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IoT-based Flood Detection and Alerting System

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***Abstract*— Traditional flood monitoring systems are highly incapable of real-time operation, which makes it inefficient for alerting the communities at the right time. This work is on the design of a comprehensive flood detection and alerting system by using Internet of Things (IoT) technology to provide early warning to reduce the impact of floods. The design of the system includes a DHT11 sensor to measure both temperature and humidity, an ultrasonic sensor for measuring the level of water, and a flow sensor to detect the flow rate.The sensors are interfaced with a Raspberry Pi Pico W microcontroller. The microcontroller processes the interfaced sensor data and then sends it to Adafruit IO, a cloud platform for live monitoring and visualization. The output from the interface sensors is sent periodically to Adafruit IO using the MQTT protocol to ensure a robust and scalable remote monitoring system. Finally, it includes a Wi-Fi module to ensure full communication to add reliability to the system. The primary objective of the project is to provide a low-cost, reliable, scalable flood detection and alerting system that can be deployed in vulnerable areas to provide timely alerts. This project will help improve disaster preparedness, enhance community safety, and save lives and property through timely intervention.**

***Keywords*— Flood Detection and Alerting System (FDAS) Internet of Things (IoT)..**

I. INTRODUCTION

Floods are among the severe forms of natural disasters. They lead to severe damage to infrastructure, loss of human lives, and displacement of communities. Rapid detection and timely alerting are extremely important to mitigate the impact of floods. The development of the Internet of Things (IoT) offers a promising solution for early flood detection and effective alerting systems. Major equipment includes different sensors, communication equipment, and data analytics platforms, to monitor water levels, rainfall intensity, and other relevant parameters through real-time monitoring. Such systems enable authorities to be able to get valuable insights and communities to take proactive measures that can ensure damages brought about by floods are minimized. The implementation of a flood detection and alerting system utilizing IoT technology. The system consists of sensor nodes deployed in flood-prone areas, which continuously collect data on water levels, weather conditions, and other relevant parameters. The data is constantly conveyed to a central server or a cloud platform for its analysis and processing. By utilizing advanced analytics algorithms, the system can detect abnormal changes in water levels or rainfall patterns, indicating the onset of a flood. Upon detection, the system triggers automated alerts through various communication channels such as SMS, email, and mobile applications, notifying authorities and residents in the affected areas. The deployment of sensors such as water level sensors, rain gauges, and weather sensors.

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These sensors will be deployed to capture data on variables such as precipitation, water levels, and other environmental conditions. Utilizing wireless communication protocols such as Wi-Fi, LoRa WAN, or cellular networks to transmit sensor data to a central server or cloud platform. By implementing data processing algorithms and analytics techniques to analyze incoming sensor data in real time. This includes pattern recognition, trend identification, and the detection of any anomalies that might suggest a potential flood.
In the following sections, the objectives, methodology, and expected outcomes of the project will be considered: ways in which the integration of different sensors and IoT technologies will empower the flood detection system to effectively fulfill its mission.

