was given by the buzzer to the community surrounding flood-prone communities, and the data was interpreted by the microcontroller and SMS messages were sent to local authorities. The use of an ultrasonic sensor to sense water level was limited due to limited range and vulnerability to give false readings in the case of an obstruction.

Jasmin Maurya et al [11] has designed a flood prevention system by IoT based on the devices like Arduino Uno micro controller, Wi-Fi module, DHT11 temperature and humidity sensor, water flow sensor, ultrasonic sensor, LCD. Here the water level was sensed by the ultrasonic sensor, temperature and humidity by DHT11 sensor. Water flow was sensed by the water flow sensor. System data was displayed by the LCD, and Wi-Fi module assisted in IoT connectivity. Due to restricted measurement range and susceptibility to temperature-related errors, the ultrasonic sensor for measuring water levels has been found to have specific limitations.

Minakshi Roy et al [12] developed a flood detection and water monitoring system based on IoT, utilizing Arduino components such as Wemos D1 R1, ultrasonic sensor, flow sensor, DHT11, float sensor, and liquid crystal display. The ultrasonic sensor gauged water height, the flow sensor measured flow rate, and the DHT11 sensor monitored temperature and humidity. The float sensor functioned as a switch that transmitted data to the Arduino Wemos D1 R1, which in turn activated SMS notifications to an Android app. The use of ultrasonic and float sensors for measuring water levels was linked to certain limitations, particularly the float sensor's inaccuracy in indicating the height of the water level.

Wan Hassan et al. [13] created a water level monitoring system that serves as a flood indicator. Water levels were assessed by a float switch sensor, which relayed information to the Arduino Uno. This microcontroller managed the GSM module to dispatch SMS notifications to both authorities and the general public. The constraint was the water measurement instrument, ZP2508 float switch

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sensors, which could only detect rising water levels without accurately measuring height.

J. G. Natividad and J.M. Mendez et al [14] have developed a flood monitoring and early warning system using an ultrasonic sensor, GSM module, and Arduino microcontroller. The ultrasonic sensor gauged the water distance, and upon surpassing the predetermined threshold, the microcontroller activated the GSM module to dispatch warning notifications to response agencies. The limitation was the application of the ultrasonic sensor for gauging water levels, as it had a limited measurement range and was affected by temperature fluctuations.

3.Contribution

In this paper, we have designed a new flood warning system for the improvement of the monitoring and response processes of flooding in order to minimize the disastrous impacts of flooding by providing timely warnings to the people and the concerned authorities. The system functions at different levels of flooding to trigger corresponding responses: at the first level, the buzzer starts beeping for a local warning; at the second level, the motor is stopped, representing a critical warning to be dealt with on a priority basis; and at the third level, the water levels are indicated on an LCD screen to be viewed in real-time. Additionally, it applies the systems of the internet of things, by which flood information can be indicated on a web page for remote monitoring. The presence of microprocessor Arduino, GSM modem, and pressure sensor to monitor the overall system. The level of water in terms of Pascals is determined by the Arduino after measuring the height of the water through pressure. The approach offers an effective real- time flood solution of monitoring, alert, and response action in flood-prone areas.

4.Proposed System

The aim of the proposed flood detection and alerting system is to avoid or lessen the damages caused by floods by offering timely notifications and monitoring the water level in real-time. For implementing an efficient scalable solution, the system uses different hardware components, including Arduino UNO, the liquid crystal display (LCD) display, the buzzer, the GSM modem, the Wi-Fi modem, and the water level detecting sensor.

4.1. System Architecture Hardware components:

- Lcd Display
- Buzzer
- Arduino UNO
- Wi-Fi Module
- GSM Module
- Water Level Sensor

Software components:

