ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)

Vol 11, Issue 5, May 2024

Seismic Disaster Resilience App for Human Survival - A Case Study of Gangtok Town

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***Abstract*— This paper discusses a specialized smartphone application designed to improve response efforts during earthquakes, emphasizing the need for innovative approaches in disaster management. Through leveraging technology, the app enhances both rescue operations and aid delivery, potentially saving lives. Focusing on areas prone to earthquakes like Gangtok Town, the paper explores the development and functionalities of the app, highlighting its ability to facilitate rapid communication in emergencies and assist experts in decision-making. By showcasing the app's effectiveness, the aim is to inspire further innovation in disaster preparedness and response strategies.**

***Index Terms*— Disaster resilience, Earthquake preparedness, Mobile application, Seismic events.**

I. INTRODUCTION

1.1 Background:

Seismic disasters, like earthquakes, are big dangers in places like Gangtok Town. But regular ways of handling them sometimes don't work well. We need new ideas to help keep people safe during earthquakes. Gangtok Town, nestled in a seismic-prone region, has faced the brunt of such disasters in the past, highlighting the urgent need for innovative solutions to enhance resilience and survival strategies.

1.2 Problem Statement:

In Gangtok Town, when earthquakes happen, there are some big problems.

Delayed Access to Important Places: It takes too long for help to reach places where it's needed most, putting lives at risk.

Hard to Get Important Information: During earthquakes, it's tough to get the right information quickly, making it hard for people to know what to do.

Can't Connect with Others for Help: Sometimes, people can't talk to each other during emergencies, making it hard to help themselves or others.

Tough to Survive After the Earthquake: After an earthquake, it's hard to get the things people need to survive, like medical help or food, leading to further hardships.

1.3 Objectives:

The primary objectives of this research are as follows:

- Develop Tailored Emergency Plans: Customize plans for Gangtok Town's seismic risks to enhance response strategies.
- Establish Local Training Programs: Create community-based training and support for increased awareness and self-rescue skills.
- Ensure Offline Access to Information: Provide offline access to critical resources using innovative technology to overcome connectivity issues during earthquakes.
- Implement User-Generated Hazard Reporting: Enable real-time sharing of hazards through a crowd-sourced mapping feature in the seismic disaster resilience app.

1.4 Scope and Limitations:

This research focuses on making a special phone app to Help during earthquakes in Gangtok Town. But there might be some problems, like not having enough

Technology or resources. Also, we won't look at bigger things like laws or how to keep things going in the long run. However, by addressing these challenges, we hope to pave the way for more effective disaster management strategies in Gangtok Town and beyond.

II. LITERATURE REVIEW

2.1. Damage and geological assessment of the 18 September 2011 Mw 6.9 earthquake in Sikkim, India using very high resolution satellite data:

The 2015 study by TR Martha et al. examined the impact of the 2011 Mw 6.9 earthquake in Sikkim, India, using high-resolution satellite data. It assessed damage and geological effects by analyzing fault rupture, ground deformation, and landslides, offering valuable insights into damage severity and distribution. Although the study benefited from precise satellite data, limitations like cloud cover and incomplete geological features may have affected the analysis comprehensiveness.

ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)

Vol 11, Issue 5, May 2024

2.2. An investigative study of seismic landslide hazards:

The 2016 research by N Vasudevan et al. examined seismic landslide hazards to improve understanding and mitigation strategies. Using field investigations, remote sensing, and geological surveys, it identified factors influencing seismic landslides and their impacts. While enhancing hazard assessment accuracy, challenges like terrain complexities and distinguishing pre-existing from earthquake-induced landslides may have affected the study's comprehensiveness.

2.3. Seismic Hazard Assessment of Gangtok Region–A Direct Amplitude-Based Approach:

In 2023, G Mishra et al. evaluated seismic hazard in Gangtok using a direct amplitude-based method. By analyzing seismic data and local geological factors, the study aimed to quantify ground shaking intensity. While robust, uncertainties in seismic data and assumptions may have affected accuracy.

