

AI-Driven Integrated Platform for Comprehensive Flood and Cyclone Disaster Management

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ABSTRACT

Disaster Management, a strategy or an activity that involves risk reduction planning and effective preparations for all stages of a crisis cycle, faces challenges in synchronization of the flow of information resulting in constant communication problems. This coordination imbalance leads to vulnerabilities in communities and makes them unprepared to respond and recover effectively. To fill these gaps, a new integrated inclusive, and accessible AI-driven platform, Surakshit Bharat has been introduced to mitigate the existing gap as mentioned above. It would integrate government agencies, NGOs, volunteers, and citizens, ensuring those who are most at risk can receive assistance and aid relief as fast as possible. Equipped with multiple technologies, the platform would be capable of sending out alerts in real time, remote assistance, a voice interface, and gamified educational training to improve self-efficacy and efficiency during preparation and rescue efforts. Elders and people with low literacy levels can easily access the platform through a simple navigated interface and multilingual guides. Utilizing cutting-edge technologies with a focus on inclusivity, the platform portrays itself as a comprehensive, integrated, and innovative solution in the crisis management system.

Keywords: Disaster management, Artificial Intelligence, Application Programming Interface

1. Introduction

A natural disaster is caused by natural processes that occur regularly. However, no natural process can be called a disaster itself. When these natural disasters interact and cause destruction in human lives and properties, they are referred to as disasters. Hence, Thattai et al. described disasters as partly anthropogenic, as the way one lives and engulfs oneself in natural processes laced with sheer management leads a normal process to a catastrophe in [1]. Amongst the natural disasters, cyclones are powerful rotating storms combined with strong winds, heavy rainfall, and low atmospheric pressure often resulting in areas such as tropical and subtropical regions including coasts. Floods normally occur due to heavy rainfall, dam failure, and more factors resulting in significant loss of property as well as life [2]. Former use of technologies under disaster management and risk mitigation has included the implementation of advanced technologies like Geographic Information Systems (GIS), IoT based remote sensing, Flood Sensor Technology, and Artificial Intelligence. For instance, the Bangladesh used GIS techniques to aid in anticipating floods and guide evacuation plans [3]. Another example would be the utilization of the machine learning and computer vision on satellite imagery using remote sensing to assess structural damage after the 2017 California wildfires. It led to quick evaluation of structural impact, assisting in decision making and escalating relief efforts [4]. It has proved to be fruitful but their implementation and execution still faced delays and issues resulting in challenges faced like communication gap, lack of coordination, ineffective resource allocation. Emami et al, also highlighted the potential efficiency in disaster analysis through the integration of artificial intelligence and GIS along with the possible hurdles such as data accuracy, ethical considerations and potential biases in algorithmic decision making leading to issues as discussed above [5]. A new approach is thus required to mitigate the risk and minimize the ineffectiveness of the current systems. Hence a new integrated, inclusive, and accessible AI-driven platform, named Surakshit Bharat, has been introduced to mitigate the existing gaps. It aims to integrate government agencies, NGOs, volunteers, and citizens, ensuring those who are most at risk can receive assistance and aid relief as fast as possible. This can be approached by using the APIs in the proposed platform using machine learning enabling seamless communication amongst diverse communities at the crucial time of hazards resulting in quick data



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transmission and interoperability. Utilizing cutting-edge technologies with a focus on inclusivity, the platform portrays itself as a comprehensive, integrated, and innovative solution in the crisis management system. Instead of presenting the fully developed implementation, the focus of this research paper is to conceptualize an AI driven disaster management platform. The study intends to examine the feasibility of incorporating blockchain and AI into crisis management frameworks, utilizing the insights from previous studies and existing technologies. Although high level discussions are held about technological specifics like model implementation, blockchain integration, and privacy protection, more research would be required for full scale testing and deployment.

2. Methodology

2.1 Integration Technique

The significant hurdle posed by the current disaster management systems was the lack of synchronization and communication gap among the various government platforms and the citizens. Palitla et al , also, emphasised the need for further advancement in communication as integral part of disaster management systems despite the developments in the discipline in [6]. To mitigate this challenge, the integration of APIs from various government sites aims to ensure seamless communication amongst diverse communities at the critical time of hazards resulting in quick response and aid. The APIs(Application Programming Interface) are a set of commands which enable the applications to intercommunicate with each other. They act as a connecting medium among various diverse software programs enabling them to exchange data and functionalities without posing a need to understand each other's work as explained in [7]. The system would involve blending of predictive abilities using an LSTM model for disaster predictions, effortlessly implemented using FastAPI to give real-time informational outlook through API endpoints as shown in Fig1. The machine learning model, Long Short Term Memory (LSTM) model, integrated with API would be trained on publicly available datasets such as NOAA (National Oceanic and Atmospheric Administration) disaster records to predict potential flood and cyclones. To evaluate the AI model's effectiveness, key performance metrics such as accuracy, precision recall, and Root mean squared error (RMSE) would be considered. These metrics would depend on the implementation of the system entirely. These will aid in determination of reliability of the model in real life scenarios. Additionally, integration of GIS and IoT sensors with the system would enhance the predictability of the crisis with more precision by providing multi-source data inputs. As this research does not involve complete model innovation, further study would focus on dataset selection, hyperparameter tuning, and real-time deployment barriers.

