IMPLEMENTATION OF INTEGRATED GEOSPATIAL PLATFORM, DATABASE, AND APPLICATION FOR DISASTER RISK MANAGEMENT IN UTTARAKHAND

Ashok Dahal, Pratichhya Sharma, and Dr. Manzul Kumar Hazarika

Geoinformatics Center, Asian Institute of Technology, P.O. Box 4, Klong Luang, Pathumthani 12120, Thailand
Email: kavreliashok@outlook.com; pratichhya@ait.asia; manzul@ait.asia

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ABSTRACT: Natural Hazard possesses greater risks due to increasing exposures and vulnerabilities of the elements-at-risk and the this may even be further aggravated as a result of climate change. For effective and efficient decisions-making during a disaster, a proper flow of information is vital for carrying out the evacuation, rescue and response operations. A Decision Support System (DSS) was developed and being implemented in the state of Uttarakhand in India as a proactive strategy for disaster risk reduction. The state of Uttarakhand is primarily exposed to earthquakes, floods, and landslides (in addition to avalanches, hailstorm, glacial lake outburst floods, lightning storms, and forest fires) and the platform can create a Common Operating Picture for an effective response. It includes hazard monitoring, alerting, and responding to incidences. The platform was developed as a user-friendly and collaborative platform to support the Emergency Operation Center of the state of Uttarakhand to support informed decision-making. The DSS was implemented in a web-based platform with the integration of a wide range of geospatial data from different sources. Along with existing baseline data, weather forecast data and field-observed data were integrated with OGC services. Further, other available Geospatial data were, extracted, transformed, standardized and integrated into the database. A system administration window was developed for the data linking process and uploading of all the available data. We reviewed the available existing best practices and methodologies for developing and operating the DSS to come up with a workflow for disaster monitoring, evacuation planning, shelter management etc. within the DSS.

INTRODUCTION

The occurrence of natural disasters with the disruption in the balance of environment causes climate change affecting human, material, economic, or environmental situational of the scene. During such events information acts as a vital component in disaster risk management and needs to be organized and circulated systematically. The efficient and effective flow of situational information during a disaster, among and within an organization is required for maintaining coordination among disaster response responsible authorities.

Uttarakhand a state of India known for its natural and religious environment, lies in the foothills of the Himalayan mountains ranging between latitudes 28°43' N to 31°27' N and longitudes 77°34' E to 81°02' E. Human-induced environmental pressure in Uttarakhand contributes to the vulnerability to cause numerous disasters. Earthquakes, floods, landslides, avalanches, cloudburst, hailstorm, glacial lake outburst floods, lightning storms, forest fires are all types of disasters that affect Uttarakhand.

The Decision Support System (DSS) for disaster management in Uttarakhand is designed that can work on the disaster monitoring, management and response in addition to information sharing with disaster volunteer centers, etc. Various data like base-line data (e.g., topography, human settlements, critical facilities, road network, river network etc.), forecast data (e.g., weather forecasts), and field-observed data (e.g., river discharges) were added to the system. The platform was developed as a user-friendly platform to support Emergency Operation Centers as well as decision-makers involved in disasters risk management. This system allows decision-makers to spatially analyze the data and get possible geographic information during a disaster.

OBJECTIVES

1) Implement a single, secure, and scalable geospatial platform, which is accessible across locations, devices, agencies, and applications for reporting, monitoring, and responding to disasters in Uttarakhand;
2) Extract and standardize geospatial data and models from existing systems at Uttarakhand State Disaster Management Authority and other Uttarakhand government agencies and make them available through into the consolidated geospatial database;
3) Connect real-time data sources from the state, central, and international sources into the geospatial platform, which can be continuously updated and augmented by Uttarakhand State Disaster Management Authority;
4) Deploy device-independent geospatial applications for Emergency Operating Centers, government agencies, decision-makers, and field staff to help them, monitor, report, analyzes, and respond to emergencies and disasters in the state;
5) Create configurable GIS services and interfaces for quick deployment of visualization, modelling, analytics, and application development.

SYSTEM OVERVIEW

The system is developed under the GNU GPL Version 4 License and will be mainly managed by Uttarakhand State Disaster Management Authority (USDMA) and the district level disaster management authorities. They will use the system for disaster management activities as well as data sharing. Moreover, during a disaster, each government organization will have unique roles and responsibilities and we have incorporated all these by developing organization-specific user interfaces in the system.