- embedded C
- Arduino uno

4.1.1 LCD Display

Fig. 1: LCD display

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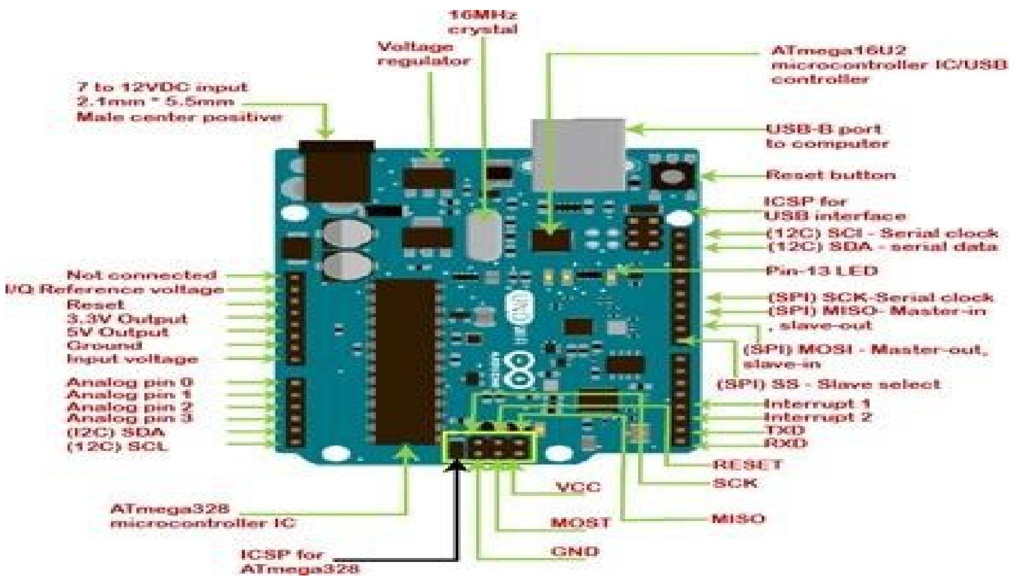
The central monitoring unit for the entire system is the Arduino, as shown (Fig. 7). The LCD (Fig. 1) (Liquid Crystal Display) is an essential component of the Smart Flood Alerting System. This display is connected to the Arduino pins. The LCD functions by manipulating light using liquid crystals; when voltage is applied, it changes the alignment of the crystals, allowing light to either pass through or be blocked, which results in visible text and images being displayed. The Arduino receives data from the water level sensor and, based on this information, sends commands to the LCD module to display the current water levels.

4.1.2 Buzzer

Fig. 2: Buzzer

The principle behind a buzzer (Fig. 2). involves converting electrical energy into audible sound. When an electric current passes through the buzzer, it makes a diaphragm or metal disc inside vibrate, producing sound. There are two primary types of buzzers: active and passive. Active buzzers generate sound automatically when powered, while passive buzzers need an external control signal to create sound. In this setup, the Arduino Uno is linked to the buzzer. When the water level hits a predetermined threshold (Level 3), the Arduino sends a signal to turn on the buzzer. A sensor monitors the water level, and if it goes beyond the predetermined water level threshold (for instance, 90% full), the Arduino activates the buzzer to warn that the area is at risk. The buzzer will sound continuously until the water level recedes to alert the user that immediate action is required, ensuring a prompt response.

4.1.3. Arduino UNO:



Arduino Uno (Fig. 3) [2] is among the most popular microcontroller boards worldwide, built around the ATmega328P microcontroller. The platform is open-source and has found wide acceptance in robotics, embedded systems, the Internet of Things (IoT), and automation industries based on its simplicity, low cost, and ease of use.

Fig. 3: Arduino UNO

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Arduino Uno is an open-source microcontroller board employing the ATmega328P. It has 14 Digital I/O pins, 6 Analog Input Pins, and can be powered either by an external 9-volt battery or USB. It is the first board in a line of USB-based Arduino boards, that also consist of Arduino Nano and Leonardo. The ATmega328 microcontroller on the board is pre-loaded with a bootloader, which makes it easy to upload the code to the board without the need of additional hardware programmer. The Arduino IDE software supports Windows, MAC, and Linux PCs, though Windows is the most popular operating system. The IDE uses programming languages such as C and C++. Arduino Uno can also be powered using Micro SD cards for extra data storage, apart from being powered through a USB cable or adapter. When powered through an external device, the board's on-board built-in voltage regulator maintains the voltage constant. It works by reading sensor inputs, processing them, and then performing actions like controlling outputs like lights, motors, or displays. In a smart flood alarm system, the Arduino Uno reads data from water level sensors to monitor the water level and control various components like an LCD display, buzzer, Wi-Fi module, and GSM module.

In this configuration, the LCD displays real-time water level, providing real-time data. When the water level is increasing, the Arduino keeps on checking the sensor readings. At Level 3 (the danger level), the buzzer goes off automatically, signaling a danger zone. The Wi-Fi module sends water level information to a remote server for remote monitoring. Also, at each of the water level thresholds (levels 0 through 3), the GSM module sends SMS alerts to inform users of the situation. In addition, when the critical water level, the GSM module places an emergency call to a registered cell number, so the risk of flood will be known immediately.

