# Hybrid IOT Based Flood Early Warning System with Adaptive Water Rise Detection

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## I. ABSTRACT

Flood events pose serious risks to life and infrastructure, often due to delayed warning systems and reliance on fixed threshold monitoring. This paper presents a Hybrid IoT-Based Flood Early Warning System with Adaptive Water Rise Detection to improve real-time flood assessment. The system integrates water level, rainfall, and vibration sensors using an AT89C51 microcontroller with ADC-based data acquisition. The proposed method applies rate-of-rise analysis along with adaptive threshold logic to dynamically evaluate flood conditions. Continuous monitoring enables early detection of rapid water level changes. When critical conditions are identified, alerts are transmitted via a GSM module, while local indications are provided through a buzzer, LED indicators, and an LCD display. The system demonstrates faster response and reduced false alarms compared to conventional approaches. It offers a cost-effective and reliable solution for deployment in flood-prone and remote areas.

**Keywords:** Flood Detection, Internet of Things (IoT), Adaptive Threshold, Rate-of-Rise Analysis, GSM Alert System, Multi-Sensor Monitoring.

## II. INTRODUCTION

Floods are among the most severe natural disasters, causing significant damage to life, infrastructure, and the environment. Increasing climate variability and extreme rainfall have intensified both the frequency and impact of flood events, especially in low-lying regions. In such conditions, reliable early warning systems are essential to reduce risk and improve preparedness.

Conventional flood monitoring systems rely on fixed threshold techniques for water level detection. These static methods are not suitable for dynamic environments, where sudden rainfall or upstream flow variations can cause rapid water level rise. As a result, such systems may generate delayed warnings or false alarms. Advances in embedded systems and Internet of Things (IoT) technologies enable continuous monitoring and real-time data processing. However, many existing systems lack adaptive decision-making and do not consider the rate of water level change, which is a critical indicator of flood conditions. To overcome these limitations, this paper proposes a Hybrid IoT-Based Flood Early Warning System with Adaptive Water Rise Detection. The system integrates water level, rainfall, and vibration sensors using an AT89C51 microcontroller with ADC-based signal processing. It employs rate-of-rise analysis and adaptive threshold logic to dynamically assess flood risk. The system further enhances performance through real-time adaptive threshold tuning, combined rainfall–vibration analysis, and rate-of-rise based prediction for early detection. The objective of this work is to improve detection accuracy, reduce false alarms, and provide timely alerts through GSM communication and local warning mechanisms such as a buzzer, LED indicators, and an LCD display. The proposed system offers a reliable and cost-effective solution for flood-prone and remote areas.

## III. LITERATURE SURVEY

Several studies have explored flood monitoring and early warning systems using sensor-based and IoT-enabled approaches. Islam et al. [1] proposed an IoT-based environmental monitoring system integrated with cloud platforms for real-time analysis. However, the system relies on predefined threshold values, limiting adaptability to dynamic conditions. Karthikeyan et al. [2] developed a flood monitoring system using water level sensors and GSM communication for alert transmission. Although it provides timely notifications, the use of single-parameter sensing reduces accuracy in complex flood scenarios.

Singh and Gupta [3] introduced a real-time flood alert system based on wireless sensor networks (WSN), improving data collection from distributed locations. However, the system lacks adaptive decision-making and does not consider the rate of water level change, which may delay critical alerts.

Rahman et al. [4] presented an IoT-based model combining rainfall and water level data. While multi-parameter monitoring improves detection, the use of fixed threshold logic can still lead to false alarms under varying environmental conditions. From these studies, key limitations include reliance on static thresholds, lack of adaptive intelligence, and insufficient analysis of rapid water level variations. To address these issues, the proposed system adopts a hybrid approach that integrates multi-sensor data with rate-of-rise analysis and adaptive threshold logic for improved accuracy and timely flood detection.

