PARSHWANATH CHARITABLE TRUST'S

A.P. SHAH INSTITUTE OF TECHNOLOGY

Department of Computer Science and Engineering

Data Science

SAFER: System for Disaster Assessment and Forecasting of Emergency Risks using Geo-Spatial Data

Group No. 8

Sonal Sonarghare	21107033
Janhavi Kasar	21107030
Aman Dhumal	21107036
Vedant Mayekar	22207007

Project Guide

Prof. Anagha Aher & Prof. Ashwini Rahude

Contents

Abstract

Disaster management in Northeast India faces challenges like frequent natural disasters, inadequate infrastructure, limited real-time data, and poor communication systems. Resource constraints and insufficient emergency services further complicate preparedness and response efforts in the region.

The "System for Disaster Assessment and Forecasting of Emergency Risks using Geo-Spatial Data" (SAFER) offers an advanced solution by integrating geospatial data for accurate disaster assessment and forecasting. Its features include a voice-controlled interface for maps, real-time alerts and an intelligent ambulance booking system. SAFER improves disaster preparedness and response through precise data analysis and real-time information sharing.

Introduction

1. Problem Domain Overview

- **High Disaster Vulnerability:** The Northeastern region of India is highly prone to natural disasters such as floods, landslides, and more, due to its hilly terrain, fragile ecosystem, and heavy rainfall.
- **Severe Impact on Lives and Infrastructure:** These frequent disasters cause significant damage to lives, infrastructure, and the local economy, with disruptions being a common occurrence.
- **Examples of Recurrent Disasters:** For instance, annual floods in Uttarakhand lead to widespread displacement and property loss, while landslides regularly block transportation routes, cutting off essential services to isolated communities.

Introduction

2. Challenges in Current Disaster Management Systems

- **Poor Infrastructure:** Disasters often destroy roads and communication networks, delaying rescue efforts.
- **Lack of Real-Time Data:** Limited access to timely data hampers quick disaster prediction and response.
- **Fragmented Information**: Incomplete integration of geospatial data weakens disaster assessment accuracy.
- **Unreliable Communication:** Breakdowns in communication systems slow down coordination during emergencies.
- **Limited Resources:** Shortages in emergency services and medical assistance challenging.

Introduction

3. Current Solutions and Persisting Issues

- **Non-Intuitive Interfaces**: Complex systems make it difficult for non-expert users to operate in real-time scenarios.
- **Static and Incomplete Data**: Reliance on historical data and limited integration of real-time inputs hampers disaster prediction and tracking.
- **Lack of Real-time Information**: Inefficient distribution of updates delays crucial information to responders and the public.
- **Inadequate Ambulance Integration:** Many solutions lack seamless coordination between disaster forecasting and ambulance services, causing delays in medical aid.

Introduction

4. Motivation

- **Frequent Disasters**: Recurrent floods, landslides, and earthquakes in Northeast India highlight the need for improved disaster management.
- **Existing Limitations**: Current systems face delays in rescue operations due to poor communication, insufficient real-time data, and inefficient ambulance dispatch systems.
- **Complex Interfaces**: Existing solutions are difficult for non-expert users, especially in areas with low digital literacy.
- **Urgency for Improvement**: The need for real-time, user-friendly solutions to enhance emergency preparedness and reduce response times.

Objectives

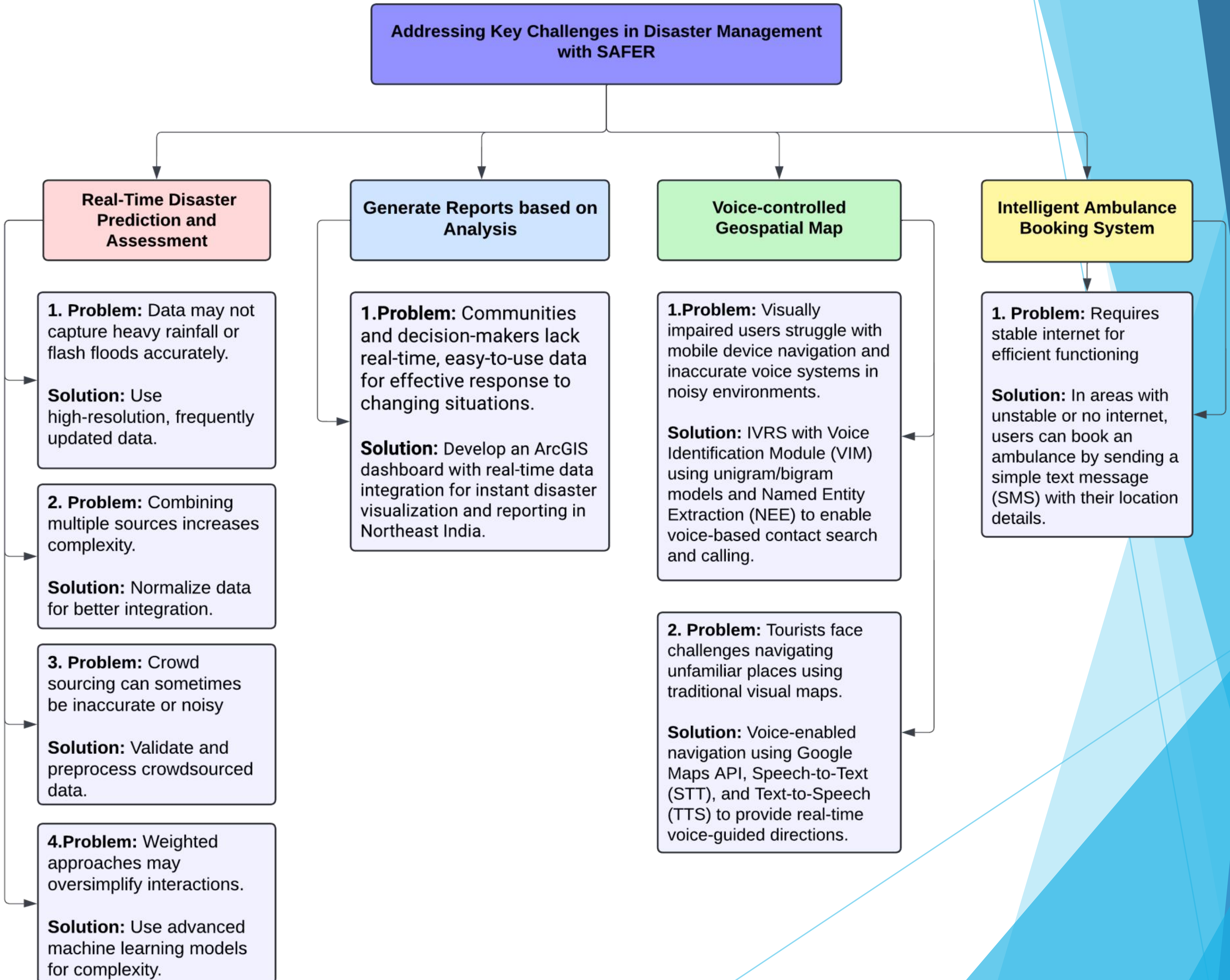
1. To integrate disaster assessment and prediction in Northeast India using an LSTM network, incorporating both raster and vector spatial data.

