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IoT-Based Real-Time Flood Monitoring and Early Warning System

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Abstract - Floods are among the most destructive natural disasters, causing serious loss of life, property, crops and infrastructure every year. Traditional manual monitoring is slow, labour-intensive and often fails to give timely warnings, especially in remote and flood-prone areas where human observation is difficult or unsafe. Delays in warning leave communities little time to evacuate and prepare, which greatly increases the damage. This paper proposes the design of an IoT-based real-time flood monitoring and early warning system that automates continuous water level observation and delivers alerts before conditions become critical. An ultrasonic sensor mounted above the water surface measures the water level of a river, dam or low-lying area at regular intervals. Because the sensor is non-contact, it is not affected by debris, corrosion or strong currents. An ESP32/NodeMCU controller processes the readings and compares them against configurable warning and danger thresholds, which can be adjusted for different locations and seasons. Based on this comparison, the system classifies conditions as Normal, Warning or Danger. The processed data is transmitted over Wi-Fi or GSM using MQTT/HTTP protocols to a cloud database, where it is securely stored for future reference and analysis. A web and mobile dashboard displays the live water level, trend graphs and current status in a simple, easy-to- understand format, so that authorities can monitor several locations from one place. When risk levels rise, a local buzzer sounds at the site and SMS or app notifications are sent instantly to authorities and nearby residents, enabling timely evacuation and better preparedness. The GSM option ensures that alerts can still be delivered in areas where internet connectivity is weak or unreliable. The stored historical data supports trend analysis and helps in understanding flood behaviour over time, which can assist planners in improving long-term flood management strategies. The proposed system is low-cost, energy-efficient, reliable and easy to install, making it suitable for deployment in rural and remote regions. It can operate on battery or solar power, reducing dependence on the electrical grid during storms. Its modular architecture is scalable and can be extended with rainfall, flow-speed and soil-moisture sensors to improve accuracy and coverage. Furthermore, AI/ML-based flood risk prediction can be integrated to forecast floods in advance rather than only reacting to rising water. Overall, the system aims to reduce flood-related damage by improving early warning, strengthening community safety and supporting effective disaster management.

Keywords— Flood Monitoring, IoT, ESP32, Ultrasonic Sensor, Early Warning System, Real-time Dashboard, Disaster Management.

1. INTRODUCTION

Floods can cause serious damage to people, homes, crops and infrastructure. India is one of the most flood-affected countries, and regions along rivers such as the Krishna and Panchganga in Maharashtra have repeatedly faced severe flooding. Heavy rainfall, overflowing rivers and sudden dam releases can submerge villages, farmland and roads within hours, leading to loss of life, damage to property and disruption of daily life.

A sudden rise in the water level of a river or stream is difficult to detect through manual observation, and warnings may be delayed when monitoring depends only on periodic inspection. Field staff must visit the site to take gauge readings, which is slow, labour-intensive and unsafe during storms. Remote locations may also lack continuous monitoring facilities altogether. Late information reduces the time available for evacuation, rescue and other safety actions, and this delay is one of the main reasons for heavy losses during floods.

Internet of Things (IoT) technology offers a practical way to address this problem. Low-power sensors and microcontrollers can measure water level continuously and send the data over the internet in real time, so that authorities and residents receive an alert when the level becomes dangerous. Such systems work round the clock without human presence at the site, and they are inexpensive enough to be installed at many locations along a river.

This paper proposes an IoT-based flood monitoring and early warning system that combines an ultrasonic sensor, an ESP32/NodeMCU controller, Wi-Fi/GSM connectivity, a cloud database and a dashboard with alert mechanisms. The ultrasonic sensor measures the water level without touching the water, so it is not damaged by debris or corrosion. The ESP32/NodeMCU controller compares each reading with configurable warning and danger thresholds and classifies the condition as Normal, Warning or Danger. The data is sent using MQTT/HTTP to a cloud database, where it is stored for later analysis.

A web and mobile dashboard shows the live water level, trend graphs and current status. When the level reaches a risky stage, a local buzzer sounds and SMS or app notifications are sent to authorities and residents. The GSM option allows alerts to be delivered even where internet connectivity is weak.

The system is low-cost, scalable and simple to install, and it can later be extended with rainfall, flow-speed and soil-moisture sensors and AI/ML-based flood risk prediction. In this way, it aims to improve early warning, reduce flood-related damage and support effective disaster management.

II. PROBLEM STATEMENT

Floods cause serious damage to human life, homes, crops and infrastructure, and the losses are often greater because warnings arrive too late. In many flood-prone areas, water level monitoring still depends on manual gauge readings and periodic inspection by field staff. This method has several limitations that reduce the time available for people to respond.