2.4. Seismic Hazard Zonation Mapping of Gangtok Block, Sikkim, India:

In 2021, B Biswas et al. aimed to develop seismic hazard zonation maps for Gangtok, Sikkim, using probabilistic assessment techniques. Considering historical seismicity and ground motion attenuation, the study informed risk reduction and land-use planning. However, uncertainties in seismic data and assumptions may have affected map accuracy.

III. METHODOLOGY

3.1 Data Collection and Analysis:

Data collection for this research involved gathering essential information related to seismic activity, emergency contacts, and geographical data. The following steps were undertaken:

- The Seismic Disaster Resilience Application integrates essential data for Gangtok Town, including seismic zone maps sourced from local authorities, Richter scale data from reputable databases, and emergency contact numbers for immediate access to local authorities and services.

Data Analysis:

- Seismic zone map analysis identified high-risk areas in Gangtok town, aiding risk assessment. Richter scale data analysis determined past seismic event frequency and intensity, informing seismic risk levels. Emergency contact numbers were categorized by response type, ensuring efficient access to essential services during crises.

3.2 Development of the Seismic Disaster Resilience Application:

The development of the Seismic Disaster Resilience Application was carried out using modern mobile app development technologies and methodologies. The following points highlight the key aspects of the development process:

- Utilization of Dart Programming Language: Dart programming language was chosen for developing the Seismic Disaster Resilience Application due to its robust and efficient cross-platform mobile app development environment.
- Integration of Flutter Framework: Flutter, an open-source UI software development kit by Google, enabled the creation of visually appealing and responsive user interfaces across Android and iOS platforms for the Seismic Disaster Resilience Application.
- API Integration for Live Geospatial Data: Live geospatial data, including real-time seismic updates, hazard info, and interactive maps from Google Maps API, were securely integrated into the Seismic Disaster Resilience Application using API key authentication mechanisms.

3.3 User Interface Design and Functionality:

- Homepage: The homepage served as a central hub for accessing essential sections, including Docs (Seismic), Precaution, Live Map, Richter Scale Visual Indicator, and Emergency Calls, with a simple and welcoming design.
- Docs (Seismic) Section: The Docs (Seismic) section provided a comprehensive collection of documents related to seismic activity in Gangtok, allowing users to access and download zone maps, hazard assessments, and safety guidelines for reference and education.
- Precaution Section: The Precaution section offered step-by-step guides on seismic event preparedness, empowering users with actionable tips and safety measures to make informed decisions and stay safe.
- Live Map: The Live Map interface displayed an interactive map of Gangtok town, featuring evacuation routes, safe zones, and hazard-prone areas, allowing users to zoom, pan, and tap for detailed information.
- Richter Scale Visual Indicator: A user-friendly Richter Scale Visual Indicator was integrated into the UI, conveying earthquake severity with easy-to-understand language and graphics, enabling users to take appropriate precautionary measures swiftly.
- Precautionary Steps Guidance: Precautionary Steps Guidance provided clear and accessible safety tips for different earthquake intensities, organized for easy understanding and implementation by users.
- Emergency Calls: Emergency contact numbers were prominently displayed and easily accessible within the application, allowing users to access emergency services quickly, even in offline mode, ensuring swift

ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)

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response and support.

3.5 Testing and Validation:

Testing and validation are essential phases in the development of the Seismic Disaster Resilience Application to ensure its effectiveness, reliability, and user satisfaction. The following testing methodologies and validation processes were employed:

- Functional Testing: Functional Testing verified all features, simulated user interactions, and ensured compatibility across devices and operating systems.
- Usability Testing: Usability Testing evaluated UI design, user experience, and identified areas for improvement in ease of use and navigation.
- Performance Testing: Performance Testing assessed responsiveness, speed, and stability under different usage scenarios, including load and stress conditions.
- Validation: Validation of the Seismic Disaster Resilience Application was conducted against predefined criteria, ensuring functionality, usability, performance, and security aligned with standards and user requirements, with results documented to ensure quality and user satisfaction.