2. To generate comprehensive reports and statistics based on analysis.

3. To provide a voice-controlled interface for seamless interaction with geospatial maps using Web Speech API and Flutter TTS & STT.

4. To integrate an Intelligent Ambulance Booking System with real-time GPS tracking and a Voice-Controlled First Aid Assistant.

Literature Review



Literature Review

Sr.no	Title	Author(s)	Year	Methodology	Drawback
1	Satellite Flood Inundation Assessment and Forecast Using SMAP and Landsat	Jinyang Du , John S. Kimball, Senior Member, Justin Sheffield, Ming Pan Colby K. Fisher, Hylke E. Beck, and Eric F. Wood	2021	A flood prediction model using rainfall data, soil moisture data, and flood events observed via satellite data, with forecasts up to 3 days using a Classification and Regression Trees (CART) model.	1. Accuracy Depends on data resolution but increase in accuracy will need more computational power. 2. Short-term events (heavy rainfall for 1hr or flash floods) may not be captured accurately if the data is not updated frequently enough.
2	Flood Forecasting System Based on Integrated Big and Crowdsource Data by Using Machine Learning Techniques	Supattra Puttinaovarat, Paramate Horikawa	2020	Develop a flood forecasting system that combines real-time and crowdsourced data with machine learning techniques to deliver accurate and timely flood predictions.	1. Accuracy depends on data quality 2. Combining multiple data sources increases complexity . 3. Crowdsourcing can sometimes be inaccurate or noisy .

Literature Review

Sr.no	Title	Author(s)	Year	Methodology	Drawback
3	Geospatial techniques for flood inundation mapping	Kuldeep, P. K. Garg, R. D. Garg	2016	A framework to identify river islands suitable for eco-friendly tourism by analyzing satellite data and flood risks to ensure these sites are Resistant to flooding.	1. Accuracy of flood modeling and land classification depends on the resolution . 2. HEC-RAS is Resource Demanding.
4	Landslide Detection Using Deep Learning and Object-Based Image Analysis	Omid Ghorbanzadeh, Hejar Shahabi, Alessandro Crivellari, Saeid Homayouni, Thomas Blaschke, and Pedram Ghamisi	2022	The paper proposes an integration framework combining Deep Learning (ResU-Net) and Object-Based Image Analysis (OBIA) for landslide detection using Sentinel-2 satellite imagery and topographic data. The ResU-Net model generates a heatmap of landslide probabilities, while OBIA refines the results by analyzing image objects instead of individual pixels, improving the precision and overall detection accuracy.	1. Pixel-based Deep Learning (DL) models can struggle to differentiate between similar-looking features (e.g., riverbeds vs. landslides).This limitation often leads to false positives in the landslide detection process.

Literature Review

Sr.no	Title	Author(s)	Year	Methodology	Drawback
5	Predicting and Understanding Landslide Events With Explainable AI	Enrico Collini, L. A. Ipsaro Palesi, Paolo Nesi, Gianni Pantaleo, Nicola Nocentini, Ascanio Rosi.	2022	The paper presents a 1-day landslide prediction model using XGBoost, incorporating static and real-time features like rainfall, temperature, humidity, and vegetation. Explainable AI (XAI) is applied to assess feature relevance both globally and locally. Data collection, processing, and publication are managed via the Snap4City infrastructure, with the model validated using data from 2013-2019 in the Metropolitan City of Florence.	1. While the model achieves better prediction accuracy than previous approaches, its implementation is computationally expensive due to the large dataset and the heterogeneity of the input data.
6	An Experimental Global Prediction System for Rainfall-Triggered Landslides Using Satellite Remote Sensing and Geospatial Datasets	Yang Hong, Robert F. Adler, and George Huffman	2007	A global system for real-time landslide prediction combines satellite rainfall data with a Landslide Risk Map to assess and forecast landslide risks.	1. Uses a weighted based approach which will oversimplify complex interactions . 2. Does not work well for landslides triggered by very intense rainfall in a relatively short time period (less than 12 h) or by processes involving rapid snow melting.

Literature Review

Sr.no	Title	Author(s)	Year	Methodology	Drawback
7	Building community resilience through geospatial information dashboards	S. Praharaj, E. Wentz	2022	The methodology involved collecting relevant local data via APIs, integrating it using a four-layer architecture with GeoNode for storage and R for data processing. A multi-view web dashboard with interactive visualizations and data segregation options was developed to help communities understand and respond to issues effectively.	1. Lack of Granular Data: Dashboards often lack sub-group data, limiting insights into the unequal impacts of crises. 2. Complex Navigation: Poor design, limited data options, and unclear narratives reduce user engagement and decision-making effectiveness.
8	An Interactive Voice Assistant System for guiding the Tourists in Historical places	R. Keerthana, Dr. T. Ananth Kumar, P. Manjubala, M. Pavithra	2020	The methodology involves a voice assistant system that converts user voice commands into text, matches it with a database of location data, and provides real-time navigation using Text-to-Speech (TTS) technology, guiding users through audio instructions to their destination.	1. Internet and Language Limitations: The system's reliance on a stable internet connection and limited language support restricts its usability in areas with poor connectivity and for non-English speakers. 2. Accuracy and Privacy Concerns: Speech recognition may face challenges in noisy environments or with different accents, and the use of location data raises potential privacy issues if not securely managed.