II. Related Works

Flood detection and management systems have undergone significant advancement with the recent development of Internet of Things (IoT) technologies. With this development, much of the research and practitioners have strived to develop better approaches and methodologies to effectively improve early detection and alert systems. This literature survey reviews significant contributions in the field, focusing on the integration of IoT technologies for flood monitoring and management.
In the proposed system, several sensors are used to detect several parameters that may cause floods. The sensors are used to monitor the conditions in real time. The PLX-DAQ Tool is used to retrieve data from the sensors in real time. An alert is triggered when there is rain detection sensor detects rainfall (gives an output of 1) and the water level (measured by the ultrasonic sensor) is very high [1].
In the study of A Prototype for Flood Warning and Management System using Mobile Networks. Several trials were carried out to assess the accuracy and timing of the sensors used to reach end users for the flood risk warning. In a controlled environment, these tests were conducted and the predetermined flood risk parameter value came out to be less than 5% for all of the sensor units which is considered to be an acceptable number [2].
An implementation of an Internet of Things (IoT) network for a flood early warning detection system has been described. Examples of measurement results are provided for status "SAFE" (0-9cm) and status “ALERT.” (10-15cm). The highest accuracy of the sensor reading is about 20%. Some developments can be made to improve the system in the future, such as enhancing the reliability of the signal by adding some modules to the system which can make the system more stable and secure.[3]
In the study of Enhanced Flood Detection System using IoT. The data is collected through the sensors installed on the water bodies. For example, the water level sensor is used to measure the level of the water in the water bodies. The other data collected is through the Metrological tower that is available throughout the city. Poondi Lake 3,231 Mcft 41% Cholavaram Lake 1,081 Mcft 10% across Chennai [4].
In another study of Real Time Flood Monitoring and Prevention Using IoT Sensors in Developing Countries, Flood Alert is composed of three key components: a miniature model with interconnected IoT sensors, the mobile app, the application server, and the database. The website is developed using Django Framework, an MVC (Model-View- Controller) framework based on Python and MySql as the relational database [5].
In this study of Smart flood disaster prediction systems using IoT & Neural Networks. The first algorithm (Gradient Descent) does not indicate sufficient resultant accuracy for rainfall prediction. The second algorithm (LM algorithm) can predict with an accuracy of around 88% which is enough for use case of rainfall prediction and ultimately flood prediction [6].
The prototype of the flood warning and management system uses a mobile network for the transmission of data. The system consisted of a water level sensor, rain gauges, and weather stations that send data in real-time to the centralized server for processing and alert generation. This approach is used in areas with limited internet connectivity, thus relying on very common mobile networks. The cost-effective nature of the prototype allows for scalability and hence fits well in remote or underdeveloped areas [7].
The study is based on the development of a smart flood monitoring system using ultrasonic sensors with NodeMCU and Blynk application. the prototype is only using a small scale of sensor detection within 50cm. In the actual world, the system needs to detect the flood for about 1 to 2 meters if the system is placed at the riverside to detect flood. this prototype needs to be improved on the water-resistant features so that when the rain starts to fall, it cannot damage the sensor node [8]
A revised flood detection system by using IoT technologies to increase flood monitoring accuracy. In this work, authors have described a flood monitoring system using water level sensors combined with flow sensors and weather sensors for obtaining an overall environmental feature. The data is uploaded onto a cloud-based platform for real-time analytics and visualization [9].

An energy-efficient cloud system for flood prediction and forecasting based on IoT. The proposed model is effectively determining the prediction and forecasting measures for the study area (Kerala, India). This framework is contributed for optimistically data generation with efficiently enhance the sensor lifetime. Dimension reduction algorithm is applied at the fog layer to maintain the optimization of network bandwidth. Moreover, the ANN predictive algorithm produces efficient results with 97.3% sensitivity, and 92.4% specificity and future flood stages are forecasted using HoltWinter'smodel at the cloud layer [10].

An IoT-based smart flood detection and awareness system utilizes several sensors to monitor environmental parameters like water level, rainfall, and soil moisture, with the advanced IoT communication protocols used to transmit data to a central server. In that server, with the help of advanced algorithms, data will be used to predict the potential of flooding of the region of interest. Also, the work includes the development of a mobile application for transferring alerts and information to the public, providing timely and efficient communication in the event of a flood. The benefits of the system are better accuracy in prediction and real-time awareness. The reliance on advanced algorithms, however, may need greater computational resources and robust network infrastructure [11]

Another study investigates the feasibility of IoT sensors for real-time flood monitoring and prevention in developing countries. The system would need to be low-cost and efficient, considering the resource constraint in which it is likely to be deployed. The IoT sensors detect water level, rainfall, and other parameters; the data is then processed and analyzed for alert generation and visualization [12].

The flood detection system has been designed for immediate notification to the local authorities. It determined the current water level using a sensor network, which provides notification via SMS and a web-based public network through a GSM modem.

Four machine-learning algorithms were utilized to classify flood data. The Random Forest algorithm provides a significant improvement in terms of accuracy over other classifications with 99.5 % accuracy in comparison to 97.7% using the Bagging algorithm.

Moreover, Decision Tree achieved 94.6% accuracy, which is slightly lower than Bagging. While, the HyperPipes algorithm obtained 89.8%, which is considered the lowest accuracy percentage acquired among other classifiers [13]. A smart flood disaster prediction system combining IoT with neural networks to enhance prediction capabilities.

The system collects data from different sensors from the Internet of Things, including water level and weather sensors, and utilizes the neural network to analyze the data and predict potential flooding events. This method uses the computing power of neural networks to increase the degree of prediction. This paper proves that the inclusion of machine learning techniques with IoT data can make flood prediction systems significantly better in terms of providing more accurate and timely warnings [14].

In this study, an attempt was made to develop an integrated food warning system by combining an efficient artificial intelligence model, namely the hybrid wavelet neural network work model (WANN), and a two-dimensional version of the well-known hydraulic model of HEC-RAS 2D, and using the concepts of the Internet of Things. This system also could inform owners and users at risk of food through voice, text, or graphical messages in terms of time and place in adapting to the input data.[15]

This study presented a framework for the prediction of floods. The framework collects information from various waterbodies surrounding the area and detects the groundwater level and the Rainfall information. The data collected is processed to find out whether there is a possibility of a flood. The system will send the information to the people through SMS. The people will take necessary steps based on the message that is received [16].