IV. CASE STUDY: GANGTOK TOWN

4.1 Seismic Vulnerabilities and Historical Incidents:

Nestled in the eastern Himalayan region, Gangtok town is vulnerable to earthquakes, as evidenced by historical seismic incidents like the 2011 Sikkim earthquake, emphasizing the need for robust disaster preparedness measures. Seismic activity in the area has resulted in significant damage to infrastructure and loss of lives, highlighting the town's susceptibility to seismic hazards.

4.2 Demographics and Infrastructure Overview:

Gangtok town boasts a diverse demographic composition and urban infrastructure, including residential, commercial, and institutional buildings, as well as critical lifeline infrastructure like roads and utilities. Despite its varied makeup, rapid urbanization and unplanned development have heightened vulnerability to seismic hazards, especially in areas with substandard construction practices and inadequate structural resilience.

4.3 Identification of High-Risk Zones:

Comprehensive risk assessment and geospatial analysis have identified high-risk zones in Gangtok town, characterized by factors like proximity to fault lines, geological instability, and substandard building construction. Densely populated neighborhoods, landslide-prone hilly terrains, and areas lacking adequate evacuation routes and emergency facilities are key concerns, informing targeted mitigation strategies and disaster resilience efforts.

V. ARCHITECTURE

Architecture of Seismic Disaster Resilience App:

The architecture of the Seismic Disaster Resilience App serves as the foundation for its development, encompassing design principles, and components and layers

5.1 Design Principles:

The design principles guiding the architecture of the Seismic Disaster Resilience App prioritize modularity, flexibility, and scalability to accommodate evolving requirements and ensure seamless integration of new features.

5.2 Components and Layers:

The architecture of the Seismic Disaster Resilience App is structured into several layers, each fulfilling specific functions and interacting with one another seamlessly. The key components and layers include:

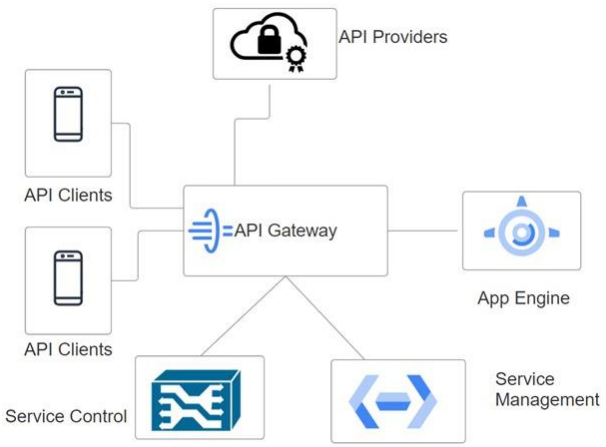

Fig. 1. System Architecture

VI. DEVELOPMENT

Development of the Seismic Disaster Resilience App:

The development of the Seismic Disaster Resilience App involved the integration of various functionalities aimed at enhancing disaster preparedness, risk assessment, and emergency response capabilities. The following sections detail the key aspects of the app's development:

6.1 Geospatial Mapping and Hazard Assessment:

The Seismic Disaster Resilience App visualizes seismic zones, evacuation routes, and hazard-prone areas in Gangtok town using geospatial mapping and hazard assessment. It integrates seismic activity records, geological surveys, and topographical maps for risk understanding. Advanced mapping technologies, like the Google Maps API, offer dynamic interfaces for efficient navigation and exploration of geospatial data.

ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)

Vol 11, Issue 5, May 2024

6.2 Emergency Response Protocols and Evacuation Plans:

The Seismic Disaster Resilience App features emergency response protocols, evacuation plans, and interactive maps for safe zones and shelters. Real-time updates inform users about evolving situations and ensure adherence to safety measures.