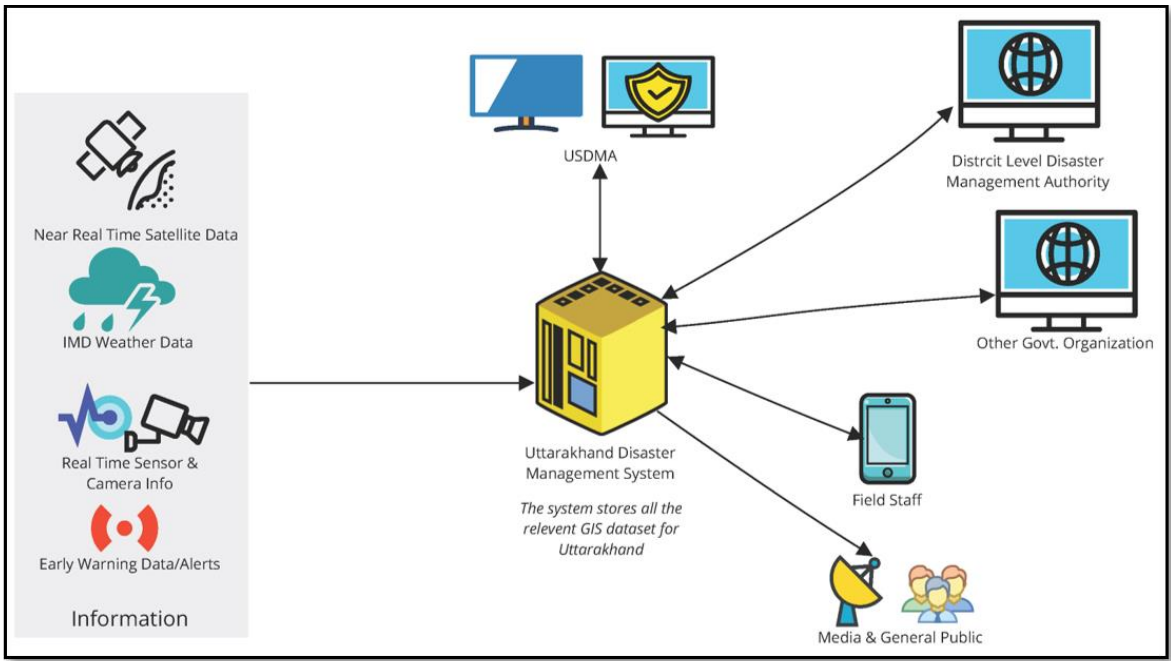

Figure 1: System Overview

Thus, the system recognizes each organization through their log-in credentials and display only the organization-specific menus. The system-administrator can decide the menu order based on the standard operation procedure (SOP) of each organization.

All the data coming from different sources to the system are extracted, standardized, transformed and uploaded to the system database as shown in Figure 1. These include baseline data, forecast data and field-observed data. The baseline data are available in the platform and can be updated by the system-administrator as new data gets available. Real-time data from different sensor networks, earth observation satellites, monitoring stations are extracted, and these are then disseminated to the State Emergency Operation Centre (SEOC) and District Emergency Operation Centers (DEOCs) using ETL tools in real-time.