## IV. PROPOSED METHODOLOGY

The proposed system provides an adaptive flood early warning mechanism by integrating multi-sensor data with intelligent processing. Water level, rainfall, and vibration sensors are used to monitor real-time environmental conditions. Sensor outputs are converted into digital signals using an ADC and processed by the AT89C51 microcontroller. The system continuously updates environmental data for real-time analysis. The core functionality is based on rate-of-rise analysis, where changes in water level over time are evaluated to detect sudden increases. This is combined with an adaptive threshold mechanism, which dynamically adjusts decision limits based on rainfall and vibration inputs, improving detection accuracy & reducing false alarms. Based on the analysis, the system classifies conditions and generates alerts through a GSM module and LED indicators, buzzer, and LCD display.

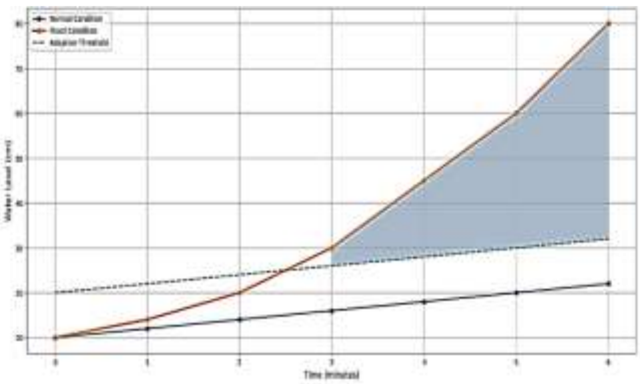

**Fig. 4.1. Rate-of-Rise Analysis with Adaptive Threshold**

## V. HARDWARE COMPONENTS

| Component | Specification |
|---|---|
| AT89C51 Microcontroller | 8-bit MCU, 4 KB Flash, 128 B RAM, 40-pin DIP, 5V |
| Water Level Sensor | Analog output, 0–5V range |
| Rain Sensor | Resistive type, analog output (0–5V) |
| Vibration Sensor (SW-420) | Digital output, 3.3–5V |
| ADC (0808/0809) | 8-bit resolution, 8-channel, 5V |
| GSM Module (SIM800L) | Quad-band (850/900/1800/1900 MHz) |
| LCD Display (16×2) | 5V supply, HD44780 compatible |
| Buzzer | 3–5V DC, piezoelectric |
| LED (Green/Red) | Forward voltage: 2–3V, current: 10–20 mA |
| Voltage Regulator (7805) | +5V output, up to 1A |
| Crystal Oscillator | 11.0592 MHz |

## VI. SYSTEM ARCHITECTURE

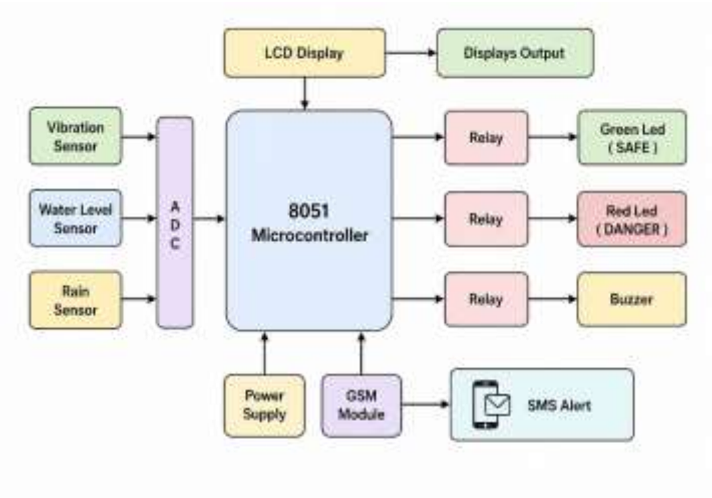


**Fig. 6.1. Overall System Architecture**

The system is organized into three layers: sensing, processing, and alert/communication. The sensing layer consists of water level, rainfall, and vibration sensors that continuously monitor environmental conditions. The sensor outputs are analog signals, which are converted into digital form using an ADC before being processed. The processing layer is built around the AT89C51 microcontroller, which acts as the central control unit. It performs real-time data analysis using rate-of-rise computation and adaptive threshold logic to classify system states as normal, warning, or critical. The alert and communication layer handles user notification and system output. A GSM module is used to transmit SMS alerts during critical conditions. Local alerts are provided using a buzzer and LED indicators (green for safe and red for danger). An LCD display is used to present real-time system status and output information. This layered architecture ensures continuous monitoring, fast decision-making, and reliable alert generation, improving performance over conventional systems.