1. Delayed detection of rising water.. A sudden rise in the water level of a river or stream is difficult to notice through manual observation. When readings are taken only at fixed intervals, a rapid increase between two visits can go undetected until the water has already crossed the danger mark.

2. No continuous monitoring in remote areas. Many villages, streams and small dams lack monitoring facilities altogether. Field staff may not be able to reach these locations, especially during heavy rain, when roads are blocked and travel is unsafe. As a result, the areas that are most at risk often have the least information.

3. Late warnings to authorities and residents. Information collected manually must be recorded, reported and then passed on to the public. This chain is slow, and late information reduces the time available for evacuation, rescue and protection of livestock and property.

4. High cost and complexity of existing systems. Advanced flood monitoring systems are expensive to install and maintain and need trained staff. Small villages and local authorities with limited budgets usually cannot afford them.

5. Lack of organized historical data. Water level records are often incomplete or stored on paper, which makes it hard to study flood patterns, compare seasons and set accurate warning limits.

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6. Dependence on weak connectivity. In rural areas, internet connectivity is often unreliable, so systems that rely only on Wi-Fi may fail to deliver alerts when they are needed most.

Because of these problems, there is a clear need for a low-cost, automated and real-time system. Such a system should measure the water level continuously, compare it with warning and danger thresholds, and alert authorities and residents immediately through a buzzer, SMS or app notification. It should also share current readings through a dashboard, store data for analysis, and work reliably in remote locations using Wi-Fi or GSM. This project addresses that need by developing an IoT-based flood monitoring and early warning system using an ultrasonic sensor and an ESP32/NodeMCU controller.

III. OBJECTIVES

The main aim of this project is to design an IoT-based flood monitoring and early warning system that reduces the damage caused by floods through timely detection and alerts. The specific objectives are:

1. Monitor: Measure the water level continuously
To use an ultrasonic sensor with an ESP32/NodeMCU controller to measure the water level of a river, dam or low-lying area at regular intervals, day and night. Continuous automated measurement removes the need for manual gauge readings and ensures that no sudden rise in water goes unnoticed, even in remote locations where field staff cannot visit regularly.

2. Detect: Identify rising water and danger thresholds
To compare each reading with configurable warning and danger threshold values and classify the condition as Normal, Warning or Danger. The thresholds can be adjusted for different locations and seasons. By tracking how quickly the level is increasing, the system can identify risky situations early, before the water reaches a critical height.

3. Alert: Notify users quickly through connected services To send instant notifications to authorities and nearby residents when the water level reaches a risky stage. A local buzzer warns people at the site, while SMS and mobile app notifications reach users over Wi-Fi or GSM. The GSM option ensures that alerts are delivered even in areas with weak internet connectivity, giving people enough time to evacuate and prepare.

4. Inform: Share current readings through a dashboard
To transmit the data using MQTT/HTTP to a cloud database and display it on a web and mobile dashboard. The dashboard shows the live water level, trend graphs and current status in a simple format, so that authorities and residents can understand the situation at a glance and take quick decisions. Stored historical data also supports later analysis of flood patterns.

Additional Goals

The system is also designed to be low-cost, energy-efficient and easy to install, so that it can be deployed in villages and remote areas with limited resources. Its modular design allows future extension with rainfall, flow-speed and soil-moisture sensors and AI/ML-based flood risk prediction, which will further improve accuracy and lead time for warnings.

IV. EXISTING SYSTEM

Floods cause loss of life and heavy damage to crops, roads and property every year. At present, flood monitoring mostly depends on traditional methods:

- **Manual gauge reading:** Staff gauges are installed in rivers and dams, and personnel visit the site to note the water level.
- **Phone / radio reporting:** Readings are sent to a control room by phone or wireless, which is slow and error-prone.
- **Satellite and radar systems:** They give wide-area forecasts but are expensive and not accurate for small streams and local areas.
- **Siren / loudspeaker warnings:** Public warnings are issued manually, often when the situation is already critical.

A. Limitations

•No real-time or continuous data; readings are periodic.• Depends on human presence, which is risky during floods.•Delayed alerts to authorities and the public. •High cost and maintenance of satellite/radar systems.• Poor coverage of small streams, nalas and remote villages.•No automatic data logging or analysis.

V. PROPOSED SYSTEM

The proposed system is an IoT-based flood monitoring and early warning system. An ESP32/NodeMCU reads an ultrasonic water level sensor, rain sensor, water flow sensor and DHT11, and uploads the data to the cloud over Wi-Fi/GSM. The values are also shown on an LCD at the site.