6.4 Alert Systems and Communication Channels:

The Seismic Disaster Resilience App includes alert systems and communication channels like in-app messaging and social media to engage stakeholders. It delivers push notifications, SMS alerts, and emails based on user preferences and location, ensuring effective information dissemination during emergencies.

VII. IMPLEMENTATION

The successful deployment and adoption of the Seismic Disaster Resilience App required a comprehensive implementation strategy encompassing deployment, training, and continuous monitoring. The following sections outline the key components of the implementation strategy:

7.1 Deployment and Accessibility:

The Seismic Disaster Resilience App prioritized accessibility through deployment via app stores, government websites, and community programs. Measures addressed language and tech literacy barriers with localized content, user-friendly interfaces, and multilingual support. Partnerships with local authorities and community groups promoted widespread adoption, ensuring inclusivity across diverse users.

7.2 Training and Capacity Building:

Training and capacity building were key in implementing the Seismic Disaster Resilience App, targeting government officials and the public. Workshops familiarized users with app features, emergency protocols, and technical proficiency, fostering collaboration and disaster awareness. Materials and online resources supported ongoing learning to enhance preparedness and response capabilities.

7.3 Continuous Monitoring and Updates:

Continuous monitoring and updates are vital for the long-term effectiveness of the Seismic Disaster Resilience App. A dedicated framework assesses performance and user engagement, tracking app usage, satisfaction levels, and emergency response effectiveness. Feedback mechanisms gather user input for improvement identification. Regular updates, informed by feedback and best practices, maintain the app's responsiveness to seismic risks and community needs, ensuring relevance and resilience over time.

VIII. RESULTS AND DISCUSSION

The implementation of the Seismic Disaster Resilience App yielded valuable insights into its effectiveness, challenges encountered, and snippets of the app. The following sections discuss the results and implications of the app's deployment:

8.1 Effectiveness of the Seismic Disaster Resilience App:

The Seismic Disaster Resilience App enhances disaster preparedness and response in Gangtok town, providing actionable information and facilitating coordination with authorities. Its mapping, risk assessment, and real-time alerts increase awareness of seismic hazards and access to emergency resources, improving disaster resilience outcomes.

8.2 Challenges and Lessons Learned:

Challenges during the Seismic Disaster Resilience App's implementation include technical issues with older devices and connectivity in remote areas, along with language and cultural barriers. Localization and community engagement are crucial. Sustaining engagement post-rollout requires ongoing support, outreach, and collaboration with local stakeholders, emphasizing user-centered design and iterative development for long-term adoption.

8.3. Snippets of the App Interface:

Fig. 2. Homepage

Fig. 3. Alert Message

IX. CONCLUSION

The Seismic Disaster Resilience App represents a significant advancement in disaster preparedness and response capabilities, providing users with essential tools and resources to mitigate seismic risks and enhance community resilience. This section summarizes the findings of the study, discusses the implications for policy and practice, and suggests future research directions:

9.1 Summary of Findings:

Key findings from implementing the Seismic Disaster Resilience App show its effectiveness in enhancing disaster

preparedness and high user satisfaction, despite challenges like technical issues and language barriers. These findings stress the importance of ongoing support and refinement to maximize the app's potential in empowering communities to respond effectively to seismic events.

9.2 Implications for Policy and Practice:

The study recommends prioritizing technology-driven solutions, like mobile apps, to strengthen disaster preparedness and response. Collaboration among local authorities, community groups, and tech providers is vital for creating user-friendly resilience tools. Capacity-building programs are advised for proficient app utilization, enhancing community resilience against seismic events.

9.3 Future Research Directions:

Future research should explore the effectiveness of disaster resilience apps across diverse contexts. Continuous refinement based on feedback and tech advancements is crucial. Long-term studies are needed to assess the apps' impact on community preparedness, facilitating ongoing improvement of resilience strategies and technologies.

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