III. METHODOLOGY

The methodology was undertaken during the analysis of System Architecture:

Sensor Integration

Water Level Sensor: Analog input pin on the Raspberry Pi Pico W

Water Flow Sensor: Digital input pin with pulse counting for flow rate measurement.

Humidity Sensor: I2C or Analog input Pins.

Ultrasonic Sensor: Digital input Pins, where trigger and echo pins will calculate the distance.

Data Acquisition

The Raspberry Pi Pico W reads data from each sensor at predefined intervals. The sensor readings are processed to ensure accuracy and filtered to exclude the noise.

Data Transmission

The formatted data is processed and sent to the Adafruit IO platform using Wi-Fi connectivity from the Pico W. It uses the MQTT protocol to send the data for efficient and reliable communication.

Data Monitoring and Alerting

Real-time data is visualized on Adafruit IO dashboards. Thresholds set for water level, flow rate, and humidity are provided to trigger an alert. Adafruit IO will send notifications using email or SMS if the threshold values have been surpassed or are close to being surpassed, which means it is nearing the flood condition.

Data Analysis and Reporting

Used Adafruit IO dashboards to keep track of data and trends in real time. Historical Data: Analyze long-term trends and patterns of historical data saved on Adafruit IO. Alert Analysis: Get the alert logs to know the frequency and severity of alert-causing potential flood incidents.

Calibrate the sensors at regular intervals. Software Updates: Update the Micro Python scripts to achieve improved efficiency and new features. System Expansion: Integrate more sensors or use more Raspberry Pi Pico W units to cover a larger area.

A. Overview of the Approach

The system is to provide a holistic solution in utilizing Internet of Things technology to combat the disastrous phenomenon of floods. Built around the Raspberry Pi Pico W microcontroller, it integrated several environmental sensors, such as water level, water flow, humidity, and ultrasonic sensors. The sensors are deployed in places that are prone to flooding, continuously monitoring parameters. The said sensors, through the Pico W Wi-Fi connectivity, relay the parameters in real time over to the Adafruit IO platform. Adafruit IO serves as the central hub for data visualization, analysis, and alerting. It will enable the recipients to act on possible flood events through the provision of usable insights. By leveraging the power of IoT and sensor technologies, the project envisions an early warning system, timely intervention, and effective mitigation to reduce the impact of flooding on human lives and infrastructure. The project has its vision focused on bettering society by utilization of new technologies, thereby fostering resilience and sustainability in flood-prone regions.

B. Description of Hardware Components Raspberry Pi Pico W

The Raspberry Pi Pico W is a compact microcontroller board

developed by the Raspberry Pi Foundation is shown in Figure-1. It is an upgraded version of the Raspberry Pi Pico, featuring built-in wireless connectivity via Wi-Fi and Bluetooth. Powered by the RP2040 microcontroller chip, the Pico W offers dual-core ARM Cortex-M0+ processors clocked at 133MHz, providing ample processing power for a wide range of applications. The onboard Wi-Fi connectivity enables seamless communication with other devices and networks, making it ideal for Internet of Things (IoT) projects and wireless sensor networks. With a plethora of GPIO pins, SPI, I2C, and UART interfaces, the Raspberry Pi Pico W offers versatility and flexibility for connecting sensors, displays, and other peripherals. Its low power consumption, affordability, and ease of use make it a popular choice for hobbyists, makers, and professionals alike, empowering them to bring their innovative projects to life. Whether used for prototyping, education, or commercial applications, the Raspberry Pi Pico W continues to inspire creativity and innovation in the world of embedded systems and electronics. The GPIO pin no. 6,7 and 8 of Raspberry Pi Pico W are connected to Buzzer, Green LED, and Red LED respectively which are used for on-ground alerting.

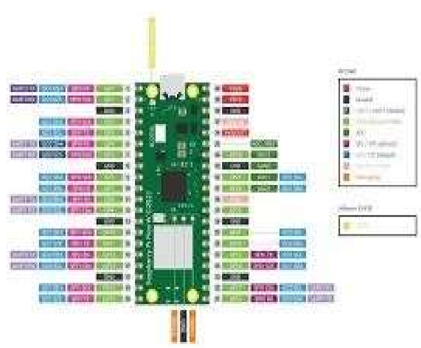

Figure:1 Raspberry Pi Pico W

Water flow sensor
The water flow sensor is a critical component of the flood monitoring system, designed to measure the rate of water flow in a given area data is then translated into flow rate measurements, typically in liters per minute or gallons per hour. The GPIO pin 27 of Raspberry Pi is connected to the data/signal pin of this sensor is shown in Figure -2.

