

IOT BASED SMART FLOOD DETECTION AND ALERT SYSTEM

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ABSTRACT

Floods are among the most frequent and destructive natural disasters, causing loss of life, damage to homes and crops, disruption of transport, and the spread of disease. Sudden floods from heavy rainfall, overflowing rivers, blocked urban drains, and the release of water from reservoirs often give people very little time to move to safety. In many areas, warnings depend on manual observation of water levels and announcements by local authorities, which may arrive late. This paper presents an IoT based Smart Flood Detection and Alert System that monitors water levels and rainfall continuously and warns residents and authorities automatically when flood risk increases.

The proposed system consists of field nodes placed at rivers, canals, drains, low-lying roads, and near vulnerable settlements. Each node uses an ESP32 microcontroller connected to an ultrasonic water level sensor, a float switch for backup detection, a rain gauge, a water flow sensor, and a temperature and humidity sensor. The node measures the water level at short intervals, calculates how quickly the level is rising, and combines this with recent rainfall to assess the flood risk at that location.

Because flood-prone areas often have poor internet coverage, the nodes communicate through LoRa radio to a gateway that may be several kilometres away, and a GSM module provides SMS alerts as a backup. The gateway forwards data through MQTT to a cloud platform. Local sirens and warning lights at each node are activated immediately when danger levels are reached, so that people nearby are warned even if the network is unavailable. Each node also reports its battery voltage and signal strength so that maintenance staff can find faulty units quickly.

The cloud platform stores all readings, displays node locations and water levels on a map-based dashboard, and applies three warning levels, namely watch, warning, and danger, based on water level, rate of rise, and rainfall. Alerts are sent by SMS, mobile application notification, and email to registered residents, disaster management officials, and local bodies. Historical data helps authorities understand flood behaviour at each location and plan drainage improvements and evacuation routes. Officials can acknowledge alerts from the dashboard, which records who responded and when.

Testing with a model river channel and a simulated rainfall setup showed that the system detected rising water reliably, classified warning levels correctly, and delivered alerts within seconds of a threshold being crossed. The use of rate of rise allowed warnings to be issued earlier than fixed level thresholds alone. The system is low in cost, solar powered, and suitable for deployment in villages and urban areas. Future work includes flood prediction using machine learning with weather forecast data and integration with government early warning services.

I. INTRODUCTION

India experiences floods almost every year, particularly during the monsoon season. Rivers overflow their banks, heavy rainfall overwhelms urban drainage, and low-lying areas are inundated within hours. Floods damage houses, roads, crops, and power infrastructure, and they force large numbers of people to leave their homes. Urban flooding has also become more common as cities expand over natural drainage channels and paved surfaces increase runoff. Underpasses, low bridges, and basement parking areas in cities can fill with water within minutes during intense rainfall, trapping vehicles and people.

Early warning is one of the most effective ways to reduce flood losses. When people receive warning in time, they can move to higher ground, protect belongings, and move livestock, and authorities can close roads and prepare relief. However, flood monitoring in many places still depends on manual gauge readings taken at fixed times and passed on by phone or radio. Small rivers, streams, and urban drains are often not monitored at all, and warnings frequently arrive after water has already entered homes.

The Internet of Things provides tools for continuous and automatic flood monitoring. Water level sensors, rain gauges, and flow sensors can be connected to low-power microcontrollers, and long-range wireless technologies such as LoRa can carry data from remote locations to a gateway without relying on mobile internet. Cloud platforms can process the data, show it on maps, and send alerts to many people at once through SMS and mobile applications. Such nodes can be installed at far more locations than conventional gauge stations for the same budget.

This paper describes an IoT based Smart Flood Detection and Alert System that uses sensor nodes to monitor water level, rate of rise, and rainfall at vulnerable locations. The nodes raise local alarms, communicate through LoRa and GSM, and report to a cloud platform that classifies flood risk and sends alerts to residents and authorities. The objective is to provide timely, reliable, and affordable flood warnings for communities that currently receive little or no automatic warning.

II. LITERATURE SURVEY

Flood forecasting and warning have traditionally been handled by hydrological agencies using river gauge stations, rainfall networks, and hydrological models. Studies of these systems show that they work well for large river basins, where water takes hours or days to travel downstream and forecasts can be issued well in advance. However, researchers have pointed out that gauge stations are sparse, expensive to install and maintain, and often located only on major rivers. Flash floods in smaller catchments, hilly regions, and urban areas develop too quickly for such networks to capture. Reviews of flood disasters have repeatedly found that the communities most affected were those located along small streams or in low-lying urban neighbourhoods where no monitoring existed. This gap has motivated research into low-cost sensor networks that can be deployed densely at local level and can deliver warnings directly to the people at risk.

