

FLOODSENSE: An Interactive Data-Driven Flood Forecasting using Dashboard

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ABSTRACT: Floods are among the most destructive natural disasters worldwide, causing severe damage to infrastructure, loss of life, and economic disruption. In India, many regions frequently experience flooding due to heavy rainfall, river overflow, and inadequate early warning systems. Existing monitoring approaches often face challenges such as delayed information sharing, limited real-time monitoring, and poor visualization tools, which hinder timely decision-making during flood events. This study introduces FloodSense, an interactive data-driven flood forecasting dashboard designed to enhance disaster preparedness and response. The system provides real-time river water level monitoring, geographic visualization of vulnerable areas, and scenario-based simulations to support planning and risk assessment. Developed using modern web technologies, FloodSense integrates spatial data into a dynamic and user-friendly interface with interactive maps and color-coded alerts to indicate potential flood risks. By enabling authorities and emergency responders to monitor flood conditions in real time, FloodSense supports faster decision-making and improved coordination during emergencies. The platform also includes simulation features for training and preparedness evaluation. This paper presents the design, architecture, and key functionalities of FloodSense and discusses its potential to improve early warning systems and disaster response planning in flood-prone regions.

KEYWORDS: Flood forecasting, real-time data visualization, geographic mapping, interactive simulation, meteorological data, early warning.

I. INTRODUCTION

Floods are among the most devastating natural disasters, affecting millions of people yearly and causing extensive damage to infrastructure and livelihoods. In India, annual floods affect over 7.5 million hectares of land and result in more than 1,600 fatalities on average. Monsoon rains, river overflow, and cyclones contribute to frequent flood events. Despite advances in weather forecasting, many regions lack real-time, actionable monitoring tools. Official flood bulletins (e.g., from India's Central Water Commission, CWC) typically provide tabular warnings of high-risk stations, which can be hard to interpret quickly by emergency staff. There is a clear need for systems that translate raw hydrological data into intuitive, spatially-aware insights.

Problem Statement: Current flood monitoring systems exhibit several limitations: (a) Delayed updates – traditional data sources (like CWC) are often updated only periodically (e.g., every 2 hours), delaying alerts; (b) Lack of spatial context – textual or static reports do not highlight where flooding is imminent on a map; (c) Limited interactivity – users cannot easily test scenarios (e.g., "if river X rises 1m, which areas flood?"); (d) Fragmented data – river-level, rainfall, and soil data often reside in separate silos. These issues hinder timely, coordinated response. For instance, by the time authorities read a textual report, the situation on the ground may have changed.

We propose FloodSense, an interactive flood forecasting dashboard that addresses these gaps. FloodSense continuously pulls river level data (treating each CWC gauge as a "virtual sensor"), classifies risk levels, and updates a web-based map in near-real time. The interface allows decision-makers to visualize flood risk geographically, identify critical sites

quickly, and simulate flood events by adjusting water levels. The system is built with widely-used web technologies (Leaflet.js for mapping, Python for data processing) to maximize usability and extensibility. FloodSense improves situational awareness and enables data-driven coordination among agencies. The primary data source is the CWC flood portal (India), but the system could ingest any compatible gauge data.

II. LITERATURE REVIEW

Flood forecasting has been an important area of research in hydrology and disaster management for several decades. Traditional flood prediction techniques are primarily based on physical hydrological models that simulate rainfall-runoff processes and river flow dynamics. These models rely on mathematical representations of watershed characteristics, precipitation patterns, and soil conditions to estimate river discharge and potential flooding events. Several studies have explored the use of hydrological simulation models such as HEC-RAS and MIKE FLOOD for predicting river water levels and floodplain inundation.

These models are widely used in engineering applications but often require detailed topographical data and computationally intensive simulations. As a result, their deployment for real-time monitoring can be challenging in regions with limited technical infrastructure. Recent research has focused on improving flood forecasting systems using data-driven approaches and modern information technologies. Machine learning methods have been increasingly applied to hydrological prediction tasks, enabling models to identify complex relationships between rainfall, river flow, and flood events. For example, recurrent neural networks and long short-term memory (LSTM) architectures have demonstrated strong performance in time-series prediction tasks related to river discharge and rainfall forecasting.

