

BCSE498J Project-II - Capstone Project

RescuePath

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ABSTRACT

RescuePath is an innovative web-based platform designed to enhance disaster preparedness and response by providing real-time, city-specific safety recommendations during natural calamities. By integrating data from geostationary satellites, geographic information systems (GIS), and real-time weather APIs, RescuePath offers users actionable insights tailored to their immediate environment. Upon entering their city or enabling location services, users receive dynamic risk assessments and personalized safety recommendations pertinent to specific disasters, such as floods or wildfires. The platform's interactive mapping feature utilizes GIS technology to highlight safe zones, evacuation routes, and nearby emergency facilities, facilitating effective navigation during crises. Additionally, RescuePath sends real-time alerts and notifications about sudden environmental changes, enabling swift and informed decision-making. Beyond immediate response, the platform is committed to enhancing public knowledge on disaster preparedness by offering a repository of educational materials, including embedded videos, infographics, and guides on best practices during various natural disasters.

The technical architecture of RescuePath comprises a robust data integration layer that aggregates inputs from multiple sources, including satellite feeds, weather services, and topographical databases. Advanced algorithms process this data to generate a cohesive understanding of the current risk landscape. The user interface is designed with a focus on usability, ensuring that individuals with limited technical proficiency can navigate the platform effortlessly. It is responsive, catering to both desktop and mobile users, and emphasizes clarity and ease of access. The backend system is engineered to handle high volumes of data and user requests concurrently, employing scalable cloud infrastructure to maintain performance and reliability, even during peak usage periods typical of disaster events. By integrating cutting-edge data processing techniques with a user-centric design, RescuePath empowers individuals and communities to act decisively during emergencies, potentially saving lives and mitigating property damage.

Keywords: RescuePath, disaster preparedness, real-time safety recommendations, geostationary satellites, geographic information systems (GIS), real-time weather APIs, dynamic risk assessment.

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1. INTRODUCTION

1.1 Background

In recent years, the frequency and severity of natural disasters have escalated, posing significant threats to human life and property. Timely and accurate information is crucial during such emergencies to guide affected populations toward safety. Traditional emergency response systems often face challenges in delivering real-time, location-specific guidance, leading to increased vulnerability for those in disaster-prone areas. The advent of advanced technologies, including geostationary satellites, geographic information systems (GIS), and real-time weather application programming interfaces (APIs), offers an opportunity to enhance disaster response mechanisms. By integrating these technologies, it becomes feasible to develop platforms that provide dynamic, personalized safety recommendations based on an individual's immediate environment. Such innovations can bridge the gap between available data and actionable guidance, empowering communities to make informed decisions during crises and potentially reducing the adverse impacts of natural calamities.

1.2 Motivation

Natural disasters are unpredictable and can leave communities vulnerable due to a lack of timely guidance. Traditional emergency response systems often struggle to provide personalized evacuation strategies, leading to delayed actions and increased casualties. The RescuePath project was inspired by the need to bridge the gap between available disaster data and actionable safety information. By leveraging technology, RescuePath aims to provide real-time, localized guidance to enhance disaster preparedness and response, ultimately reducing loss of life and property.

1.3 Scope of the Project

RescuePath is a web-based platform that provides real-time, city-specific safety recommendations during natural disasters. It focuses on delivering evacuation guidance and safe zone identification based on weather APIs and GIS mapping. The platform will support floods and wildfires initially, offering users interactive maps and real-time alerts to navigate emergencies efficiently. The system is designed to be lightweight and accessible, ensuring ease of use during crises. While its primary function is disaster response, it will also include basic educational resources to help users prepare for emergencies. Future enhancements may incorporate improved route optimization and expanded disaster coverage based on feasibility.