Water level measurement is the central function of most flood monitoring systems, and several sensing methods have been studied. Float switches and resistive level probes are simple and inexpensive but provide only a few discrete levels and can be affected by debris. Pressure transducers placed under water give continuous readings but are prone to clogging and require waterproof cabling. Non-contact ultrasonic sensors mounted above the water surface have become popular in low-cost systems because they measure distance to the surface continuously without touching the water.

Researchers have noted that ultrasonic readings can be affected by temperature, wind, rain, and floating objects, and have recommended temperature compensation, median filtering of several readings, and the use of a backup float switch. Radar level sensors offer better performance in harsh conditions but remain more expensive for community deployment. Some studies also used camera images of a painted gauge board to confirm sensor readings visually during critical events.

Communication is a major concern in flood monitoring because flood-prone areas often have weak mobile coverage and power supply may fail during storms. Early wireless sensor network studies used ZigBee radios, which offered low power consumption but limited range, requiring many relay nodes. GSM-based systems sent SMS alerts directly from the sensor node and were widely adopted in academic prototypes due to their simplicity, but they depend on mobile network availability and have running costs. More recent research has focused on LoRa and LoRaWAN, which provide ranges of several kilometres with very low power consumption, allowing a single gateway to serve many nodes spread across a catchment. Studies comparing these technologies have concluded that LoRa for data collection combined with GSM for critical alerts provides a good balance of range, reliability, and cost. Solar charging with small lithium batteries was shown to keep such nodes running through several days of cloudy weather.

Researchers have also examined how flood risk should be assessed from sensor data. Simple systems raise an alert when the water level crosses a fixed threshold, but this may give very short warning if the water is rising quickly. Studies have shown that the rate of rise is a valuable early indicator, since a rapid increase suggests that dangerous levels will be reached soon even if the current level is still moderate. Rainfall intensity measured by tipping-bucket gauges has also been used to anticipate rising water in small catchments and urban drains. Multi-level warning schemes, such as watch, warning, and danger, have been recommended so that residents can prepare progressively and are not exposed to unnecessary panic. Machine learning models trained on historical level and rainfall data have been explored for short-term prediction of water levels at monitored points. These models were reported to be useful for lead times of a few hours but required several seasons of local data before they became reliable.

The dissemination of warnings to the public has been studied as a critical final step. Research has found that warnings are most effective when they reach people through several channels, including sirens, loudspeakers, SMS, mobile applications, and community volunteers, and when they contain clear information about the location and expected severity. Local sirens are important because they work without phones or networks and can reach people who are asleep. Cloud-based dashboards with map views help authorities coordinate responses across several locations. Recent IoT flood systems combine these elements, and authors emphasise solar power, battery backup, and robust enclosures for field nodes. The system presented in this paper integrates ultrasonic and float-based level sensing, rainfall and flow measurement, rate-of-rise analysis, LoRa and GSM communication, local sirens, and a cloud platform with multi-level alerts.

III. SYSTEM ANALYSIS

The smart flood detection and alert system is analysed as a network of field nodes, a communication backbone, and a cloud warning platform. Each field node is mounted on a pole or bridge above a river, canal, or drain and contains a waterproof ultrasonic sensor facing the water surface, a float switch at the danger level, a tipping-bucket

rain gauge, a flow sensor in drains, and a DHT22 for temperature compensation. An ESP32 samples the sensors, applies median filtering, converts distance to water level, and computes the rate of rise over a moving window. It combines level, rate of rise, and recent rainfall to assign a local risk level and immediately drives a siren and warning lights when danger is detected. Data packets are transmitted through an SX1278 LoRa module to a gateway, and a SIM800L GSM module sends direct SMS alerts if the gateway is unreachable. Each node runs on a solar panel with a lithium battery. The gateway forwards data by MQTT to the cloud, which stores readings, shows a map dashboard, and sends alerts to registered users.

Existing System

In many regions, flood monitoring is carried out manually by staff who read staff gauges at bridges and river banks at fixed times and report the readings to control rooms by telephone or wireless radio. Readings may be taken only a few times a day, and during heavy rain the observers themselves may be unable to reach the gauge safely. Small streams, canals, and urban drains are generally not monitored. Warnings are issued by officials through announcements, local media, or village heads, and they may reach residents late or not at all, particularly at night. Some automatic gauge stations exist on major rivers, but they are expensive and few in number. Low-cost prototypes described in academic projects often rely on a single sensor with a fixed threshold and on SMS alone, and they stop functioning when mobile networks or power fail. There is little historical data at local level to help authorities understand flood patterns and plan drainage or evacuation.