In addition to predictive modelling techniques, geographic information systems (GIS) have played a critical role in flood monitoring and disaster management. Web-based GIS platforms allow researchers and decision makers to visualize spatial patterns of flooding and analyse environmental conditions across large geographic regions. Interactive mapping tools such as Leaflet and Open Layers have become widely used for developing web-based spatial applications due to their flexibility and open-source nature. Several studies have also explored the integration of hydrological data with real-time monitoring systems. These systems often rely on sensor networks, satellite observations, and meteorological datasets to detect potential flood conditions. By combining multiple data sources, such platforms can improve situational awareness and support early warning mechanisms.

Despite these advancements, many flood monitoring systems remain difficult to access or require specialized technical knowledge. Furthermore, the lack of centralized dashboards that integrate hydrological data with intuitive visualization tools continues to limit the effectiveness of flood risk communication. The FloodSense platform builds upon these research developments by integrating publicly available hydrological datasets with web-based GIS technologies. Rather than focusing exclusively on predictive modelling, the system emphasizes data accessibility, real-time visualization, and decision support, enabling disaster management authorities to quickly interpret river conditions and identify flood-prone areas.

III. PROPOSED METHODOLOGY

FloodSense is designed as a data-driven flood monitoring and visualization platform that utilizes publicly available hydrological data to identify potential flood risks. The proposed methodology consists of four primary modules: (A) Data Acquisition, (B) Data Processing, (C) Flood Risk Assessment, and (D) Visualization and Decision Support. Each module performs a specific role within the overall system pipeline and collectively enables the real-time monitoring of river conditions.

A. Data Acquisition Module

The data acquisition module is responsible for collecting hydrological information from the Central Water Commission (CWC) river monitoring network. The CWC maintains numerous river gauge stations across India that continuously monitor water levels and discharge rates in major rivers. These measurements are publicly available through the CWC online portal and are typically updated at intervals of approximately two hours. Within the FloodSense framework, automated scripts developed in Python periodically retrieve water level data from the CWC website. The collected dataset includes information such as river station name, geographic coordinates, observed water level, and predefined warning or danger levels.

B. Data Processing Module

The data processing module performs data cleaning, transformation, and analysis operations to convert raw hydrological measurements into actionable insights. Once the water level data are retrieved, the system applies preprocessing techniques such as data validation, removal of incomplete records, and normalization of measurement units. After preprocessing, the system compares the observed river water levels with predefined flood thresholds including safe level, warning level, and danger level. These thresholds are typically defined by hydrological authorities based on historical flood behaviour of each river basin. The Python backend performs these calculations and stores the processed information in a structured dataset.

C. Flood Risk Assessment Module

The flood risk assessment module evaluates river conditions and identifies locations where flooding is likely to occur. The system analyses processed water level data and determines the severity of risk using predefined thresholds. When the observed water level approaches or exceeds the warning level, the system flags the station as a potential flood-prone location. This module enables disaster management authorities to quickly identify emerging flood threats without manually analysing large datasets. The classification results also serve as the basis for generating alerts and visual indicators on the dashboard interface.

D. Visualization and Decision Support Module

The final stage of the methodology focuses on presenting the analysed data through an interactive visualization interface. The FloodSense dashboard is developed using HTML, CSS, and JavaScript, while Leaflet.js is used for rendering geospatial maps. Each river monitoring station is displayed on the map as a marker with a color-coded indicator representing its flood risk status. Green markers indicate safe water levels, yellow markers indicate warning levels, and red markers indicate critical flood conditions. Users can click on individual markers to view additional details such as station name, current water level, and risk classification.

IV. SYSTEM ARCHITECTURE

The FloodSense architecture is designed as a modular web-based system that integrates data acquisition, processing, and visualization components. The architecture consists of several interconnected layers that collectively support real-time flood monitoring and risk assessment.

A. Data Collection Layer

The data collection layer is responsible for retrieving hydrological data from external sources, particularly the CWC river monitoring system. Python-based scripts periodically access the CWC website and extract updated river water level information. Because the CWC database updates approximately every two hours, the system maintains near real-time monitoring capabilities. The collected data are stored in a structured format that includes station identifiers, river names, geographic coordinates, and recorded water levels.