When the water level crosses the set threshold, the buzzer and LEDs are triggered and an SMS/mobile app alert is sent automatically to the authorities and nearby residents.

A. Comparison with Existing System

Parameter	Existing System	Proposed System
Monitoring	Manual / periodic	Automatic / continuous
Data Transmission	Phone / radio	Wi-Fi / GSM to cloud
Alert Time	Delayed	Instant (seconds)
Cost	High	Low
Data Storage	Paper records	Cloud database and graphs
Human Risk	High	Minimal

VI. SYSTEM ARCHITECTURE

The system has four layers. Sensors collect field data, the microcontroller processes it, the communication module sends it to the cloud, and the application layer shows it and raises alerts.

Fig. 1: System Architecture of IoT-Based Flood Monitoring System

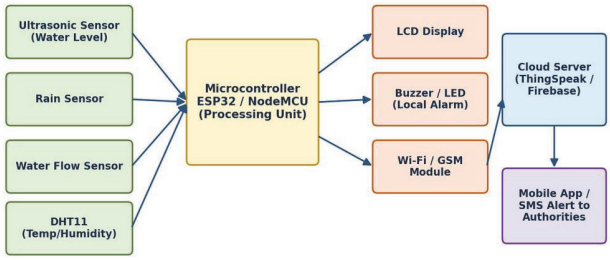


Fig. 1: System Architecture of IoT-Based Flood Monitoring System

- **Sensing layer:** Ultrasonic (water level), rain, water flow and DHT11 sensors.
- **Processing layer:** ESP32/NodeMCU reads the sensors and compares values with thresholds.
- **Communication layer:** Wi-Fi or SIM800L GSM module for cloud upload and SMS.
- **Application layer:** ThingSpeak/Firebase/Blynk dashboard and mobile alerts.

VII. HARDWARE AND SOFTWARE REQUIREMENTS

A. Hardware

Sr.	Component	Purpose
1	ESP32 / NodeMCU	Main controller with built-in Wi-Fi
2	Ultrasonic Sensor (HC-SR04 / JSN-SR04T)	Water level measurement
3	Rain Sensor	Rainfall detection

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Sr.	Component	Purpose
4	Water Flow Sensor (YF-S201)	Flow rate measurement
5	DHT11	Temperature and humidity
6	SIM800L GSM Module	SMS alerts without internet
7	16x2 LCD (I2C)	Local display of readings
8	Buzzer and LEDs	Local audio-visual alarm
9	Power supply / Solar panel and battery	Continuous field operation
10	Waterproof enclosure, wires, PCB	Connections and protection

B. Software

- Arduino IDE (Embedded C/C++)
- ThingSpeak / Firebase / Blynk cloud platform• Android / web dashboard
- •Fritzing / Proteus for circuit design
- Windows 10/11 or Linux

VIII. WORKING METHODOLOGY

The system works in a continuous loop of sensing, processing, decision and alert, as shown in the flowchart.

Fig. 2: Working Flowchart

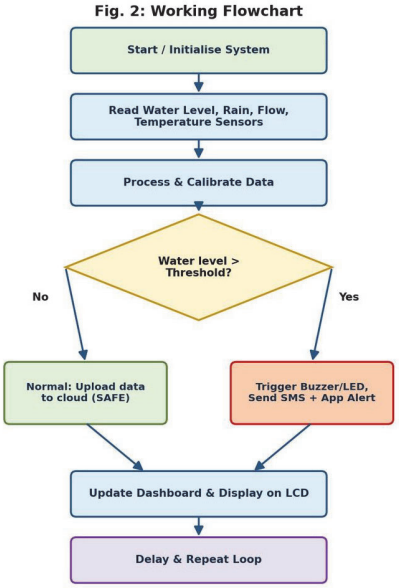


Fig. 2: Working Flowchart

1. The system starts and the microcontroller initialises all sensors and the communication module.
2. The ultrasonic sensor, fixed above the water, measures the distance to the surface. Water Level = Sensor Height – Measured Distance.
3. Rain, flow, temperature and humidity are read at the same time.
4. The microcontroller compares the water level with the preset thresholds.
5. If the level is safe, the data is only uploaded to the cloud.
6. If the level crosses the warning or danger limit, the buzzer/LED is activated and an SMS/app alert is sent.
7. The dashboard is updated and the cycle repeats after a short delay (for example 15 seconds).