Figure:2 Water flow sensor

Water Level Sensor
The sensor generally operates with a mechanism of using a float or a capacitive measurement method to record water levels. It is connected to the GPIO pin 26 of the Raspberry Pi Pico W, and the voltage is then transmitted, relative to the water level, to the Raspberry Pi Pico W. In this case, the sensor is placed in the best strategic position to capture and give timely and accurate readings with water level sensor shown in figure -3

Figure:3 Water level sensor

DHT11 sensor
The sensor includes a capacitive humidity sensor and a thermistor for detecting temperature, both built within a compact enclosure. The DHT11 communicates with a microcontroller using a single-wire digital protocol, which is handy when working with projects having limited GPIO pins. The data pin of the DHT11 sensor is connected to GPIO pin 0 of Raspberry Pi Pico W shown in Figure -4.

Figure:4 DHT11 sensor

Ultrasonic sensor
An ultrasonic sensor is a device that measures the distance to an object by using sound waves was shown in figure-5. It operates by emitting ultrasonic waves, typically at a frequency above the range of human hearing, and then detecting the waves that bounce back after hitting an object. The time it takes for the sound waves to return is used to calculate the distance to the object. The echo and trig pin of the ultrasonic sensor is connected to GPIO pin 15 and pin 14 of Raspberry Pi Pico W.

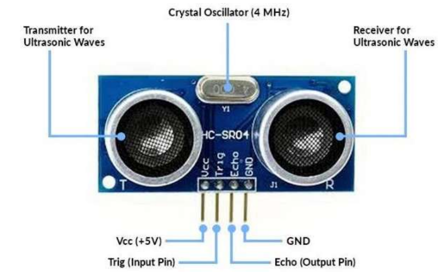

Figure:5 Ultrasonic sensor

C. Hardware Setup and Connections

The hardware implementation of the flood monitoring system involves the interfacing of the Raspberry Pi Pico W microcontroller with different environmental sensors to measure water level, water flow, humidity, and distance. The Raspberry Pi Pico W is small and compact with built-in Wi- Fi, acting as the central microcontroller. The water level sensor is interfaced with the analog input pins, the water flow sensor is interfaced with the digital input pins for pulse counting and the humidity sensor is interfaced through I2C or an analog input. An ultrasonic sensor is used to measure the distance and is interfaced using digital pins. A 5V supply is given to the system, making its components work without any fault. Each sensor is placed strategically in those areas most susceptible to flooding, with the whole assembly inside a weatherproof enclosure to further protect it from environmental elements. All the sensors, post assembly, and the whole system undergo repeated tests and calibration to get authentic readings and faultless data transfer to the Adafruit IO platform for live monitoring and real-time alerts

D. Implementation

The software implementation, on the other hand, works to program the Raspberry Pi Pico W using Micro Python and interfacing the different sensors to send the data to the Adafruit IO platform. The implementation begins by setting up the development environment, installing Micro Python into Pico W, and scripting to read data from the water level, water flow, humidity, and ultrasonic sensors. Each script is written carefully to ensure noise filtering and accurate data acquisition. The software configures the Pico W for Wi-Fi connectivity to send collected sensor data to Adafruit IO, using the MQTT protocol. The data is then visualized on the dashboards of Adafruit IO, real-time monitoring, and threshold setting of alerts for timely interventions and effective management of floods. The software also includes routines for calibrating sensors and handling potential errors. Through continuous integration and testing, the system ensures reliable data transmission and alerts on time for potential flood conditions to enhance timely interventions and effective management of floods.

The block diagram shown in figure-6 which has multiple sensors are interfaced with the Raspberry Pi Pico W which is the heart of this system. The Raspberry Pi Pico W processes the sensor data received activates on ground alerting system and sends the processed data to Adafruit IO and further levels of alerts are sent and displayed. If there is a flood-like condition then an email is sent through Adafruit giving an alert and turning the LED and bugger and if not then an email is sent with the message "You are safe" as shown in figure-7.