## VII. WORKING PRINCIPLE

The system operates through continuous monitoring and intelligent analysis of environmental parameters. The working flow is illustrated in Fig. 7.1.

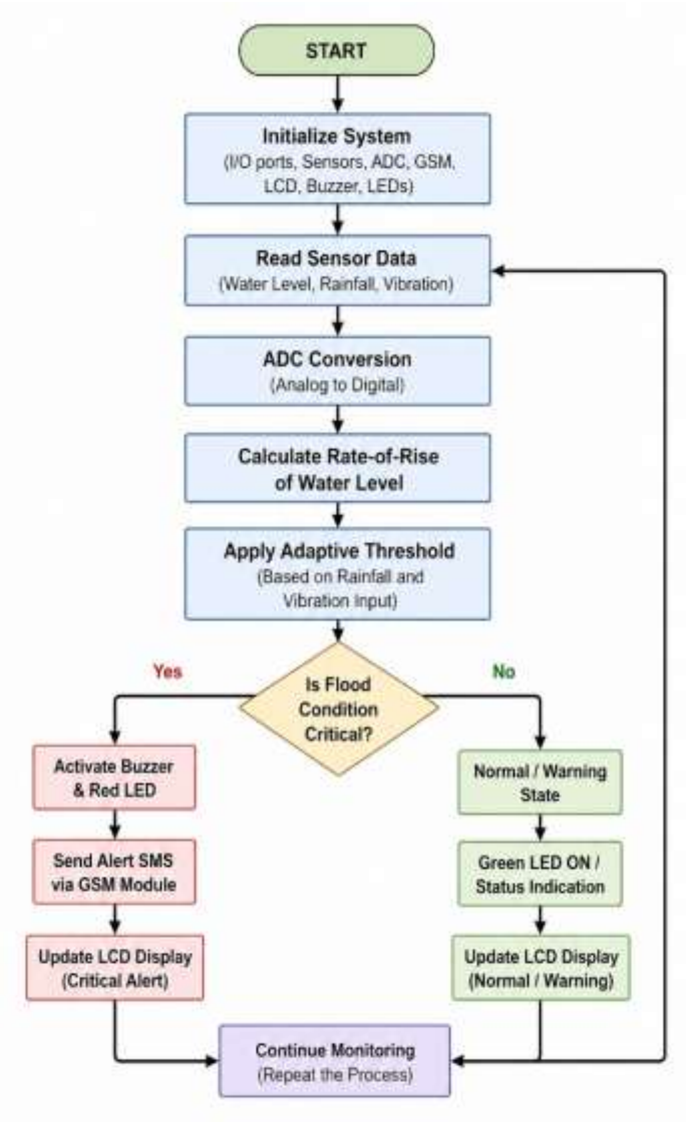


**Fig. 7.1. Flow Chart**

### 7.1 Data Acquisition

Water level, rainfall, and vibration sensors continuously collect environmental data. The analog outputs are converted into digital signals using an ADC.

### 7.2 Data Processing

The AT89C51 microcontroller processes the sensor data in real time and updates system status continuously.

### 7.3 Rate-of-Rise Calculation

The system evaluates the rate of change in water level over time. A rapid increase indicates a potential flood condition.

### 7.4 Adaptive Threshold

Threshold values are dynamically adjusted based on rainfall intensity and vibration input for improved accuracy.

### 7.5 Decision Making

Based on processed data, the system classifies the condition as normal, warning, or critical.

### 7.6 Alert Generation

In critical conditions, SMS alerts are sent via GSM. Local alerts are provided using a buzzer, LED indicators, and LCD display.