Disadvantages of Existing System

- Water levels are read manually only a few times a day.
- Observers cannot safely reach gauges during heavy rain and flooding.
- Small streams, canals, and urban drains are usually not monitored.
- Warnings reach residents late, especially at night.
- Fixed level thresholds give little warning when water rises quickly.
- Automatic gauge stations are expensive and sparsely installed.
- SMS-only systems fail when the mobile network is unavailable.
- Field devices stop working when mains power fails during storms.
- Authorities lack a live map of water levels across locations.
- No local historical data is kept for planning and analysis.

Proposed System

The proposed system is an IoT based network of solar powered flood monitoring nodes that detect rising water early and deliver alerts through several channels. Each node uses an ESP32 with an ultrasonic level sensor, a float switch as backup, a rain gauge, a flow sensor, and a temperature sensor for compensation. The node filters readings, calculates water level and rate of rise, and combines them with rainfall intensity to assign one of three warning levels, namely watch, warning, and danger. At the danger level the node sounds a siren and flashes warning lights immediately, without waiting for any network response. Readings are sent through LoRa to a gateway that can serve many nodes over several kilometres, while a GSM module sends SMS alerts directly when the gateway cannot be reached. The gateway publishes data by MQTT to a cloud platform that stores readings, displays node positions and water levels on a map, and sends SMS, app, and email alerts to residents and officials.

Advantages of Proposed System

- Monitors water level and rainfall continuously at vulnerable locations.

- Uses rate of rise to give earlier warning than fixed thresholds alone.
- Provides three warning levels so people can prepare progressively.
- Sounds local sirens that work even without network or phones.
- Uses LoRa to cover remote sites over several kilometres at low power.
- Sends backup SMS alerts through GSM when the gateway is unreachable.
- Runs on solar power with battery backup during power failures.
- Shows a live map of water levels to disaster management officials.
- Stores historical data for flood analysis and drainage planning.
- Built from affordable components suitable for villages and towns.

IV. METHODOLOGY

The methodology begins with the identification of monitoring locations and the measurement of normal, warning, and danger water levels at each site with the help of local records. The field node is assembled with the ESP32, sensors, LoRa and GSM modules, siren, lights, solar panel, and battery in a weatherproof enclosure. The ultrasonic sensor is calibrated against a measured scale, and temperature compensation is applied to correct the speed of sound. The firmware samples the sensors every few seconds, takes the median of several readings, converts distance to water level, and computes the rate of rise over a moving window. Rainfall is measured by counting rain gauge pulses. A rule set combines level, rate of rise, and rainfall to determine the warning level, which drives the siren and lights locally. Data packets are sent through LoRa to the gateway, which publishes them by MQTT to the cloud, and GSM is used as a fallback. The cloud dashboard and alert service are configured, and the system is tested using a model channel with controlled water inflow and simulated rainfall.

SYSTEM ARCHITECTURE

The architecture of the flood detection and alert system is arranged in layers that move information from the water body to the people at risk. The Sensing Layer includes the ultrasonic level sensor, float switch, rain gauge, flow sensor, and temperature and humidity sensor at each field node. The Edge Processing Layer on the ESP32 filters readings, computes water level and rate of rise, and measures rainfall intensity. The Risk Assessment Layer combines these values to assign watch, warning, or danger levels. The Local Alert Layer drives the siren and warning lights at the node. The Power Layer consists of the solar panel, charge controller, and battery. The Communication Layer transmits data through LoRa to a gateway and uses GSM for fallback SMS. The Gateway and Cloud Layer receives data through MQTT, stores readings, and applies alert rules across nodes. The Application Layer provides a map-based dashboard for officials and delivers SMS, app, and email alerts to residents.