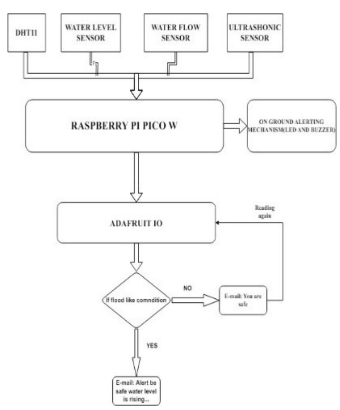

Figure:6 Block Diagram

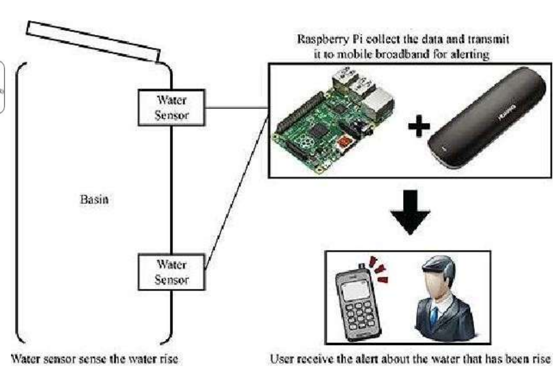

Figure:7 Proposed work

E. Testing Methodology

To ensure that accurate sensor readings are obtained, data transmission is reliable, and the system is robust, the flood monitoring system is tested thoroughly. Every sensor—water level, water flow, humidity, and ultrasonic—is first tested individually for proper connection and functionality. This involves checking the output from the sensors against several known values and making adjustments to calibration if required. Micro Python scripts are tested to ensure the right data acquisition and its transmission to the Adafruit IO platform. The real-time monitoring of data is done to ensure that the data that is shown on the Adafruit IO dashboards presents congruently with what is being input by the sensors. The system is also taken through varying environmental conditions to test its durability and response to different flood scenarios. Alert thresholds are adjusted, and the notification system is tested to issue timely alerts. Finally, the system is tested with realistic environmental conditions through iterative testing and debugging, so that after closing this phase, the proposed system will work flawlessly.

F. Normal Condition

Temperature: Varies widely depending on the region and season, but generally not extreme.
Humidity: Moderate, typically between 30% to 60%. Water Level: < 40 cm Water Flow sensor: low. Alert condition
Temperature: High enough to support significant rainfall in temperate and tropical regions (generally above 15°C or 59°F). In colder regions, temperatures below freezing can lead to snow melt contributing to flooding.
Humidity: High, usually above 70%, indicating potential for heavy rainfall.
Water Level > 40 cm Water Flow sensor: high

IV. RESULTS

Experiments have been successfully done, the IoT sensors, placed in flood-prone areas, detect a rise in water levels or other preconditions for flooding much earlier than usual. With timely response, this leads to mitigation measures. The Sensor data is updated and stored in the cloud in real-time. IoT sensors are, therefore, able to avail real-time data with a great level of accuracy, helping in knowing the patterns of flooding, the intensity, and the time taken by the flooding.
The system is made water resistant due to the implementation of two sensors for measuring the water level using an ultrasonic sensor and a water level sensor where the ultrasonic sensor measures the water level from outside while the water level sensor with contact in water gives the high accuracy of water level. The real-time data is shown on the Adafruit dashboard shown in figure-8.

Figure:8 Adafruit dashboard

It would help the emergency response teams to deploy resources instantaneously through real-time monitoring, including but not limited to rescue teams, evacuation procedures, and relief supplies.
The thonny IDE readings are shown below in figure-9:

```
>>> TEMPERATURE value : 27
HUMIDITY value: 64
water_level value (ADC): 64.56641 cm
water_level value (Ultrasonic): 99.05675 cm
water_flow value: 0
Msg sent
TEMPERATURE value : 27
HUMIDITY value: 63
water_level value (ADC): 63.64411 cm
water_level value (Ultrasonic): 99.0396 cm
water_flow value: 0
Msg sent
```

Figure:9 Thonny IDE Readings

Such warnings on a timely basis would greatly reduce the extent of damage to property, loss of human life, and business losses in cases of flooding events.

V. CONCLUSION

The use of IoT technology in the implementation of a flood detection and alerting system has many benefits for mitigating the flood impact and increasing public safety. The following are drawn from the above descriptions: Early detection is a key factor in IoT-based flood detection systems, which provides scope for the administration as well as individuals to take necessary measures for a minimum level of damage and safety issues. Using sensors located in areas where a flood can be anticipated, these systems can detect changes in water level or other indicators of impending flooding before it becomes critical. Data is collected with the help of IoT sensors, working 24/7 on water levels, precipitation, and other relevant parameters with real-time monitoring and analysis. This makes decision-making and action for the next second possible—for example, immediate evacuations or immediate deployment of flood barriers. IoT devices guarantee accuracy in data collection, thereby minimizing false alarms and increasing reliability.

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