## VIII. PERFORMANCE ANALYSIS

| Parameter | Conventional System | Proposed System |
|---|---|---|
| Threshold | Fixed | Adaptive |
| Detection | Level-Based Only | Rate-of-Rise + Level |
| Sensor | Single Sensor | Multi-Sensor Integration |
| Accuracy | Moderate | High |
| False Alarm Rate | High | Low |
| Response Time | Slower | Faster |

## IX. RESULTS AND DISCUSSION

The proposed system was evaluated under varying conditions by altering water level, rainfall intensity, and vibration inputs. It successfully performed real-time monitoring and responded dynamically using rate-of-rise analysis and adaptive threshold logic. The system demonstrated improved detection of rapid water level increases compared to conventional fixed-threshold methods, generating early warnings with faster response during sudden rise conditions.

During normal conditions, the system maintained a safe state indicated by a green LED, while critical conditions triggered a red LED along with alert notifications. The adaptive threshold mechanism effectively reduced false alarms by adjusting decision levels based on environmental variations. Multi-sensor integration enhanced detection reliability by considering combined parameters rather than a single input. The GSM module reliably transmitted alert messages to users, while local indicators such as LEDs, buzzer, and LCD display provided immediate on-site warnings. The experimental results confirm that the system accurately classifies safe and danger conditions, achieving higher accuracy, faster response, and improved reliability compared to traditional flood monitoring systems.

1. NORMAL ( SAFE ) CONDITION


**Fig 9.1** Normal (Safe) condition – Green LED ON, LCD display and SMS alert

2. WARNING / DANGER ( CRITICAL ) CONDITION


**Fig 9.2** Warning / Danger (Critical) condition – Red LED ON, LCD display and SMS alert

3. REAL-TIME SYSTEM SETUP

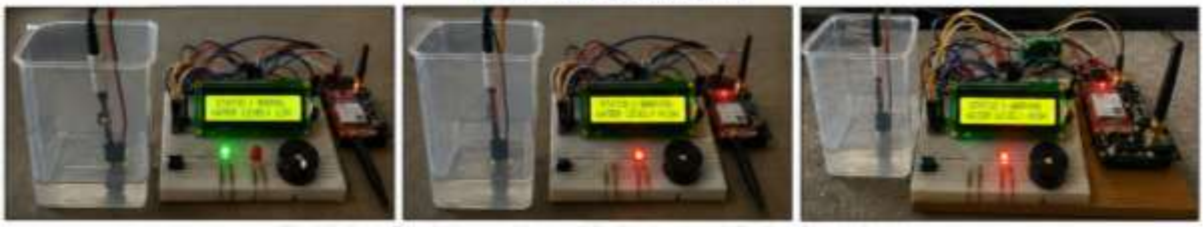

**Fig 9.3** Overall real-time working model of the proposed flood early warning system

## X. CONCLUSION

This paper presented a Hybrid IoT-Based Flood Early Warning System with Adaptive Water Rise Detection to improve the reliability and responsiveness of flood prediction. The proposed system integrates multiple sensors with an AT89C51 microcontroller to continuously monitor environmental conditions such as water level, rainfall, and vibration. By incorporating rate-of-rise analysis along with adaptive threshold logic, the system effectively overcomes the limitations of conventional fixed-threshold methods. It enables early detection of rapid water level changes, resulting in improved accuracy, faster response time, and reduced false alarms.

The system successfully generates alerts through both GSM communication and local indicators such as LEDs, buzzer, and LCD display. Experimental results demonstrate that the system can reliably classify conditions into normal and critical states, ensuring timely warning delivery.
Overall, the proposed system provides a cost-effective, efficient, and scalable solution for flood monitoring, making it suitable for deployment in flood-prone and remote areas.

## XI. FUTURE SCOPE

The proposed system can be further enhanced by integrating cloud-based IoT platforms for real-time data storage, monitoring, and remote access. This enables users and authorities to continuously track environmental conditions from any location and respond more effectively during emergency situations. Machine learning algorithms can be incorporated to analyze historical and real-time data, enabling accurate prediction of flood conditions and early risk assessment. This will improve the intelligence of the system beyond threshold-based decision making.

The use of advanced communication technologies such as LoRa and NB-IoT can extend the communication range and ensure reliable data transmission in remote and rural areas while reducing power consumption. Additionally, integration of real-time weather forecasting APIs and GPS-based location tracking can enhance system accuracy and provide location-specific alerts. These improvements will support large-scale deployment and make the system more robust, scalable, and efficient for real-world flood monitoring applications.

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