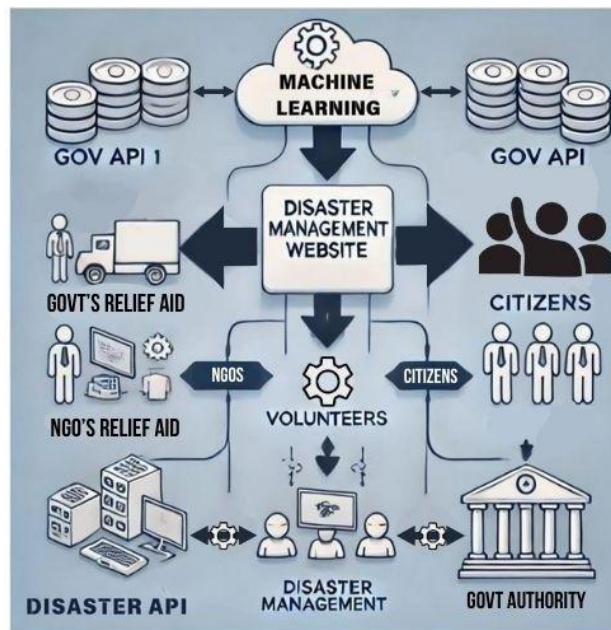


Fig1. Showcasing implementation of APIs using Machine Learning

Another technology used, Bluetooth mesh networks would allow communication even in low network areas, enabling access to accurate information regularly for all users. Additionally, for upcoming advancements USSD (Unstructured Supplementary Service Data) and IVR (Interactive Voice Response) would be able to assist non-smartphone users. Insufficient training to the response teams or lack of active engagements from communities in adapting to the solutions may act as a barrier in effective implementation of this system. Such cases include inadequate handling of advanced tools like GIS and IoT and the inability of the local community to respond effectively because of lack of digital literacy. To counter these hindrances, this conceptualized platform aims to garner a symbiotic relation between the NGOs, relief teams and government agencies by assisting them with crucial relevant real-time information and statistics in exchange for the funds and the workforce. This collaboration makes

sure that the volunteers are made adept in handling the situations effectively during a crisis in case the professional teams face delays. Being user centric, the system incorporates interactive tutorials to aid novice users surfing through the system. NGOs and volunteers would be assisted by specialised training modules tailored to their roles. The platform intends to maintain the engagement beyond crisis period by incorporating gamified content focused on disaster preparedness and precautions, specifically for children and elderly, to ensure essential safety protocols remain fresh in their memories. Further study also aims to develop an emergency override mechanism which temporarily halts the other device applications to display an unmissable warning text based on the severity of the crisis.

2.2 Interface of the System

The proposed system contains a User-Centered Design (UCD) which means it has a simple framework, which is easy to access as well as navigate without any ambiguity as shown in Fig2. The dashboard is provided for users to easily locate necessary tools to get aid in preparing for and responding to emergencies. Its home page provides instant control of the latest disaster notices, safety protocols, and important emergency services. The design, likewise, focuses on providing up-to-date information and quick decision making. The interface has been developed to emphasize the diversity in the targeted audience, citizens, and easy to follow tutorials to browse through the platform for digitally inferior users. In addition, the data provided on the system would be implemented through customizable text sizes & contrast to be accessible for the visually impaired.