4.1.4. Wi-Fi Module:

Fig. 4: Wi-Fi Module

The ESP8266 Wi-Fi module (Fig. 4) is a low-cost Wi-Fi chip with an onboard TCP/IP stack, which equips microcontrollers such as Arduino to access the internet over a wireless network. It sends and receives data across a wireless network through the use of the Wi-Fi protocol. The module is programmable, and can support a local wireless connection. This allows it to transmit data to an external server or receive instructions from the internet.
Smart flood alert system's ESP8266 module is the factor that provides the connection of the system to the internet. The water level data from the sensor, which Arduino receives, will be sent to a remote server by ESP8266 by HTTP requests or other protocols. This data will be stored and analyzed by the server and the server will give real-time monitoring and alerts. With this configuration, the system can upload water level data continuously or at set intervals, which allows users to view water levels with the web interface or app from a remote location when they are not at the location where the system is. Also, the system can be remotely accessed and continuously log data, in which ESP8266 can perform the additional functionality.

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4.1.5. GSM Module

Fig. 5: GSM Module

An instrument that uses the aid of a cellular network for making and receiving calls and text messages is called a GSM (Fig. 5) (Global System for Mobile Communications) module. The GSM module is very important in alerting the users of the flood rise in the smart flood alerting system. Water level sensors, a microcontroller (e.g., an Arduino or Raspberry Pi), and a GSM module (e.g., the SIM800L or SIM900) constitute the system. The microcontroller receives data from the sensors when the water level rises, and the GSM module is subsequently triggered to deliver alert messages. SMS alerts are delivered to households and authorities at Levels 1 and 2. In order to guarantee that prompt action is done, the system not only sends an SMS but also automatically makes a call when the flood exceeds Level 3, which indicates a serious scenario. The GSM module is linked to the microcontroller using UART (TX and RX) for serial communication, along with power (VCC, GND).This automated notification system boosts flood preparedness and helps limit damage by ensuring prompt responses.

4.1.6 Water Level Sensor

Fig. 6: Water Level Sensor

A water level floating sensor operates on the principle of buoyancy, where a floating device rises or falls with the water level. As the float moves, it triggers switches or sensors to detect the position. These movements are often converted into electrical signals. The sensor can be mechanical, with a rod or lever, or magnetic, using a Hall effect sensor to detect the position of a magnetic float.

In a smart flood alerting system with four levels, the sensor monitors the water at predefined thresholds:

Level 1: Safe, normal water level.

Level 2: Moderate rise, monitoring alert. Level 3: High water level, warning issued.

Level 4: Dangerously high, immediate action needed.

This system helps prevent flooding by providing real-time alerts and warnings, allowing early intervention. It can integrate with IoT devices for remote monitoring and control.

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4.2. Hardware Model:

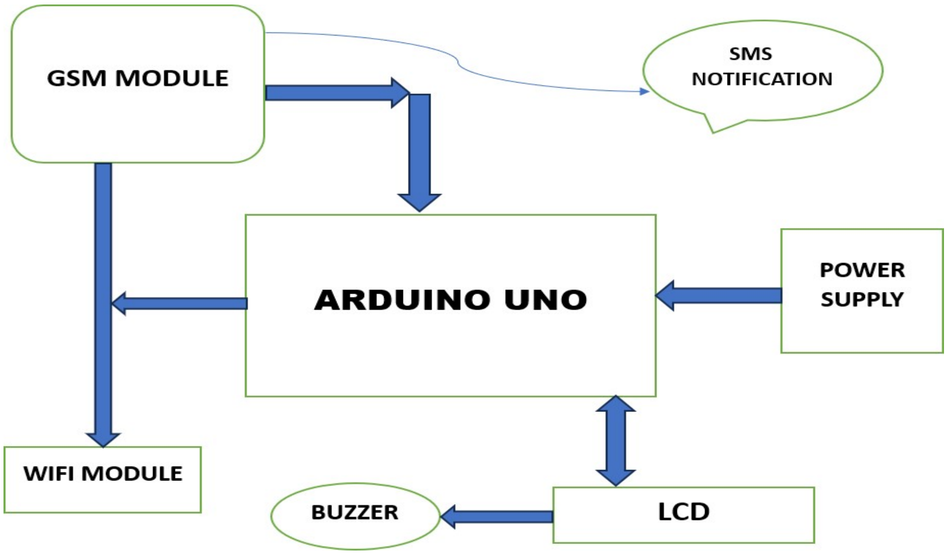

Fig. 7: Hardware connections

The Smart Flood Alerting System's hardware Architecture is shown(Fig. 7).The Smart Flood Alerting System's hardware implementation is shown(Fig. 8). To monitor the water levels in this configuration, the Arduino UNO is connected to the Water Level Sensor. The Arduino and ESP32 Wi-Fi module interface to post data to the cloud, and the SIM800L module is linked to send SMS alerts when the water level rises above the predetermined level. Furthermore, an LCD display is utilized to display real-time water level readings, and a buzzer is attached to the Arduino to offer an audio indication. For reliable operation, a 5V DC power supply powers every component.