Literature Review

Sr.no	Title	Author(s)	Year	Methodology	Drawback
9	Voice Enabled Interface with Intelligent Voice Response System to Navigate Mobile Devices for Visually Challenged People	Michael Raj T.F. , RajaKumar B. , Swaminathan S. , RamKumar M.	2013	The framework integrates a voice-enabled interface with an Intelligent Voice Response System (IVRS) to assist visually challenged users in navigating mobile devices. It processes voice commands through a Voice Identification Module (VIM), enabling hands-free tasks like contact search and calls.	1. Noise Sensitivity: Struggles with accuracy in noisy environments. 2. Command Limitations: Restricted to predefined voice commands 3. Accent Variability: May misinterpret commands due to accent differences.
10	The Ambulance Booking and Tracking System	Anbarasu P Arunkumar S Gowtham R Deepak S Latha M (Professor)	2024	A mobile app allows users to book ambulances, which are tracked in real time via GPS. A server processes requests, matches ambulances, and sends updates. Notifications provide estimated arrival time, and a database stores relevant data.	1. Internet Dependency: Requires stable internet for efficient functioning. 2. Limited Coverage: Less effective in rural areas with poor network or ambulance availability.

Literature Review

Sr.no	Title	Author(s)	Year	Methodology	Drawback
11	Ambulance Booking System	R. Jyothsingh (Assistant Professor, SRK Institute of Technology) Thota Swathi Kareti Lepakshi Pulivarthi Akash Puvvaladasu Hemanth	2024	The Ambulance Booking System uses a mobile app where users enter emergency details to request an ambulance. The system processes these requests, matches them with available ambulances, and provides real-time tracking and notifications about the ambulance’s status and arrival.	1. Internet Reliance: Depends on stable internet for functionality. 2. Limited Features: May lack advanced features compared to more comprehensive systems
12	Optimal Ambulance Positioning for Road Accidents with Deep Embedded Clustering	Dhyal Desai Dhyani Joyeeta Dey Sandeep Kumar Satapathy Shruti Mishra Sachi Nandan Mohanty Pallavi Mishra Sandeep Kumar Panda	2023	The study proposes using Deep Embedded Clustering to optimize ambulance positioning for quick response to road accidents. The system clusters accident-prone areas using historical data and positions ambulances accordingly, reducing response time.	1. Data Dependency: Requires extensive and accurate historical accident data.

Research Gap (Limitations of existing systems)

- Current disaster assessment and forecasting frameworks are not fully implemented as apps or websites, limiting their interactivity.
- They often lack precision, especially for short-duration events like intense rainfall, which can be improved by using higher-resolution data.
- Techniques like the weighted-based approach oversimplify complex interactions in landslide prediction. Advanced machine learning techniques should be used to model these interactions more effectively.
- Crowd-sourced data can be noisy and unreliable without proper validation.
- Existing systems face delays in real-time information distribution, and there is a need to improve the integration of emergency services with real-time tracking systems.

Problem Definition

- **Inaccurate Disaster Assessment and Forecasting:** The existing methods for assessing and forecasting disasters lack precision due to inadequate integration of raster and vector spatial data and outdated predictive models.
- **Non-Intuitive User Interfaces:** Existing disaster management systems have complex, non-user-friendly interfaces, making it difficult for users to interact with geospatial data effectively.
- **Delayed Real-Time Information Distribution:** There is a lack of timely updates and real-time information dissemination, which hampers effective decision-making and response during emergencies.
- **Limited Emergency Services Integration:** Emergency services lack integration with real-time tracking, affecting the efficiency of overall emergency response.

Scope

- Provide **Emergency Responders** with real-time disaster information and predictions.
- Assist **Local Governments** in planning and allocating resources for disaster preparedness.
- Enhance dispatch efficiency with smart ambulance booking and alert **Emergency Rescue teams**.
- Allow the **public** to access disaster forecasts and locate safe zone.
- Help **Disaster Management Authorities** make informed decisions with predictive models and analytics.

Technological Stack

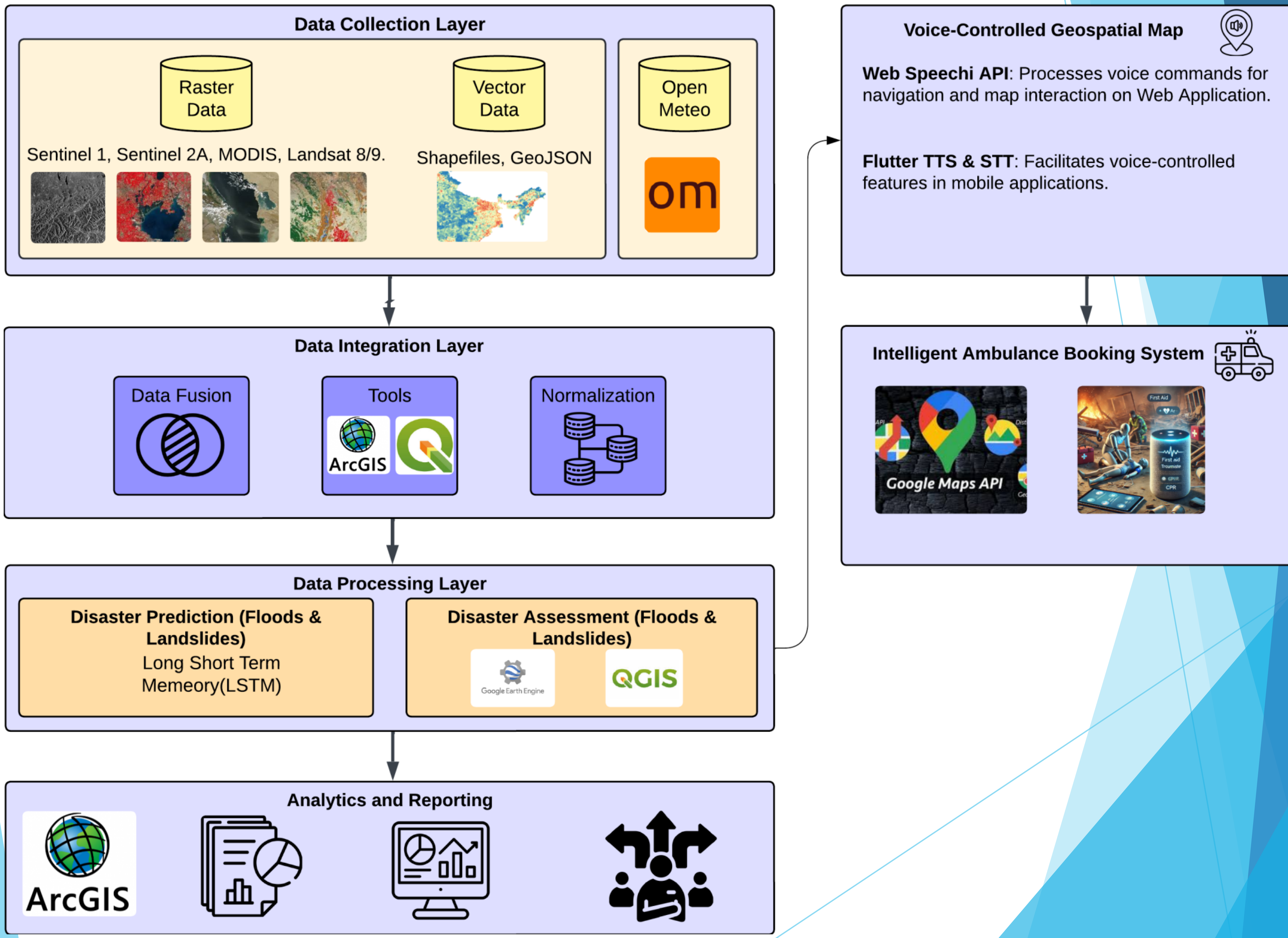
- **Frontend:** Flutter 3.22 (App)
- **Framework:** Django 5.1.1 (Web)
- **Input Data:**