iot based smart flood detection and alert system

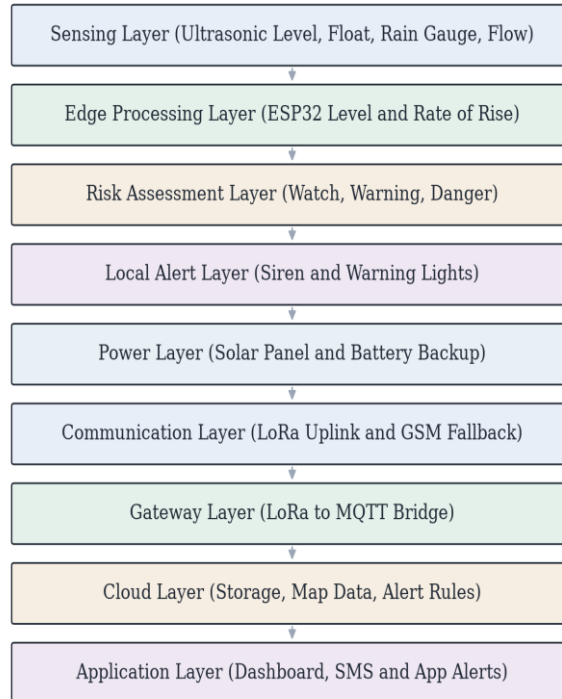
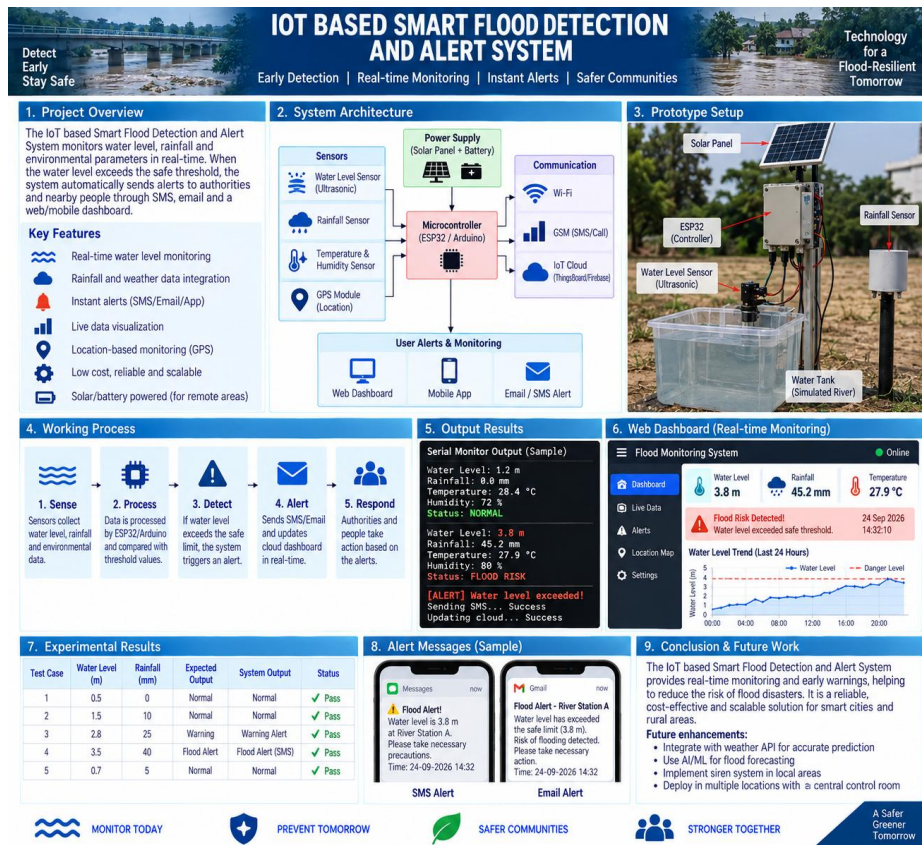


Fig. 1 System Architecture

V. RESULT AND OUTPUT



VI. CONCLUSION

This paper presented an IoT based Smart Flood Detection and Alert System that monitors water levels and rainfall at vulnerable locations and warns residents and authorities automatically when flood risk increases. The system uses solar powered field nodes with ultrasonic and float-based level sensing, rainfall and flow measurement, and an ESP32 controller, and it communicates through LoRa, GSM, and a cloud platform. Each node is self-contained and can be mounted on an existing bridge, culvert, or pole without civil works.

The use of rate of rise together with water level and rainfall allowed the system to identify dangerous conditions earlier than a fixed level threshold alone. The three-level warning scheme of watch, warning, and danger gives people time to prepare progressively, reducing both late warnings and unnecessary panic. Testing with a model channel and simulated rainfall showed that the system detected rising water reliably and classified warning levels correctly. Alerts reached registered phones within a few seconds of a threshold being crossed.

The design pays particular attention to reliability during severe weather. Local sirens and warning lights operate independently of any network, LoRa communication covers remote sites without relying on mobile internet, GSM provides a backup alert path, and solar power with battery storage keeps nodes running during power failures. The cloud dashboard provides officials with a live map of water levels across all monitored locations, supporting coordinated response and evacuation. Node health reporting, including battery voltage and last contact time, helps maintenance staff find and repair faulty units before the monsoon season begins.

Future work will include short-term flood prediction using machine learning models trained on historical level and rainfall data together with weather forecasts, integration with official early warning services, and the addition of camera-based verification of flooding at critical points. Larger deployments along entire streams and urban drainage networks will allow the system to track how floods move through an area. Long-term field trials during monsoon seasons will be needed to evaluate durability and refine warning thresholds for each location.

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