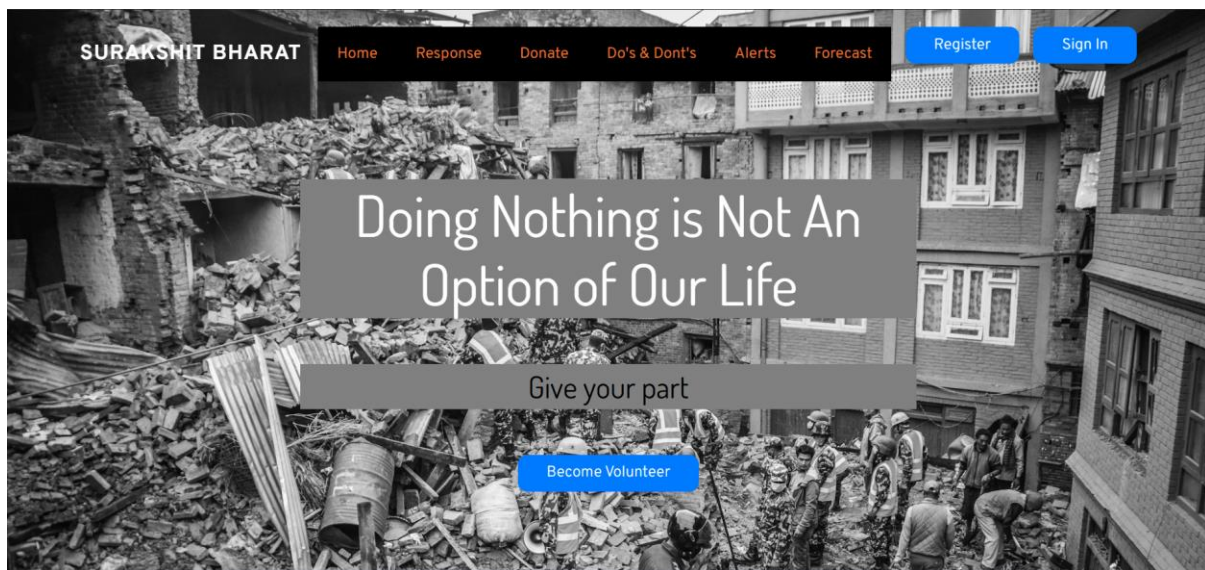


Fig2. Interface of the website Surakshit Bharat

The system provides real time alerts through notifications about the occurrences of disasters and the current state of emergency in the region. By merging data from the government with AI-based predictive analytics, the system can send notifications via SMS and email to maximize the reach and effectiveness of the service. Also, the Forecast function utilizes meteorology and AI models to assess vulnerability to different levels of disasters. Users can retrieve information on severe weather conditions, flood risk, and other calamities in both the short term and long term. This ability allows proactive preparedness to minimize the risk and effect of the disaster.

Although an actual implementation is beyond the scope of this study, the feasibility of smart contracts, parametric insurance and decentralized ledgers is examined based on current models. A decentralized approach for resource allocation and accountability in disaster management can be offered by the blockchain technology. It would ensure transparent and trusted ledger of funds and resources. Blockchain can also be used in insurance. While traditional insurance requires an assessment of damages suffered prior to the payout which causes undesirable delays, parametric insurance automates payouts based on predefined situations or parameters for disasters. This leads to instant deployment of payouts without manual intervention improved with security and trust. While the blockchain's inherent immutability provides a secure audit trail, management of permissioned access and prevention of personal data hinders the data privacy in the system. The study does not conduct empirical testing, so the proposed systems such as Zero Knowledge Proofs, homomorphic encryption, and multi-party computation are considered to address these issues and the potential solutions in future implementations.

The users are provided access, under the 'response' tab, to report disasters in geo-tagged real time and the emergency contacts including government and NGO relief aid. They also would be able to request medical, rescue, or evacuation assistance. Also, the users could contribute to community engagement by financial and material assistance at the time of a disaster under the 'donate' tab. A user can contribute funds, supplies, and volunteer time through secure verified channels. An informative and educational guide, listed under the dos and don'ts segment assists in the preparation for the disasters through all stages: before, during, and after disasters. It provides systematic guidelines for the best action plan during times of crisis. The content is

simplified for easy readability and includes visual aids, sign language support, infographics, and interactive elements to enhance its domain for user comfort considering all user demographics.

2.3 Phases of the Cycle of Disaster Management

An efficient disaster management system ensures preparedness and risk mitigation techniques in broadly two categories: pre-disaster and post-disaster management [8]. This can be further classified into reduction and preparedness in the pre-disaster stage, and response and recovery under the post-disaster phase. Hence, the proposed system further follows the four phases cycle and provides tailored utilities to assist in risk mitigation as explained below.

Pre-Disaster Stage This stage consists of actions for risk evaluation, mitigation planning and preparedness training to reduce potential damages [9]. For this, the forecast function utilizes the weather report from the government platforms and predicted AI model to provide users with real time data of occurrence and intensity of the disasters. Along with this, educational and training modules, including multimedia content with voice guided or sign language supported tutorials, infographics, and interactive videos prepare the users for the crisis window. The do’s and don’ts practices consist of step by step guided tutorials on the basics of the preventive measures to be followed. The multilingual chatbot, using the NLP (Natural Language Processing) technology, also be available for the assistance of the users.