  i. Raster Data: Sentinel 1, Sentinel 2A, MODIS, Landsat 8/9

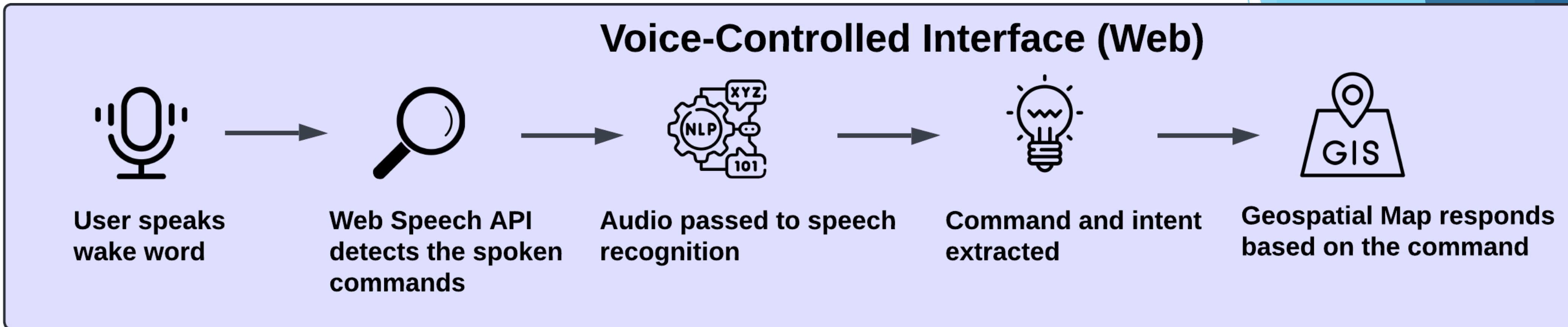
  ii. Vector Data: Shapefiles, GeoJSON

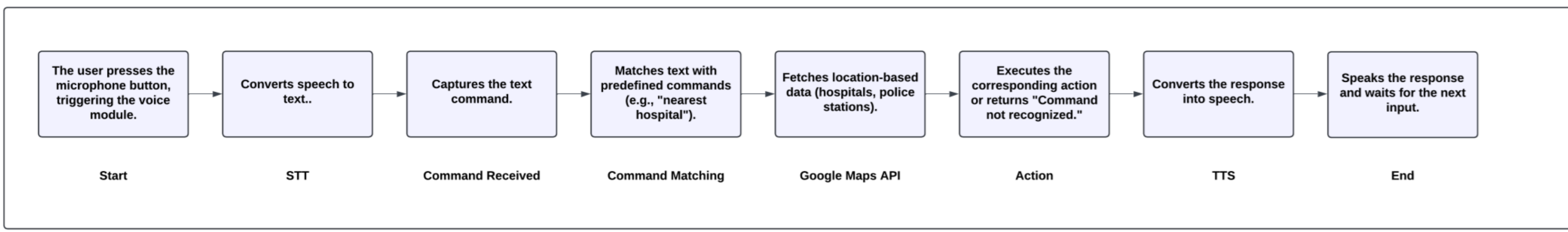
  iii. Weather Data: OpenMeteo
- **Disaster Prediction and Assessment:** Google Earth Engine, ML-Time Series (LSTM)
- **Analysis and Dashboard:** QGIS 3.24
- **Voice-Controlled Geospatial Map:** MapmyIndia JavaScript SDK, Geoapify API, Web Speech API, Google Maps API, OSM API
- **Intelligent Ambulance Booking:** Google Maps API