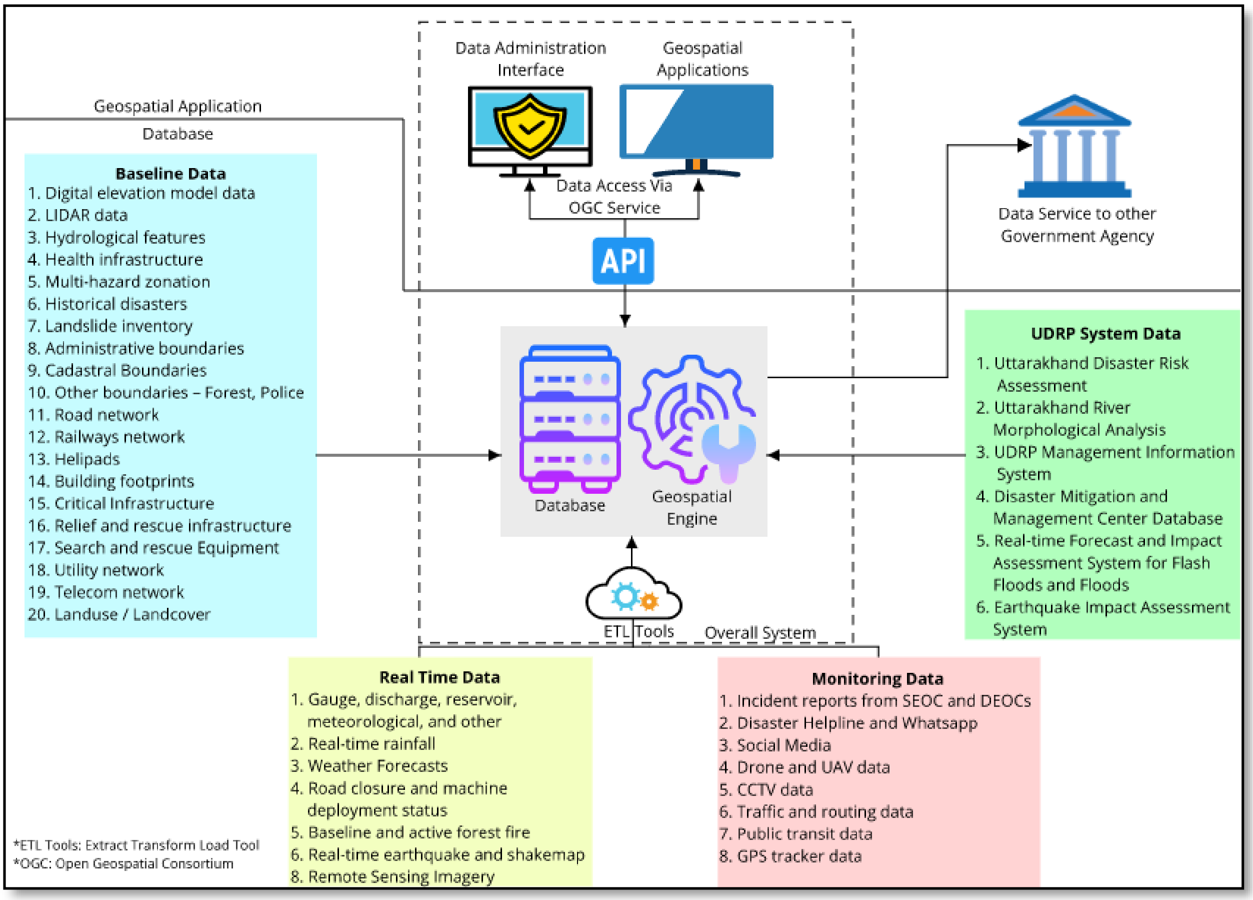

Figure 2: System Framework

For the easy and secure administration of the platform, there are two interfaces; (1) Data Administration Interface and (2) Disaster Management System Interface (Geospatial Application). The Data Administration Interface is maintained by the system administrator(s) to manage the data layers, access levels and API authentications. This interface allows to create, update or remove a database, user access, maps, layers and styles and cannot be accessible by ordinary users who don't have authorized username and password. The Disaster Management System Interface is used by the different organization for extracting, geo-tagging and displaying different disasters alerts, monitoring the disaster, preparing disaster response plan, field operations and have specific access levels as specified by the system administrator(s).

This Disaster Management System Interface has two types of login - Normal situation and Emergency situation. In a normal situation, the user can login and visualize all the data and manage them but cannot make any modifications. When an alert is generated by the system based on the real-time information, the system-administrator can activate it as an emergency upon verification with the ground staff, which will enable the users to act upon the specific disaster and edit the information. In emergency mode, the decision-makers can activate the disaster management plans and instruct to follow the standard operating procedures (SOP's) including monitoring of the available resources on the ground and mobilization of required resources according to the need. Components of this interface are arranged in a menu in which each component will have sub-components with task-lists to be followed during an emergency operation. A task-list is designed based on the SOP defined for each organization. The system has been designed in such a way that each component can be executed independently. Important components include the basic functionality of the system that can assist in monitoring and observation, providing situational information, disseminating evacuation instructions, collecting and reporting of damage information, activating rescue operations, activating shelter, routing vehicles etc. The System has a functionality to allow communicate with different organizations during disasters and give instructions through different means of communication including voice messages, SMS, e-mail and social-media.

The DSS design also incorporates log records and historical data for each change made on the system. This capability will allow administrative personnel to track the history of all DSS users to provide history, error identification, and accountability for system users.

SYSTEM ARCHITECTURE

The platform is designed to enable coordination and collaboration among different agencies and deploy resources, human resources, and expertise for mitigation, response, and recovery from different geophysical, hydro-meteorological, and man-made disasters. The overall architecture of the geospatial platform includes components to ingest data from various sources and manage them as a scalable and extensible database. Baseline data as basic statistics, UDRP data (containing modelled data for several disaster-prone in Uttarakhand), field-observed data coming in every 15 to 20 minutes and external data (mainly remote-sensing data derived maps) coming from various national and international sources. The geospatial engine renders those data from the database following the OGC standards, which is used by different API running on the platform. Geospatial applications developed has several working API with an authentication system to access the data stored in the database. The system is based on a relational database with its disaster management and decision support functions. Since the relational database cannot manage and render data in OGC standards, therefore a geospatial engine is used for this purpose. We have a database server supporting/ managing hundreds of various data sources from different organizations around the world as well as thousands of reports from public and government staff. All the data stored in the system is automatically synchronized to the cloud database (daily in a normal situation and hourly in a disaster situation. so that if any problem occurred in the server at USDMA, we could restore all the data changed before maximum one hour.