Fig. 3: Alert Level Classification



Fig. 3: Alert Level Classification

IX. IMPLEMENTATION

- **Circuit assembly:** The ultrasonic sensor uses TRIG and ECHO pins, the rain sensor an analog pin, the flow sensor an interrupt pin, and the LCD is connected over I2C.
- **Programming:** Code is written in Arduino IDE using the WiFi, DHT, LiquidCrystal_I2C and ThingSpeak libraries.
- **Calibration:** Sensor height is measured and thresholds are set (Safe < 50 cm, Warning 50–80 cm, Danger > 80 cm).
- **Cloud integration:** A ThingSpeak channel with fields for water level, rainfall, flow, temperature and humidity stores the data.
- **Alert setup:** GSM module or Blynk/IFTTT notifications are configured for warning and danger levels.
- **Testing and deployment:** The system is tested in a water tank, then placed in a waterproof box on a bridge or dam wall.

X. RESULTS AND DISCUSSION

The prototype was tested by gradually increasing and decreasing the water level in a tank and comparing the readings with a manual scale. Alerts were checked at each threshold.

Fig. 4: Water Level vs Time (Sample Test Observation)

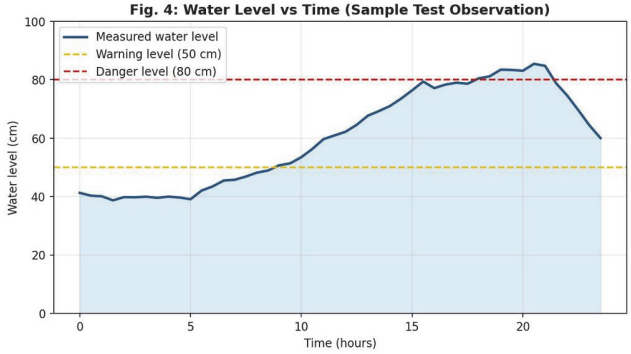


Fig. 4: Water Level vs Time (Sample Test Observation)

Actual Level (cm)	Measured (cm)	Error (cm)	System Status
20	20.4	0.4	SAFE
40	39.5	0.5	SAFE
55	55.6	0.6	WARNING – Buzzer ON
70	69.2	0.8	WARNING – Buzzer ON
85	85.9	0.9	DANGER – SMS Alert Sent

Note: These are sample readings; replace them with your actual values.

A. Discussion

- •Accuracy was about ±1 cm, which is enough for flood warning.• Cloud data updated within 15–20 seconds, so monitoring is almost real-time.
- Buzzer and SMS alerts worked instantly at the threshold.
- •Waves and floating debris cause small fluctuations; averaging several readings reduces the noise.
- •The system worked well on battery/solar power, so it suits remote locations.

XI. ADVANTAGES AND APPLICATIONS

A. Advantages

- Provides real-time monitoring of water levels.
- •Detects rising water levels at an early stage.
- Sends automatic alerts during flood situations.
- •Helps authorities take quick and immediate action, improving safety.•Helps to save human lives and protect property.
- •Reduces the need for manual monitoring, saving time and human effort.
- Provides quick and accurate information.
- •Supports better emergency and rescue management.
- Reduces the risk of damage caused by floods.

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B. Applications

- River, dam and canal water level monitoring
- Flood-prone villages and urban drainage systems
Smart city stormwater management
- Disaster management authorities and weather departments
- Agricultural water management
- Detecting floods in low-lying areas
- Monitoring heavy rainfall conditions
- Providing early flood warnings to people
- Monitoring water levels in reservoirs

XII. FUTURE SCOPE

- Machine learning to predict floods using rainfall and historical data.
- LoRa/LoRaWAN for long-range communication where Wi-Fi/GSM is weak.
- Drone, satellite and GIS integration for flood mapping and evacuation routes.
- Multilingual voice and SMS alerts for rural people.
- Larger solar-powered sensor networks linked to government disaster portals.
- Development of a mobile application for real-time flood updates.
- Use of GPS technology to identify flood-affected areas.
- Sending SMS alerts directly to people's mobile phones.

XIII. CONCLUSION

The IoT-based flood monitoring system is a low-cost and reliable alternative to manual monitoring. It measures water level and weather parameters in real time and sends instant alerts through Wi-Fi/GSM and the cloud, giving authorities and the public time to act.

Test results show that the system is accurate and responsive, and it can be expanded with more sensors and prediction algorithms to reduce human and economic losses from floods.

The Flood Monitoring System is a useful and effective system for detecting floods and monitoring water levels in real time. It helps to provide early warnings and automatic alerts during dangerous situations. This system reduces human effort and helps protect human lives, animals, and property. In the future, it can be improved with advanced technology for better flood prediction and disaster management.

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