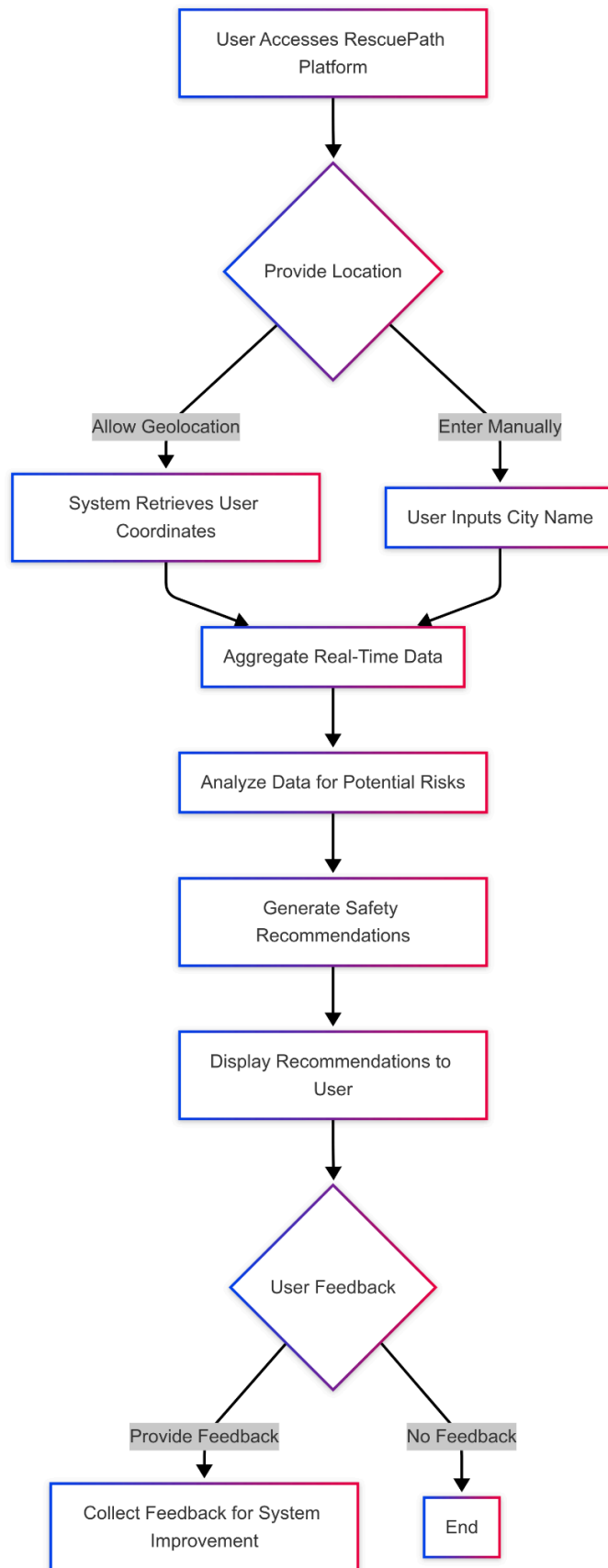


Figure 1: Workflow Model Diagram

2. PROJECT DESCRIPTION AND GOALS

2.1 Literature Review

1. How Geospatial Technologies Aid in Effective Disaster Management

Methodology: Explores the application of Geographic Information Systems (GIS) and remote sensing in disaster management.

Key Findings: Geospatial technologies enhance all disaster management stages, from preparedness to recovery.

innovationnewsnetwork.com

2. Exploring the Use of AI and IoT in Disaster Management

Methodology: Examines the integration of Artificial Intelligence (AI) and Internet of Things (IoT) technologies in disaster response.

Key Findings: AI and IoT enable faster, more accurate disaster anticipation and response, reducing casualties and damage.

iot2market.com

3. Smart City Integration: How IoT is Reducing Emergency Response Times and Saving Lives

Methodology: Investigates IoT applications in urban emergency response systems.

Key Findings: IoT integration in smart cities improves emergency response times and efficiency.

publicsafety.ieee.org

4. Role of GIS in Disaster Management

Methodology: Analyzes the role of GIS in collecting, analyzing, and visualizing geospatial data during disasters.

Key Findings: GIS is crucial for effective emergency management strategies.

ellipsis-drive.com

5. Enhancing Emergency Operations Centers with Artificial Intelligence: A New Frontier in Emergency Management

Methodology: Explores AI applications in Emergency Operations Centers (EOCs).

Key Findings: AI enhances data analysis, resource management, and communication in EOCs.

firehouse.com

6. Using Geospatial Data for Natural Disaster Management

Methodology: Discusses the use of geospatial data in disaster preparedness and response.