Proposed system architecture/Working



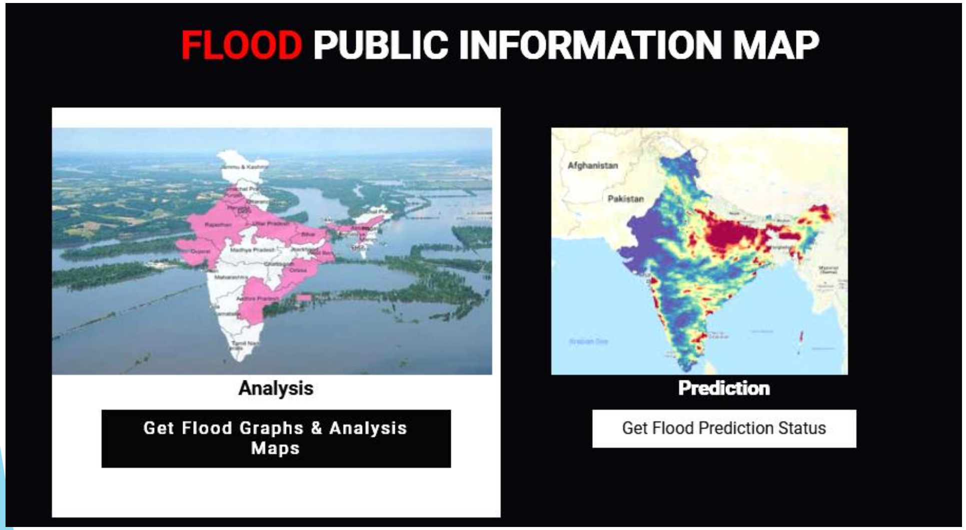
Proposed system architecture/Working

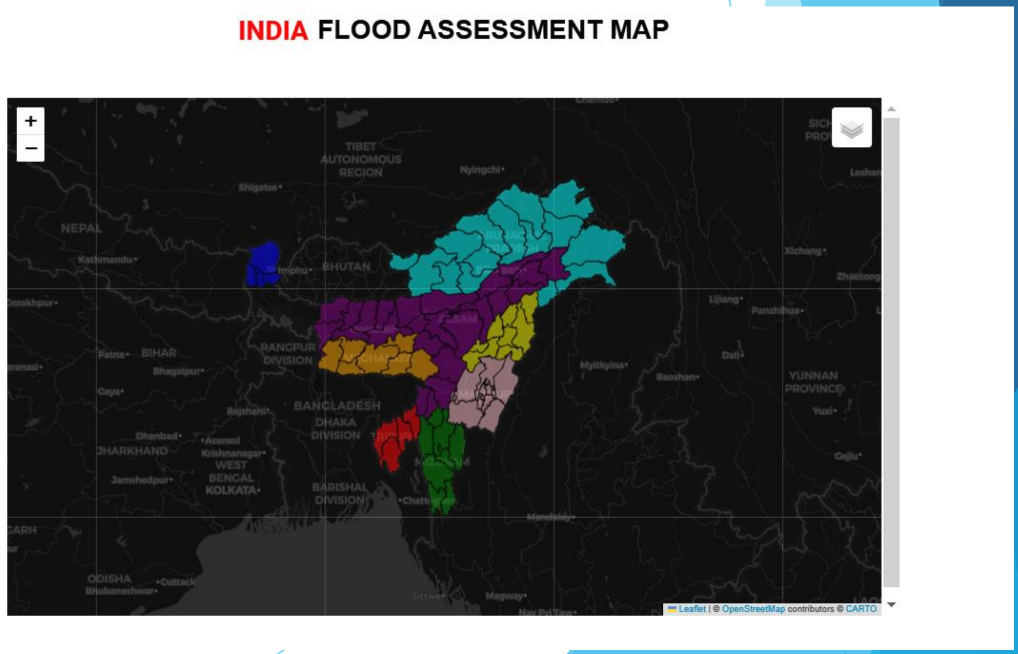




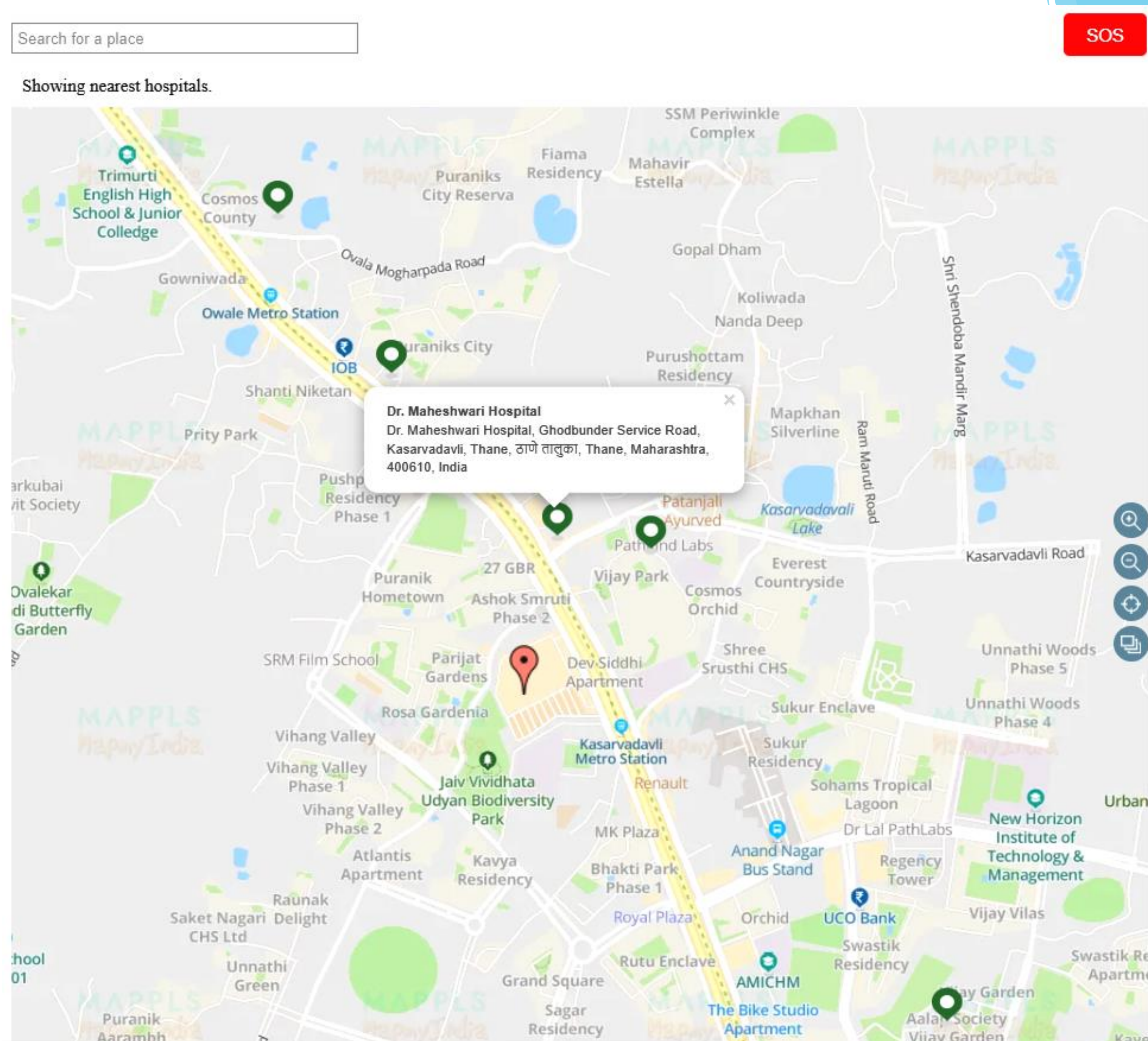
System Architecture of Voice Controlled Maps