B. Backend Processing Layer

The backend processing layer forms the analytical core of the FloodSense system. This layer is implemented using Python, which handles data preprocessing, flood risk analysis, and database management. The backend scripts process incoming water level measurements and compare them against predefined threshold values associated with each monitoring station. If the water level exceeds the warning threshold, the system classifies the station as a potential flood risk location.

C. Database and Data Management Layer

The database layer stores both raw and processed hydrological data. This includes historical water level measurements, station metadata, and flood risk classifications. The database enables efficient retrieval of information required for generating visualizations and performing trend analysis. Maintaining historical data also allows the system to analyse patterns of river behaviour over time, which can support future improvements such as predictive flood modelling.

D. Visualization Layer

The visualization layer represents the frontend interface of the FloodSense platform. It is developed using HTML5, CSS3, and JavaScript, while Leaflet.js enables the system to display river monitoring stations as dynamic map markers.

Each marker reflects the current flood risk status based on the processed data provided by the backend. Users can interact with the map by zooming, panning, and selecting markers to view detailed station information.

E. User Interface Layer

The user interface layer provides a centralized dashboard through which users interact with the system. The dashboard includes a sidebar panel displaying a list of monitoring stations, water level readings, and alert notifications. Through this interface, disaster management authorities and emergency response teams can monitor river conditions, identify flood-prone areas, and make informed decisions regarding evacuation or resource allocation. The design emphasizes clarity and accessibility to ensure that critical information can be interpreted quickly during emergency situations.

V. RESEARCH OUTCOME

The development and implementation of the FloodSense platform demonstrate the practical feasibility of integrating open hydrological datasets with modern web-based visualization technologies for flood monitoring applications. By utilizing river water level data obtained from the CWC, the system successfully converts raw hydrological measurements into meaningful visual insights that can support disaster management authorities in identifying potential flood risks.

During the implementation phase, the platform was tested using multiple river monitoring stations whose data are periodically updated through the CWC database. Since the CWC updates river water level information approximately every two hours, the FloodSense system provides near real-time monitoring of river conditions. The Python-based backend effectively retrieves and processes this data, while the visualization layer dynamically updates the map interface to reflect the latest water level measurements.

The results indicate that the use of color-coded geographic markers significantly improves the interpretability of river monitoring data. Instead of analysing raw numerical values from multiple stations, authorities can quickly identify flood-prone locations through visual indicators displayed on the interactive map. Stations approaching critical water levels are highlighted using red markers, allowing decision makers to immediately recognize areas that may require urgent attention.

Another important outcome is the improvement in situational awareness during flood monitoring operations. Traditional monitoring approaches often rely on static reports or tabular data formats, which can make it difficult to interpret conditions across multiple locations simultaneously. In contrast, the FloodSense dashboard presents monitoring stations within a unified geographic interface, enabling authorities to observe river behaviour across an entire region in a single view.

The platform also demonstrates the advantages of using web-based geospatial technologies such as Leaflet.js for disaster management applications. Because the interface is accessible through standard web browsers, the system can be deployed in control rooms, administrative offices, or field monitoring environments without requiring specialized software installations. Furthermore, the modular architecture provides opportunities for future expansion — additional datasets such as rainfall forecasts, satellite imagery, or IoT-based river sensors can be integrated to enhance predictive capabilities.

VI. CONCLUSION

FloodSense demonstrates a modern approach to flood monitoring by uniting real-time data, GIS mapping, and interactive tools into a coherent platform. Built on open web standards, it provides disaster managers with an intuitive view of flood risk — mapping each monitored station, color-coded by danger level. Our prototype shows that even a simple threshold-based system can deliver timely and accurate alerts with low latency. The inclusion of simulation tools addresses a key gap in many systems, enabling proactive planning.

By adhering to a layered, extensible architecture, FloodSense is ready for future enhancements including IoT sensor networks and AI-driven forecasts. We emphasize the importance of accessibility (web-based, no special software) and usability (clear visuals and interaction) in crisis contexts. In conclusion, FloodSense contributes a practical, scalable solution for flood preparedness and response. Its deployment could help authorities identify threats faster, coordinate

resources more effectively, and ultimately save lives and property during flood events. Future enhancements including sensors, deep AI algorithms, and mobile deployment will further boost its capabilities. By making complex flood data accessible and actionable, FloodSense aims to support safer, more resilient communities in flood-prone regions.

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