Key Findings: Geospatial data aids in identifying high-risk areas and planning effective disaster responses.

planwisely.io

7. AI in Disaster Management: How Artificial Intelligence is Saving Lives in Emergencies

Methodology: Examines AI's role in emergency management.

Key Findings: AI improves disaster prediction, resource allocation, and real-time decision-making.

hashstudioz.com

8. Applications of Geospatial Technology/Data in Support of Disaster Management

Methodology: Reviews geospatial technology applications in disaster management.

Key Findings: Geospatial technologies provide valuable information for emergency preparedness and response.

cepal.org

9. How IoT Is Revolutionizing Disaster Prevention and Response

Methodology: Explores IoT's impact on disaster management.

Key Findings: IoT sensors offer early warnings and aid in managing disaster aftermaths.

iotforall.com

10. AI in Emergency Management: Uses & Challenges

Methodology: Analyzes AI applications and challenges in emergency management.

Key Findings: AI automates communication, optimizes resources, and supports real-time decisions in emergencies.

safetyculture.com

2.2 Research Gap

1. Data Integration and Interoperability: Challenges persist in seamlessly integrating diverse geospatial and real-time data sources due to varying formats and standards, hindering comprehensive situational awareness.

tandfonline.com

2. Real-Time Decision Support Limitations: Existing Geographic Information Systems (GIS) often lack the capability to provide timely, actionable insights during disasters, necessitating enhancements for real-time application.

researchgate.net

3. AI Implementation Challenges: The deployment of AI in disaster risk management faces obstacles such as data quality issues, system compatibility, and ethical considerations, which require systematic solutions.

researchgate.net

4. Advanced Geospatial Applications: While geospatial technologies are employed in earthquake research, their full potential in comprehensive disaster management remains underexplored, suggesting opportunities for broader application.

mdpi.com

2.3 Objectives

- 1. Develop a User-Friendly Web Platform:** By 19th February, create an intuitive web application enabling users to input their city and receive tailored safety recommendations for various natural disasters.
- 2. Integrate Real-Time Data Sources:** Within 7th March, incorporate data from geostationary satellites, GIS, and live weather APIs to provide up-to-date information on disaster risks.
- 3. Implement Advanced Risk Assessment Algorithms:** Design and deploy algorithms by 4th April that analyze satellite imagery, elevation maps, and weather forecasts to identify high-risk areas and suggest optimal evacuation routes.
- 4. Ensure Platform Accessibility:** Achieve full accessibility compliance by 10th April, ensuring the platform is usable across various devices and by individuals with disabilities.
- 5. Establish Feedback Mechanisms:** Implement features by 20th April that allow users to provide feedback, enabling continuous improvement of the platform based on user experiences.
- 6. Monitor and Evaluate Performance:** Establish metrics and conduct evaluations every week to assess the platform's effectiveness in real-world scenarios, making necessary adjustments to improve performance.

2.4 Problem Statement

In the face of escalating natural disasters, communities often lack timely, location-specific guidance for safe evacuation and risk mitigation. Existing systems frequently fail to integrate real-time data from diverse sources—such as geostationary satellites, geographic information systems (GIS), and live weather updates—into a cohesive, user-friendly platform. This deficiency hampers individuals' ability to make informed decisions during emergencies, potentially leading to increased harm and loss. The challenge lies in developing an accessible solution that synthesizes dynamic data to provide actionable, city-specific safety recommendations during various natural calamities.

2.5 Project Plan

1. Project Initiation:

- *Duration:* 2 weeks
- *Activities:*
 - Define project scope and objectives
 - Identify stakeholders

2. Requirements Gathering:

- *Duration:* 1 week
- *Activities:*
 - Analyze existing systems
 - Document functional and non-functional requirements

3. System Design:

- *Duration:* 3 weeks
- *Activities:*
 - Design system architecture
 - Develop data integration framework
 - Create user interface mockups

4. Development Phase:

- *Duration:* 4 weeks
- *Activities:*
 - Set up development environment
 - Implement backend services
 - Develop frontend application
 - Integrate real-time data sources

5. Testing Phase:

- *Duration:* 2 weeks
- *Activities:*
 - Perform unit testing
 - Conduct system integration testing
 - Execute user acceptance testing

6. Deployment and Training:

- *Duration:* 2 weeks
- *Activities:*
 - Deploy system to production environment
 - Conduct user training sessions
 - Prepare user manuals and documentation