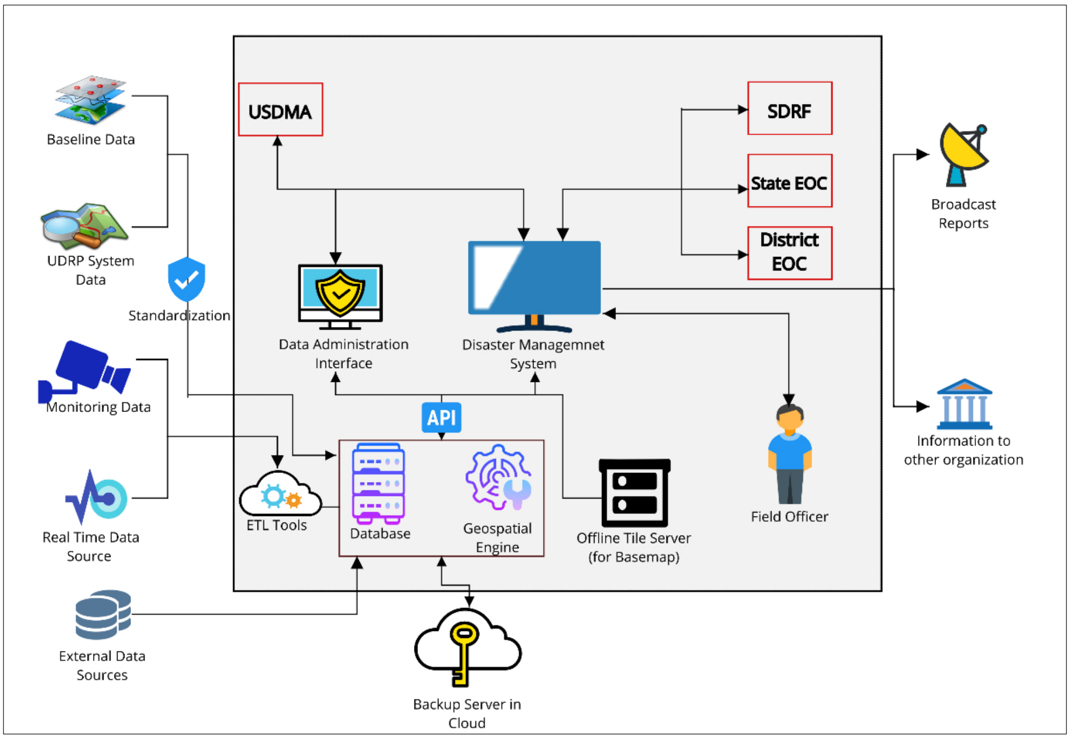

Figure 3: System Architecture

The database will be updated by USDMA, who is responsible for the system administration. The system administrator can manipulate the data including adding or deleting data as required. System administration can allow an user to access to Data Administration Interface and Disaster Management System. Disaster Management System can be accessed by the State Emergency Operating Center, the District Emergency Operating Center and other organizations authorized by the System Administrator. Field Officers can input and update the field situation in the system with an android mobile application using a QR code.

The proposed geospatial platform is reliable and secured and it is developed based on the following principles:

1) Support standard disaster response;
2) System design applicable to the actual circumstances of local and state disasters management authorities;
3) Unified management of information such as base maps, imagery, vector, digital elevation, real-time sensor data etc.;
4) Easy to understand interface;
5) Redundant system design to make the platform running even in worst-case scenarios;
6) Secured, device-independent and configurable
7) Support big data and field data collection and reporting etc.

The system can be accessed offline. To develop the offline system, we host a server with a local database in each district and synchronize it with the central server system at the USDMA. During internet connection breakdown, the system can be accessed via a local server, but the live data coming from the different organization will not be effective until the internet connection is restored. Any necessary modifications to the dataset can be made and these will then be synchronized to the central server system once the internet is restored.

DESIGN CONSTRAINTS

We have identified several constraints that may impact and limit the design of the tool. To date, the following constraints have been identified:

1) Standard Operating Procedures, policies and guidelines will impact the tool by requiring specific standards of coding, user interfaces, security, and management of the tool;
2) The Decision Support System must be compatible with existing user software suites;
3) Understanding of the system from a user perspective is very much essential during the disaster so that the menu and the workflow should be as simple as possible to make it easy to learn;
4) The system is designed in such a way that it can incorporate the various type of information for the management of the data available from different organization and proper utilization of it.

RESULT

A geospatial platform that integrates data from static and real-time data from different sources and having easy ETC for data integration is developed. DSS has an advance alert mechanism that sends an alert email to concerned authority when discharge exceeds High Flood Level (HFL), USGS sense Earthquake or IMD issues any warning. CAP alerting protocol is implemented in the system. Free Routing services has been developed and integrated as AIT routing service. The routing services discover the best possible most feasible route and an alternative path in case of road blockage. The service also provides isochrone service.