Fig. 8: Hardware setup

4.2.1 Working

Intelligent Flood Alarm System is the system that automatically track the level of water in real time by sending alerts through a number of communication modes. The system consists of the Water Level Sensor, Arduino, LCD Display, Buzzer, Wi-Fi Module and GSM SIM Module.

Step-by-Step Working:

1. **Water Level Sensing:**
   - The water level sensor provides continuous monitoring of water level. It detects changes in the water height.
   - It has four levels, Level 0 Level 1, Level 2, and Level 3.
2. Processing by Arduino:
   - Arduino takes in the signals from the water level sensor and acts accordingly.
   - Analysis of the water level enables Arduino to send signals to multiple components.
     - LCD Display (to show the current water level)
     - Wi-Fi Module (to update the server)
     - GSM Module (to send alerts to registered mobile numbers)
     - Buzzer (for high-risk alerts)
3. Water Level Alerts:
   - **For Levels 0, 1, and 2:**
     - The LCD displays the current water level.
     - Wi-Fi module refreshes server with water level status.
     - The GSM module dispatches SMS alerts to authorized mobile numbers.
   - For Level 3 (Critical Level - Flood Warning):
     - The LCD displays the water level.
     - The Wi-Fi module provides the server with an update about a flood warning.
     - The GSM module will send an emergency call to the registered cellular numbers.
     - The buzzer is engaged to sound a harsh signal.

This system offers real-time monitoring and immediate warning of the possibility of flooding to prevent the impact by informing the authorities and individuals in time.

4.3. Software Implementation:

The Arduino Integrated Development Environment (IDE):

The Arduino Integrated Development Environment (IDE) (Fig. 9) is a sophisticated and user-friendly solution that has made embedded programming a breeze for both professionals and hobbyists. Designed for Arduino microcontrollers, the IDE allows for programming and uploading, making it an ideal solution for both beginners and professionals. The main advantage of the Arduino IDE is a simple interface that includes a code editor with syntax highlighting, auto-complete suggestions and error control. With Arduino, it is possible to write a clean and understandable code. The IDE gives users the ability to use C and C++ features, while reducing the complexity of these languages. This way, beginners can learn programming without getting overwhelmed. Arduino IDE comes with libraries. These libraries have code for controlling various devices like motors, sensors, or displays. The availability of a wide range of libraries for Arduino has significantly increased ease in experimenting, and speed of development for most developers.