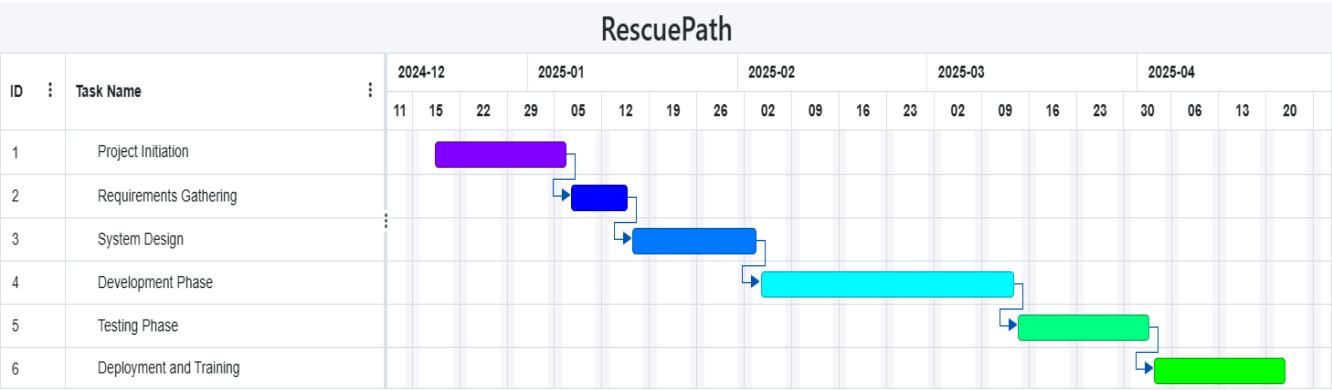


Figure 2: Gantt Chart

3. REQUIREMENT ANALYSIS

3.1 Introduction

RescuePath is envisioned as a unified emergency assistance platform that delivers real-time, location-based information—such as nearby hospitals, emergency contacts, and disaster awareness multimedia—to users in critical situations. The requirement analysis below defines the system’s essential functions, performance targets, and technical specifications necessary to ensure rapid response, robust reliability, and user-friendly interaction during emergencies.

3.2 Functional Requirements

- User Location Acquisition:
 - Capture user location using the HTML5 Geolocation API and support manual address entry with autocomplete.
- Emergency Resource Search:
 - Query third-party services (e.g., Google Places API) to retrieve and display nearby hospitals and medical centers in an interactive map interface.
- Multimedia Disaster Awareness:
 - Embed disaster awareness videos (via YouTube iFrame API) that allow dynamic switching without requiring redirection, ensuring users can access educational content rapidly.
- Real-Time Notifications and Alerts:
 - Provide push notifications and SMS alerts for emerging incidents and crisis updates using cloud-based messaging services.
- Reporting and Analytics:
 - Log user interactions and incident data to support post-incident analysis and continuous improvement of emergency response protocols.

3.3 Non-Functional Requirements

- Performance:
 - Ensure API responses are delivered within 2 seconds to maintain real-time situational awareness.
- Scalability:
 - Design for auto-scaling and load balancing using cloud-native solutions (e.g., Docker and Kubernetes) to handle concurrent users during peak emergency events.
- Security:
 - Enforce HTTPS across all communications, manage API keys securely, and use OAuth for user authentication to protect sensitive information.
- Usability:
 - Develop a responsive, intuitive user interface (UI) that minimizes cognitive load and is accessible across devices.
- Reliability:

- Achieve a target of 99.9% system uptime with robust error handling and redundancy measures.
- Maintainability:
 - Adopt a modular microservices architecture to facilitate future enhancements and ease of maintenance.