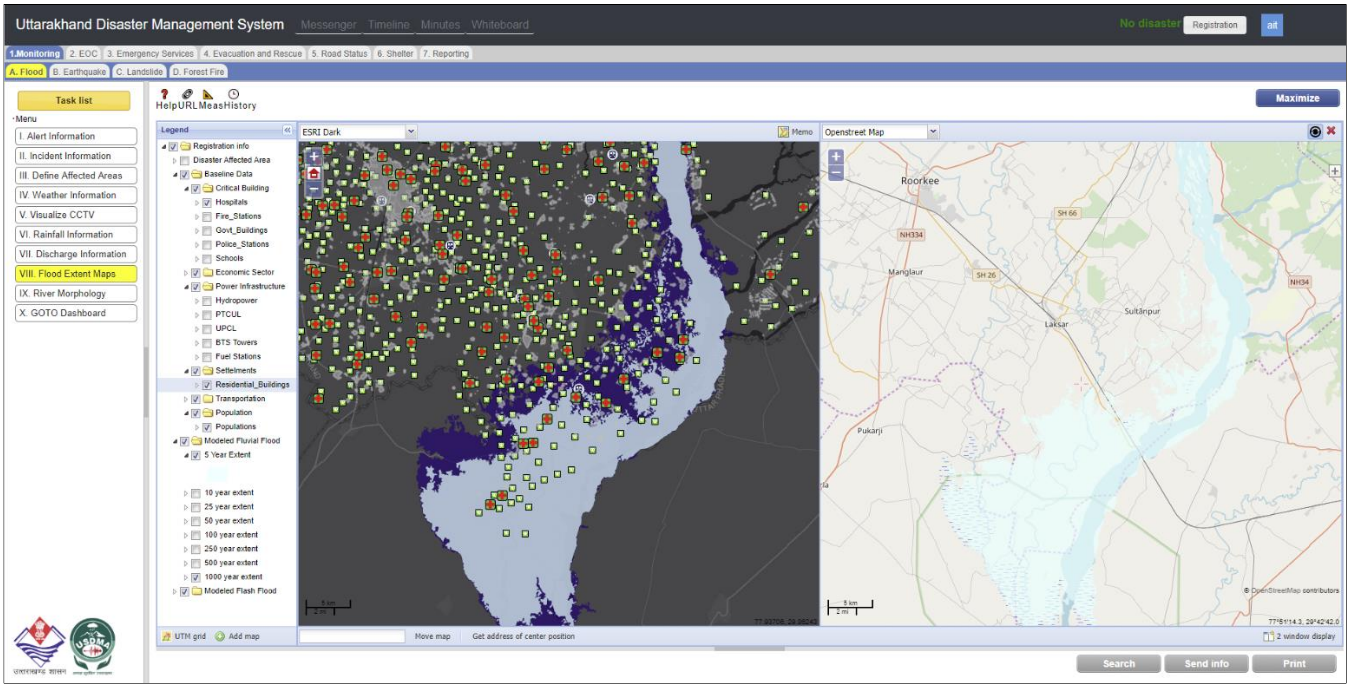

Figure 4: Geospatial Platform

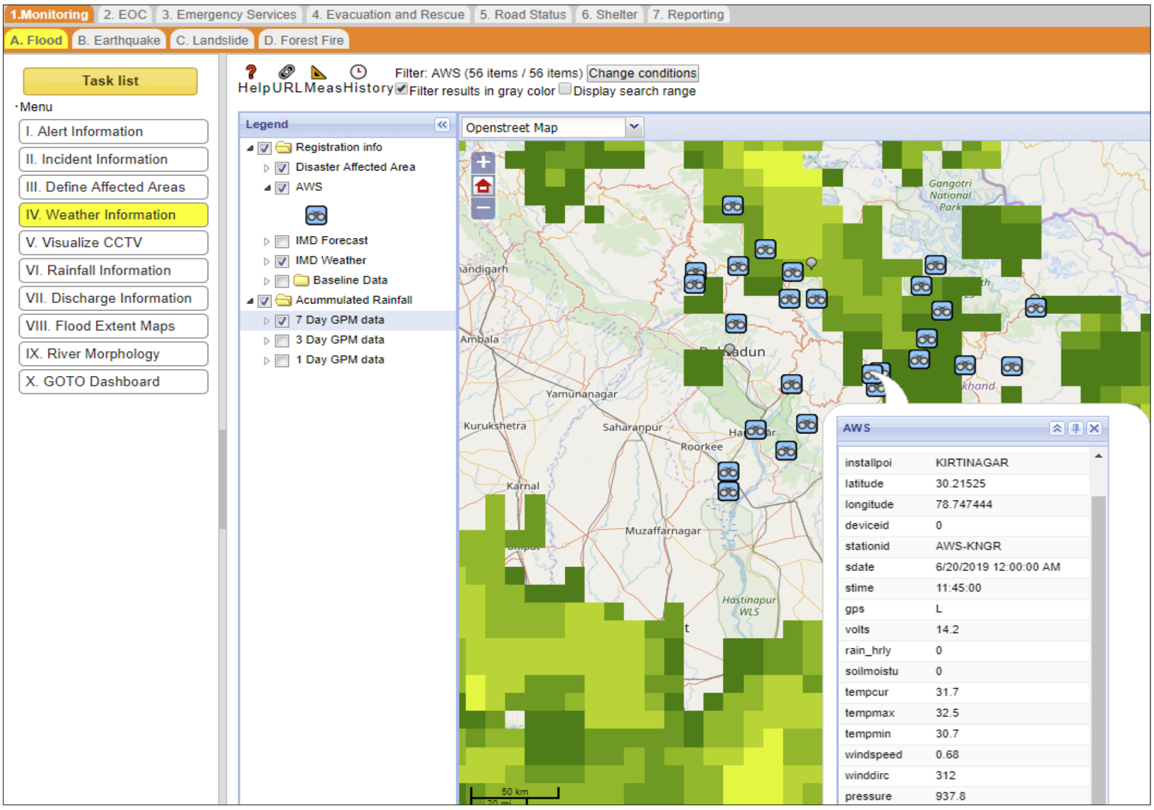

Figure 5: Real time Weather Information

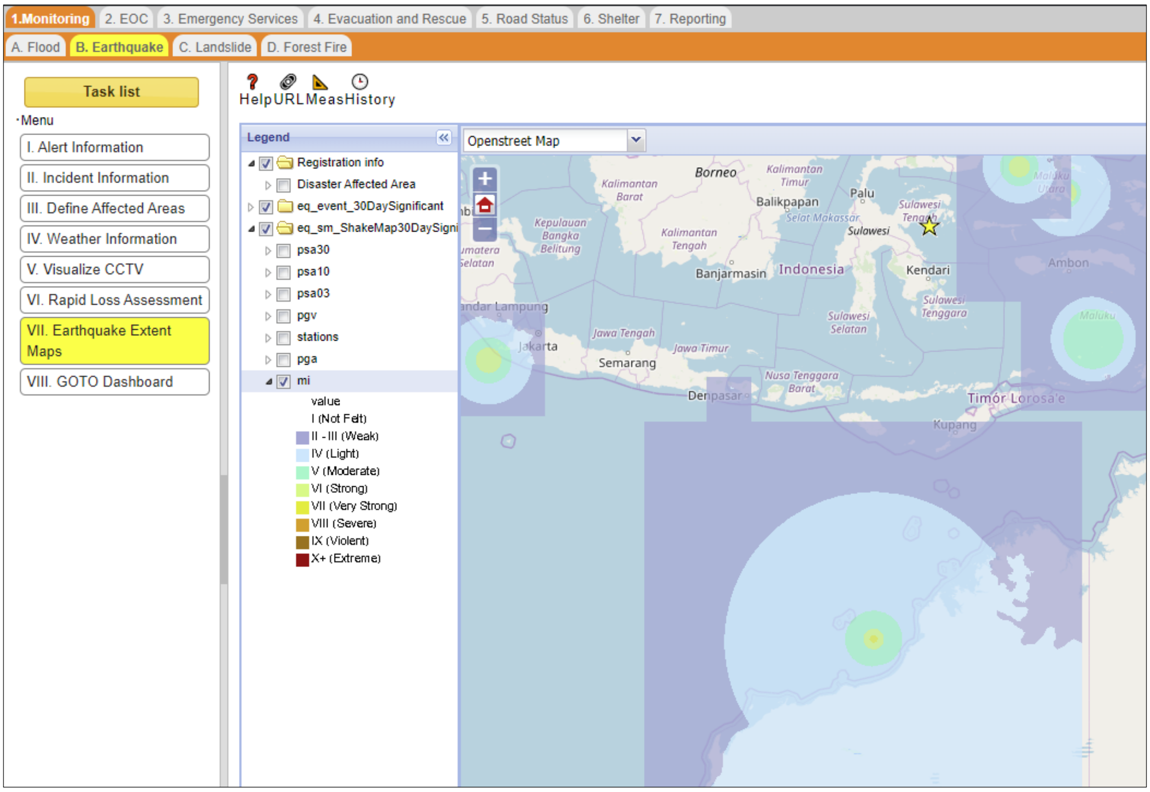

Figure 6: Real time Earthquake Extent Maps

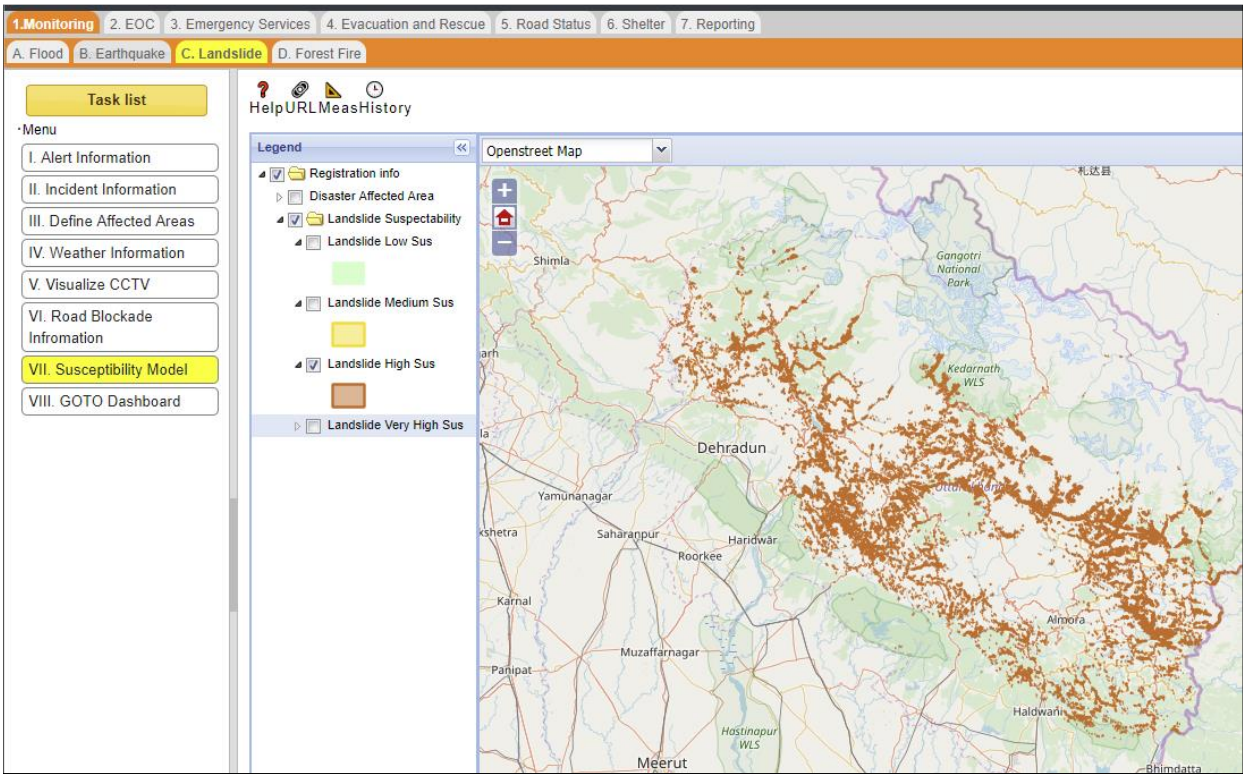

Figure 7: Landslide Susceptibility Model

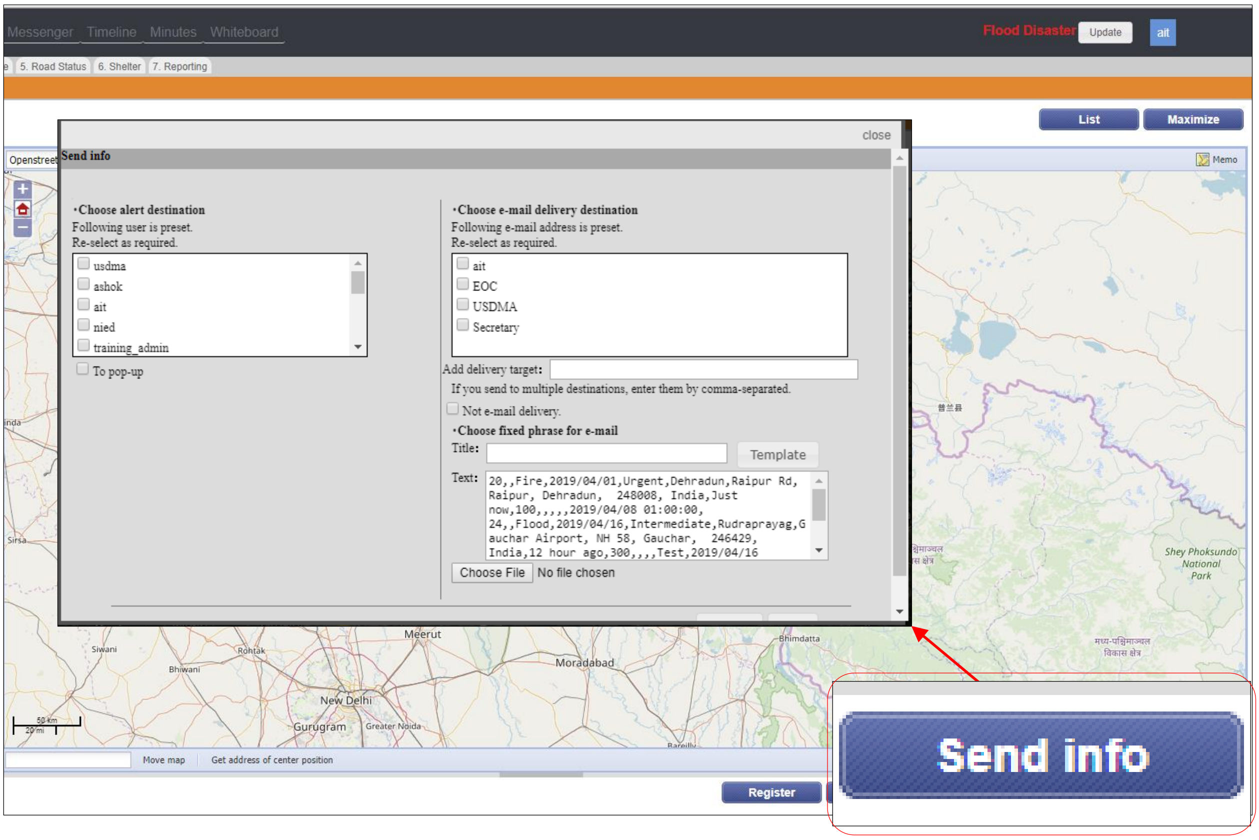