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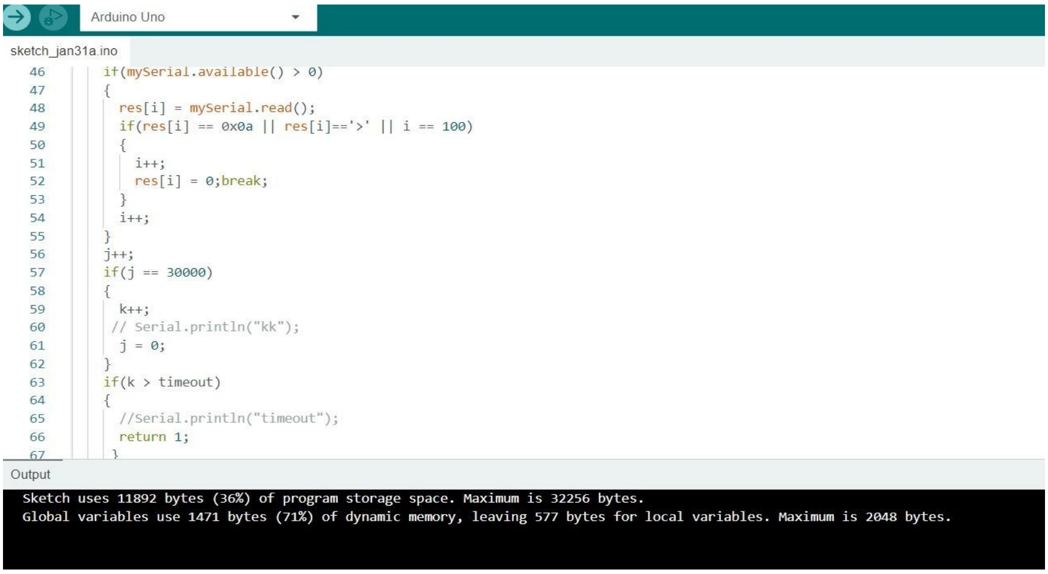
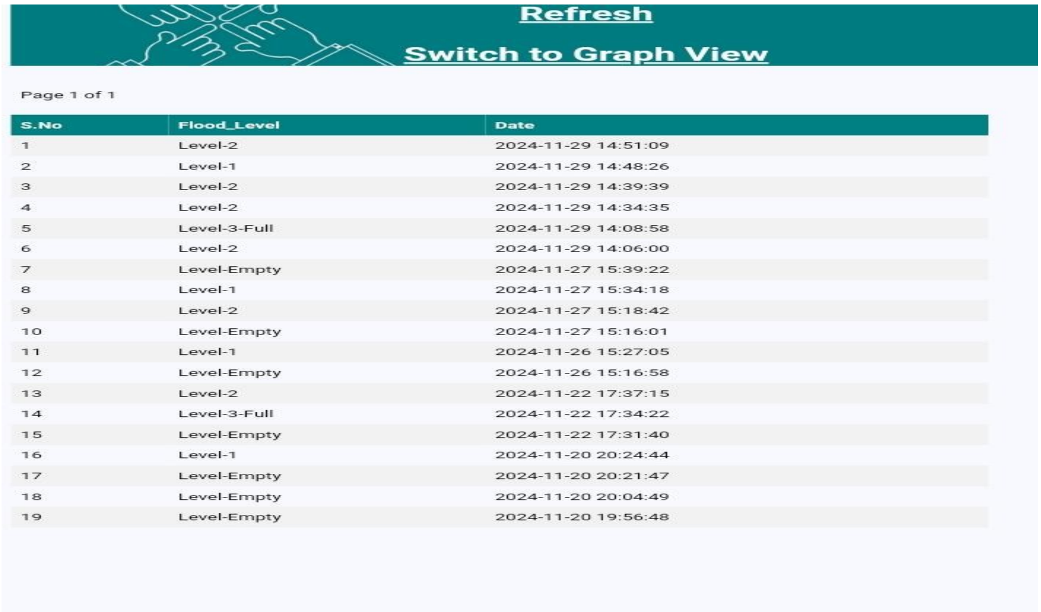


Fig. 9: Software Implementation

5.Result:



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S.No	Flood_Level	Date
1	Level-2	2024-11-29 14:51:09
2	Level-1	2024-11-29 14:48:26
3	Level-2	2024-11-29 14:39:39
4	Level-2	2024-11-29 14:34:35
5	Level-3-Full	2024-11-29 14:08:58
6	Level-2	2024-11-29 14:06:00
7	Level-Empty	2024-11-27 15:39:22
8	Level-1	2024-11-27 15:34:18
9	Level-2	2024-11-27 15:18:42
10	Level-Empty	2024-11-27 15:16:01
11	Level-1	2024-11-26 15:27:05
12	Level-Empty	2024-11-26 15:16:58
13	Level-2	2024-11-22 17:37:15
14	Level-3-Full	2024-11-22 17:34:22
15	Level-Empty	2024-11-22 17:31:40
16	Level-1	2024-11-20 20:24:44
17	Level-Empty	2024-11-20 20:21:47
18	Level-Empty	2024-11-20 20:04:49
19	Level-Empty	2024-11-20 19:56:48

Fig. 10: Result

The flood detection system's developed model led us to collect readings from the putty console (Fig.10), then all logs generated from the web console for flood monitoring, and lastly, SMS alert and call-alert outputs as part of flood alerting. The feasibility and significance of the proposed flood detection system were assessed through simulation prior to construction. The simulation was conducted using the Proteus 8 Professional program, as shown in Fig. 6. Discrete software and hardware components make up the complete system development process. By creating and testing distinct system pieces, the procedure increased speed, efficiency, and decreased troubleshooting time.

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6. Conclusion:

The suggested intelligent flood warning system could greatly improve catastrophe response and management, ultimately preventing fatalities and minimizing financial damages. This system is ideal for usage in rural and underdeveloped areas due to its cost, energy efficiency, and scalability. To further enhance flood detection and mitigation efforts, future work will concentrate on extending the system's deployment to additional regions and integrating it with current emergency response frameworks.

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