Implementation Status

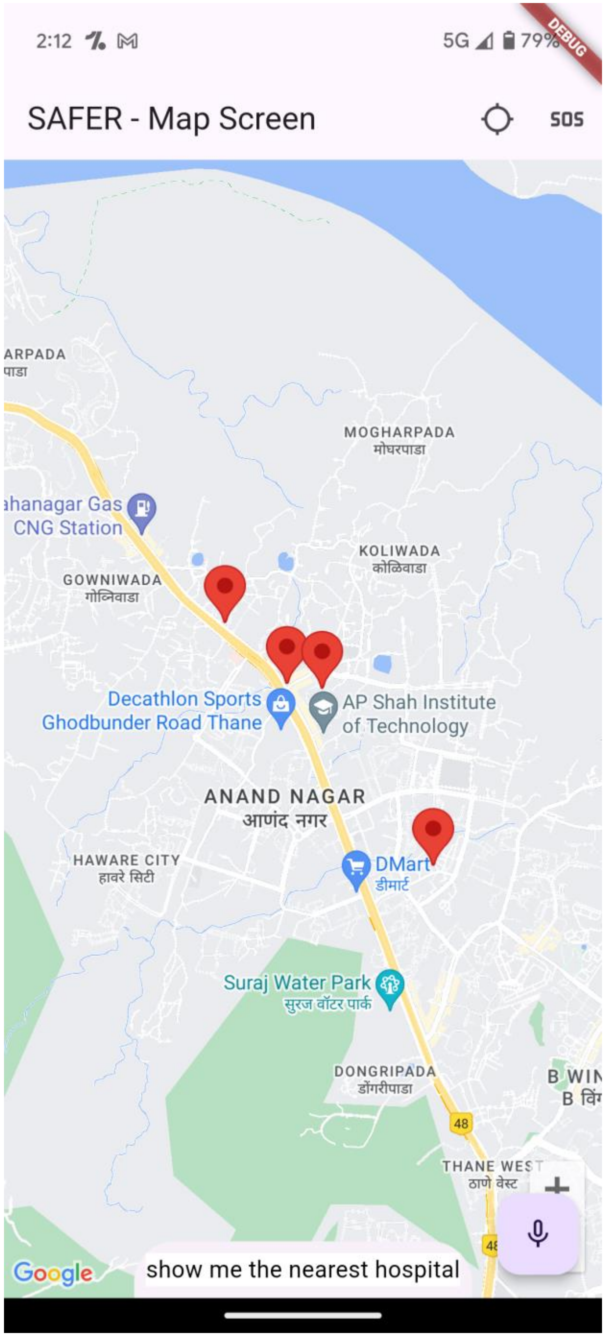


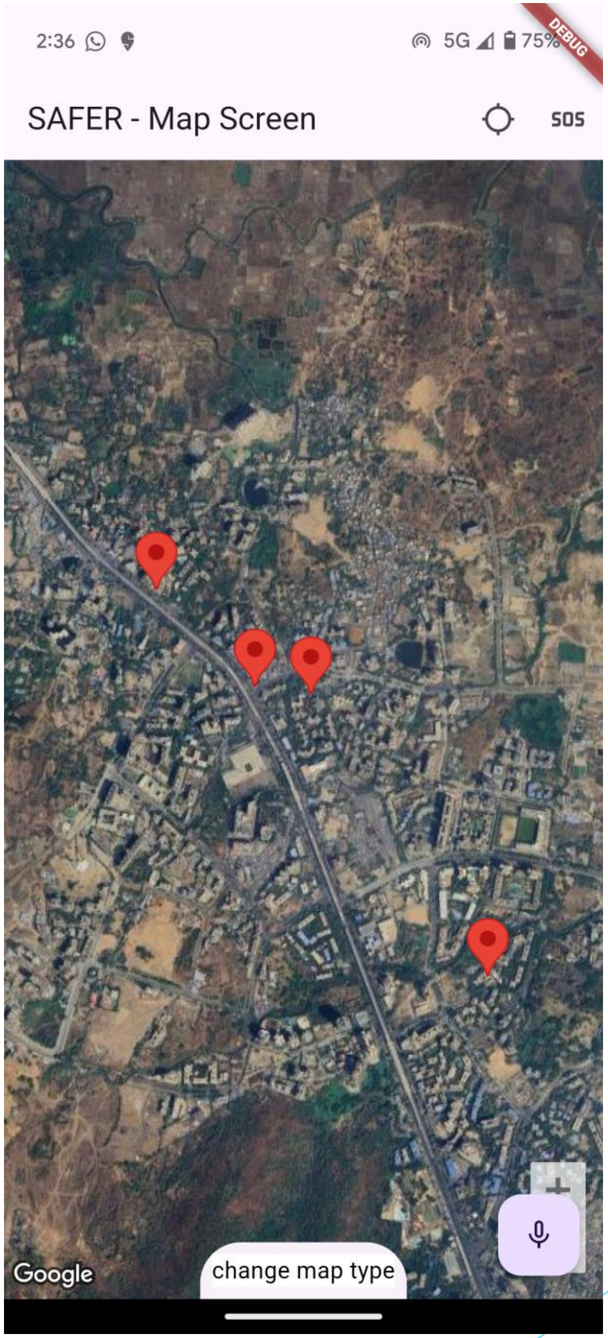


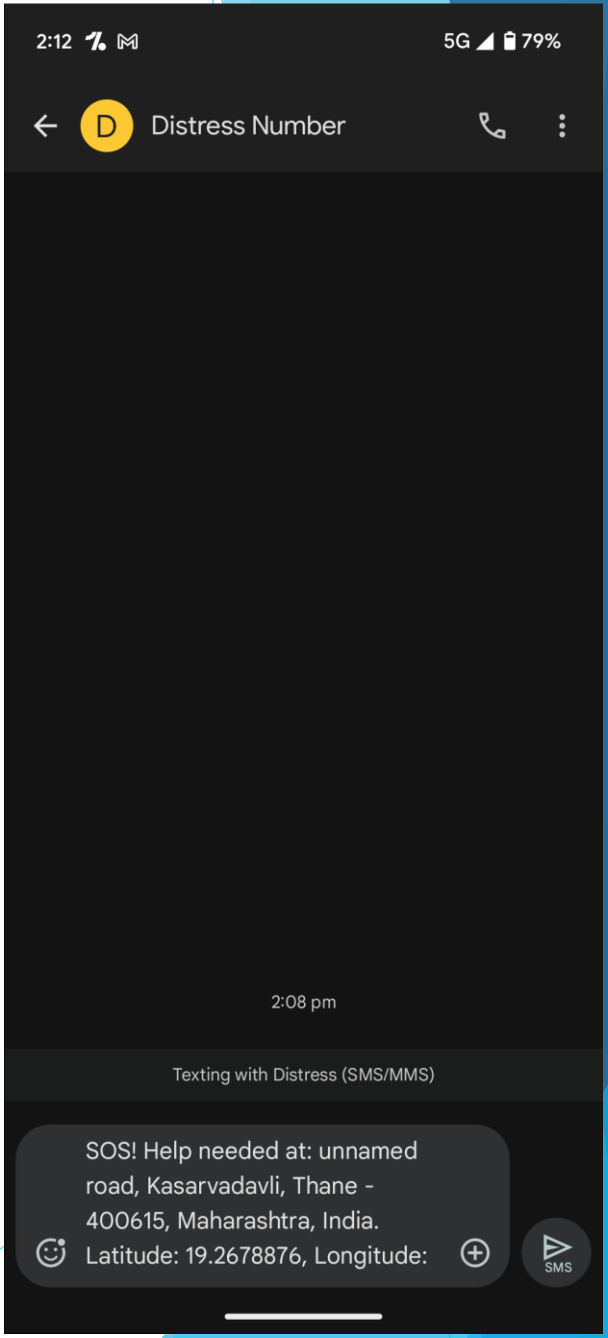
Implementation Status



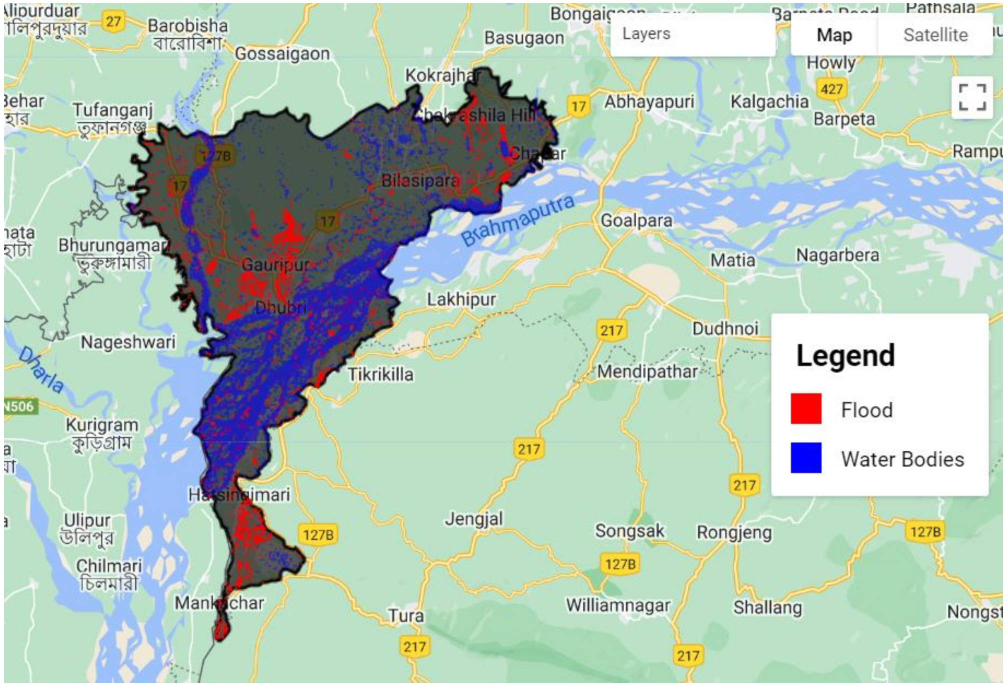
Implementation Status



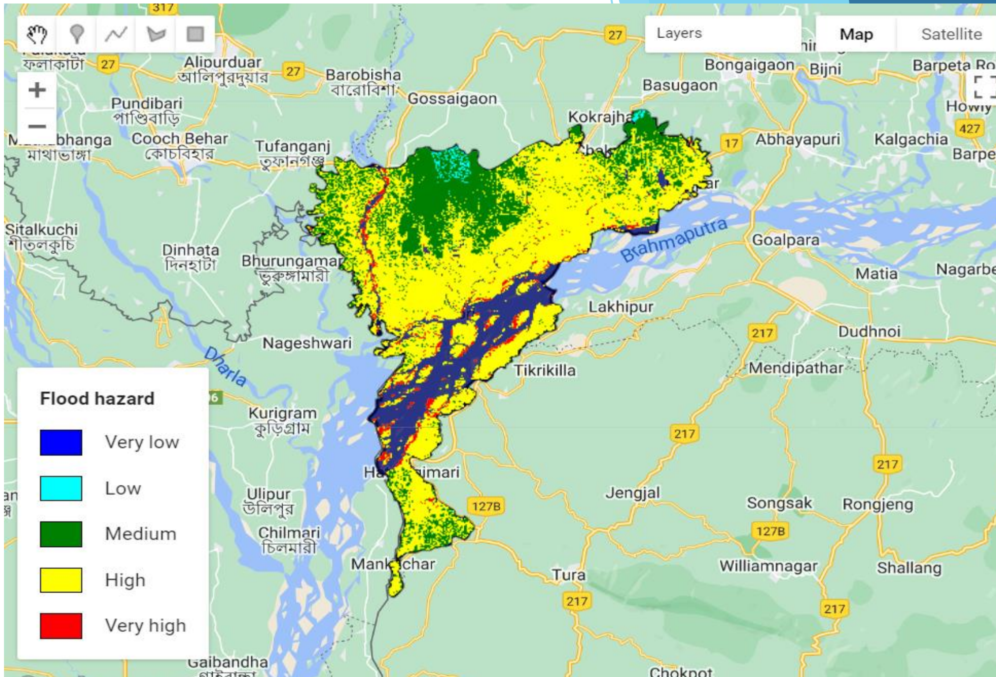




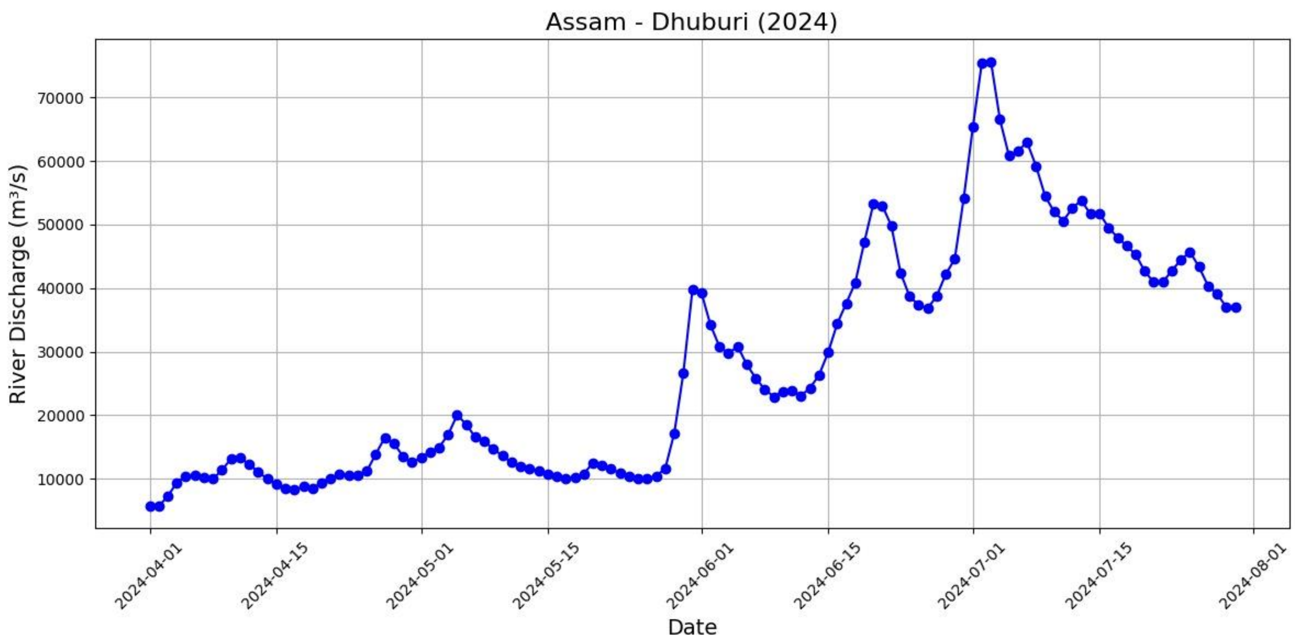
Implementation Status



Flood Assessment



Flood Hazard Risk Map



Review Suggestions (Given in Last meeting)

References

[1] Jinyang Du, John S. Kimball, Justin Sheffield, Ming Pan, Colby K. Fisher, Hylke E. Beck, Eric F. Wood, "Satellite Flood Inundation Assessment and Forecast Using SMAP and Landsat," IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, Volume 14, Pages 6707-6715, 2021.

https://ieeexplore.ieee.org/document/9465655

[2] S. Puttinaovarat, P. Horkaew, "Flood Forecasting System Based on Integrated Big and Crowdsource Data Using ML Techniques," IEEE Access, Volume 8, Pages 5887-5893, 2020.

https://www.researchgate.net/publication/338376683_Flood_Forecasting_System_Based_on_Integrated_Big_and_Crowdsource_Data_by_Using_Machine_Learning_Techniques

[3] Kuldeep Chaurasia, P. K. Garg, Rahul Dev Garg, "Geospatial Techniques for Flood Inundation Mapping," IEEE International Geoscience and Remote Sensing Symposium (IGARSS), July 2016.

https://www.researchgate.net/publication/309778410_Geospatial_techniques_for_flood_inundation_mapping