Figure 8: Mailing Feature in the System

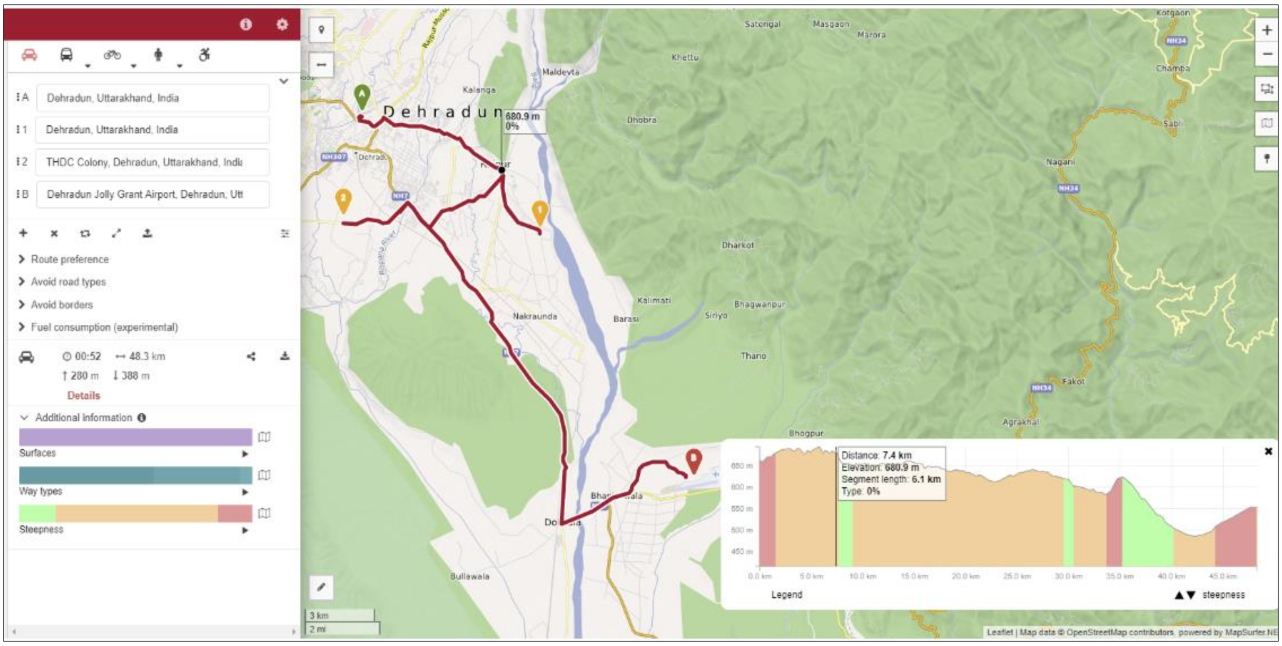

Figure 9: Routing System

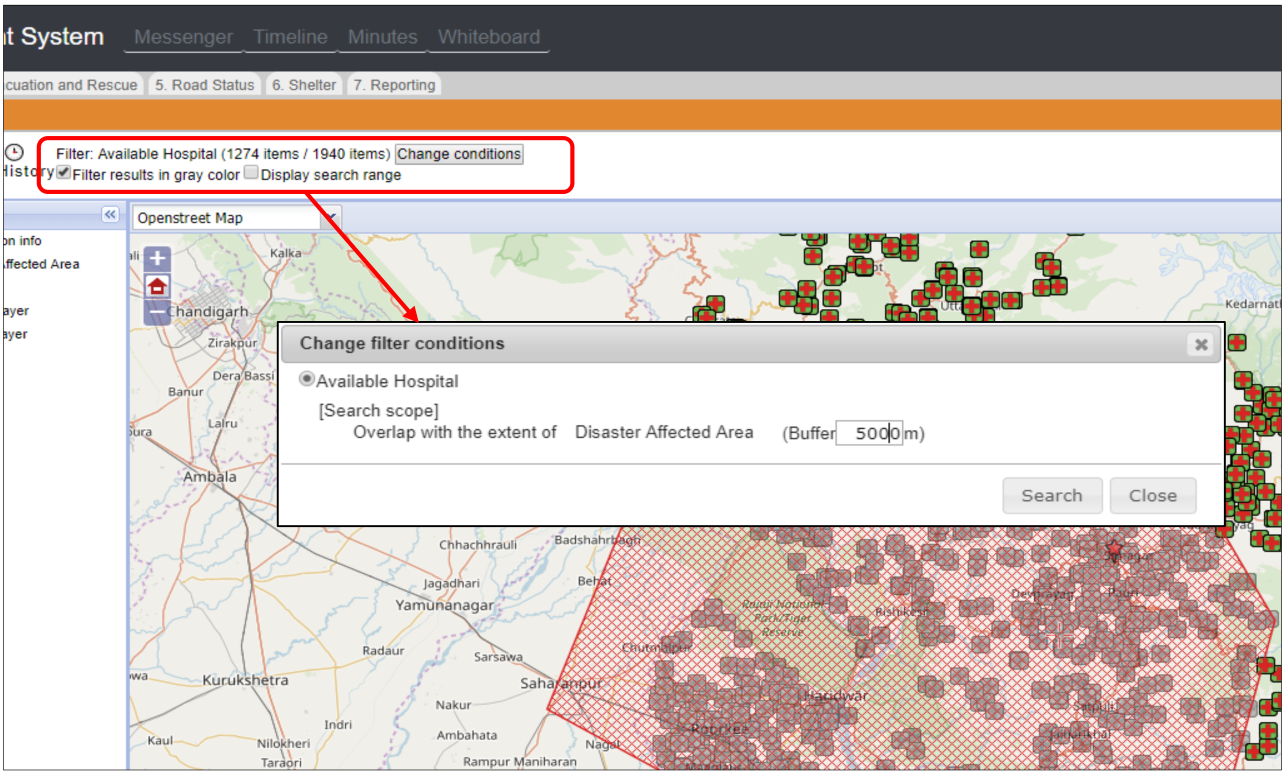

Figure 10: Filtering Functionality

This Decision Support System has menus that answer a question that decision-makers will have during a disaster and gives priority for what is essential. For users having good geospatial knowledge, they can perform geospatial as well as statistical data analysis in the system and are free to modify and implement the system as and when necessary as being an open-source system. An intelligent routing platform with multiple vehicle routing and road blockade management is developed in the system.

CONCLUSIONS

A single, secure, user-friendly and scalable geospatial platform, which is accessible across locations, devices, agencies, and applications for reporting, monitoring, and responding to disasters in Uttarakhand has been developed. The platform will support the Uttarakhand State Disaster Management Authority to monitor hazards, take appropriate measures for preparedness, and respond to disasters.

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