3.4 Hardware Requirements

- Server/Cloud Infrastructure:
 - Multi-core processors (e.g., Intel Xeon or equivalent)
 - Minimum 16 GB RAM (scalable based on load)
 - SSD-based storage (≥ 500 GB) with redundancy
 - High-speed, reliable internet connection
- Client Devices:
 - Smartphones (Android/iOS), tablets, and desktops with modern browsers supporting HTML5, CSS3, and JavaScript

3.5 Software Requirements

- Frontend:
 - Languages: HTML5, CSS3, JavaScript
 - Framework: React.js with libraries such as React Router and Axios
 - Tools: Webpack, Babel, and PWA service workers for offline support
- Backend:
 - Languages: Node.js with Express.js
 - Database: NoSQL (e.g., MongoDB) for high-velocity data and SQL (e.g., PostgreSQL) for structured data
 - Integration: APIs (e.g., Google Maps, Overpass, YouTube iFrame API) for dynamic data retrieval
 - Security: OAuth-based authentication and secure API key management
- Deployment:
 - Cloud platforms (AWS, Google Cloud, or Azure)
 - Containerization: Docker with orchestration via Kubernetes

4. REFERENCES

1. An Analysis of Geospatial Technologies for Risk and Natural Disaster Management

Summary: This paper discusses the use of spatial data, including remote sensing and GIS, in natural disaster management, emphasizing the importance of spatial data sharing through Spatial Data Infrastructures (SDIs).

[researchgate.net](https://www.researchgate.net)

2. Dynamic Disaster Management with Real-Time IoT Data Analysis and Response

Summary: The research focuses on integrating IoT technologies and data analysis into existing disaster management systems to enhance real-time response capabilities.

ieeexplore.ieee.org

3. The Role of Geospatial Technologies in Disaster Management

Summary: This paper highlights the significance of geospatial technologies in various disaster management phases, including early warning systems, risk assessment, and search and rescue operations.

psychologyandeducation.net

4. Geospatial Technology for Effective Disaster Risk Reduction: Best Practices in Capacity Building

Summary: The paper underscores the importance of integrating geospatial technology into disaster risk reduction strategies to build resilient communities and minimize disaster impacts.

[researchgate.net](https://www.researchgate.net)

5. A Real-Time Decision Support Tool for Disaster Response: A Mathematical Programming Approach

Summary: This study proposes a mathematical programming approach utilizing real-time disaster-related information to optimize post-disaster decisions for emergency supplies delivery.

[researchgate.net](https://www.researchgate.net)

6. Real-Time Big Data Analytics for National Emergency Response

Summary: The research focuses on utilizing multiple real-time data sources, including sensors, social networks, and IoT devices, to enhance national emergency response systems.

[irjet.net](https://www.irjet.net)

7. GIS and Geospatial Studies in Disaster Management

Summary: This study emphasizes the vital role of geospatial technologies in all stages of disaster management, from prevention to recovery.

link.springer.com

8. Applications of Geospatial Technology in Disaster Management

Summary: The paper discusses how geospatial technologies facilitate the acquisition, storage,

processing, and distribution of geographic data for effective disaster management.

ijirmf.com

9. Machine Learning for Real-Time Disaster Response and Recovery in the US

Summary: This paper explores the integration of machine learning techniques into disaster management frameworks, focusing on real-time applications to enhance situational awareness and resource allocation.

researchgate.net

10. Multimodal Data Analytics and Integration for Emergency Response and Disaster Management

Summary: The research provides solutions for critical information analysis challenges in disaster information management, emphasizing rapid key information identification and efficient multimodal data integration.

sccvo.org

11. A Comprehensive Review of Geospatial Technology Applications in Earthquake Research and Disaster Management

Summary: This literature review surveys geospatial technologies employed in earthquake research and disaster management, highlighting their applications in prediction, preparation, and damage assessment.

mdpi.com

12. Leveraging Disruptive Technologies for Faster and More Efficient Disaster Response

Summary: The research explores how emerging technologies can be effectively utilized to improve disaster response, particularly in low-income communities.

mdpi.com

13. Special Issue on 'Next-Generation Geospatial Technologies: Advanced Deep Learning Approaches for Disaster Risk Reduction Using Geospatial Data'

Summary: The paper discusses the integration of deep learning techniques with geospatial data to enhance disaster risk reduction strategies.

grss-ieee.org

14. An Evaluation of Integrating Multisourced Sensors for Disaster Management

Summary: This research focuses on the integration of multisourced sensors in disaster management, particularly during disaster response phases.

tandfonline.com

15. The Needs and Geospatial Technologies Available for Disaster Management

Summary: The paper examines emerging geospatial technologies and their applications in addressing disaster situations, emphasizing the incorporation of these technologies into disaster management practices.

ieeexplore.ieee.org