References

[4] Ghorbanzadeh, O., Shahabi, H., Crivellari, A. et al. Landslide detection using deep learning and object-based image analysis. Landslides 19, 929–939 (2022).

https://link.springer.com/article/10.1007/s10346-021-01843-x

[5] E. Collini, L. A. I. Palesi, P. Nesi, G. Pantaleo, N. Nocentini and A. Rosi, "Predicting and Understanding Landslide Events With Explainable AI," in IEEE Access, vol. 10, pp. 31175-31189, 2022.

https://ieeexplore.ieee.org/document/9732490

[6] Yang Hong, Robert F. Adler, George Huffman, "An Experimental Global Prediction System for Rainfall-Triggered Landslides Using Satellite Remote Sensing and Geospatial Datasets," IEEE Transactions on Geoscience and Remote Sensing, Volume 45, Issue 6, Pages 1671-1680, June 2007.

https://ieeexplore.ieee.org/document/4215054

References

[7] Praharaj, S., and E. Wentz. "Building community resilience through geospatial information dashboards." The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences 48 (2022): 151-157.

https://isprs-archives.copernicus.org/articles/XLVIII-4-W5-2022/151/2022/

[8] R. Keerthana, Dr. T. Ananth Kumar, P. Manjubala, M. Pavithra, "An Interactive Voice Assistant System for Guiding the Tourists in Historical Places," 2020 International Conference on Communication and Signal Processing (ICCSP), Pages 1-6, 2020.

https://ieeexplore.ieee.org/abstract/document/9262347

[9] Michael Raj T.F., Rajakumar B., Swaminathan S., Ramkumar M., "A Novel Approach: Voice Enabled Interface with Intelligent Voice Response System to Navigate Mobile Devices for Visually Challenged People," 2013 IEEE International Conference on Computer Communication and Informatics (ICCCI), Pages 1-6, 2013.

https://ieeexplore.ieee.org/document/6496535

References

[10] Anbarasu P, Arunkumar S, Gowtham R, Deepak S, Latha M, "The Ambulance Booking and Tracking System," International Research Journal of Modernization in Engineering Technology and Science, Volume 06, Issue 04, Pages 1-10, April 2024.
https://www.irjmets.com/uploadedfiles/paper//issue_4_april_2024/54412/final/fin_irjmets1714503331.pdf

[11] R. Jyothsingh, Thota Swathi, Kareti Lepakshi, Pulivarthi Akash, Puvvaladasu Hemanth, "Ambulance Booking System," International Journal of Innovative Science and Research Technology, ISSN No: 2456-2165, April 2024.
https://doi.org/10.38124/ijisrt/IJISRT24APR2102.

[12] Dhyan Desai Dhyani, Joyeeta Dey, Sandeep Kumar Satapathy, Shruti Mishra, Sachi Nandan Mohanty, Pallavi Mishra, Sandeep Kumar Panda, "Optimal Ambulance Positioning for Road Accidents with Deep Embedded Clustering," IEEE Access, Volume 11, Pages 59917-59934, 2023.
https://ieeexplore.ieee.org/document/10147832

Thank You...!!