During Disaster Stage In this phase, instant response actions such as emergency aid operations, search and rescue strategies, and the allocation of necessary services to affected individuals are crucial to minimize damage and stabilize the situation swiftly [10]. During the ongoing crisis, the users would be alerted in emergencies using push notifications, SMS, red flash alerts, haptic alerts, and voice cues. The red flash alerts and haptic alerts, consisting of vibration models and LED indicators for the sensory impaired users would intensify with the severity of the situation. Also, a large pushbutton enabled with a voice interface can be accessed by users to dial emergency contacts with a single click. Voice commands implementing NLP for speech recognition would allow hands-free interaction in the situation of panic. Offline Functionality achieved through Bluetooth Mesh integration ensures data synchronization even in low connectivity areas. Incident Mapping & Safe Shelter data would provide GPS with GIS mapping equipped with colour coded icons and respective feedback as shown in Fig3. It uses the user’s location to easily and effectively guide them to the nearest shelter.

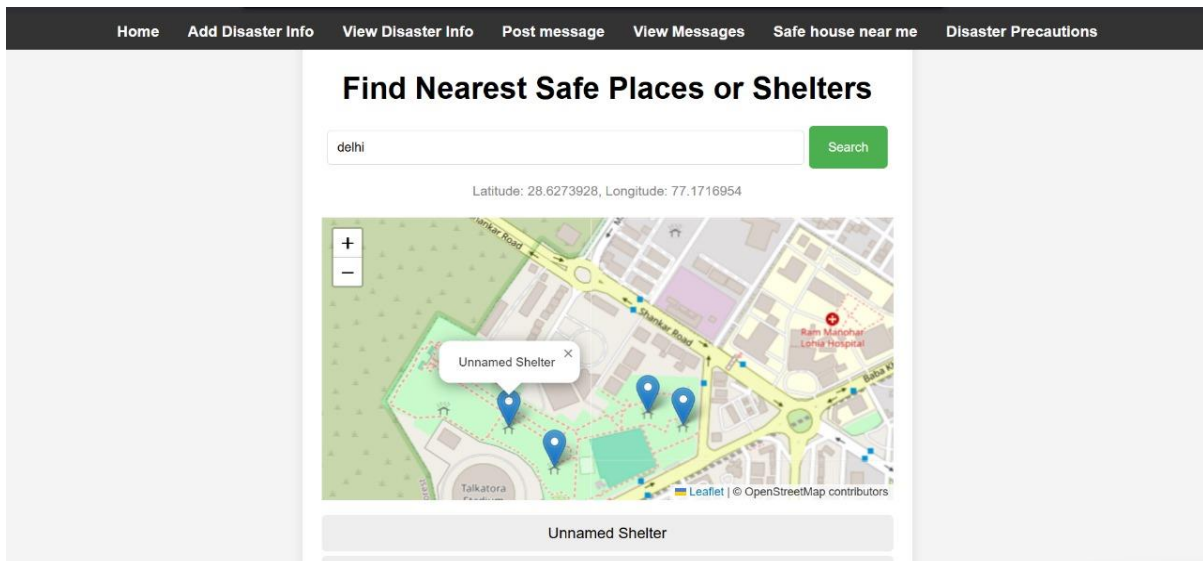


Fig3. Safe House Feature: Increasing the Efficiency of Getting Emergency Shelters

The safe shelter feature can be effectively used by typing in the user’s location or auto-scanning it through the GPS. Once the location of the user is entered, the system analyses the information and verifies its database for certified safe zones and emergency shelters to provide the user with the nearest safe bunkers or shelters amidst a crisis. The results are presented on an interactive map as well as a list form for those who prefer more detailed informatics. In addition to providing real-time navigation and directions, the app ensures that risk prone and delayed routes are not recommended. Additionally, the user can report their location through the platform in emergencies requiring immediate rescue.

Post Disaster Stage Here, the focus involves recovery through rebuilding the infrastructure, offering psychosocial aid, and implementing preventive measures for future crises [11]. A significant part of this is community engagement and support. The system ensures this by merging the community with the relief team to enhance the recovery efforts. The unlocated citizen data, which can be gathered in the system through user reports aided by geo-tags in the preferred language, is an immediate necessity following any calamity. Each request is geotagged for NGOs and authorities to access the location and is validated using AI and community feedback to allocate resources efficiently. Furthermore, the platform uses the Geographic Information System

(GIS) to assess a region after a disaster and assign resources. Resource allocation and recovery strategy are optimized by assessing the severity of affected regions and effectively allocating these resources. The users can engage in community empowerment by offering financial aid through blockchain technology. The process of the transactions for the disaster relief funds would be tracked in a transparent and unforged ledger ensuring the donations are directed to the targeted users.

3. Result and Discussion

The proposed technologies approach focuses on minimizing response time, easy accessibility, and accuracy of information. It emphasizes the recovery and resilience against potential risks as a community. The expected outcome of this platform is a significant reduction in the communication gap which ensures diversity for all groups including disabled, illiterate, and partially literate individuals, elderly people as well as children. It ensures that no one gets left behind and the community faces all stages of disasters altogether. This allows the system to perform real-world implementations as shown in Fig4.

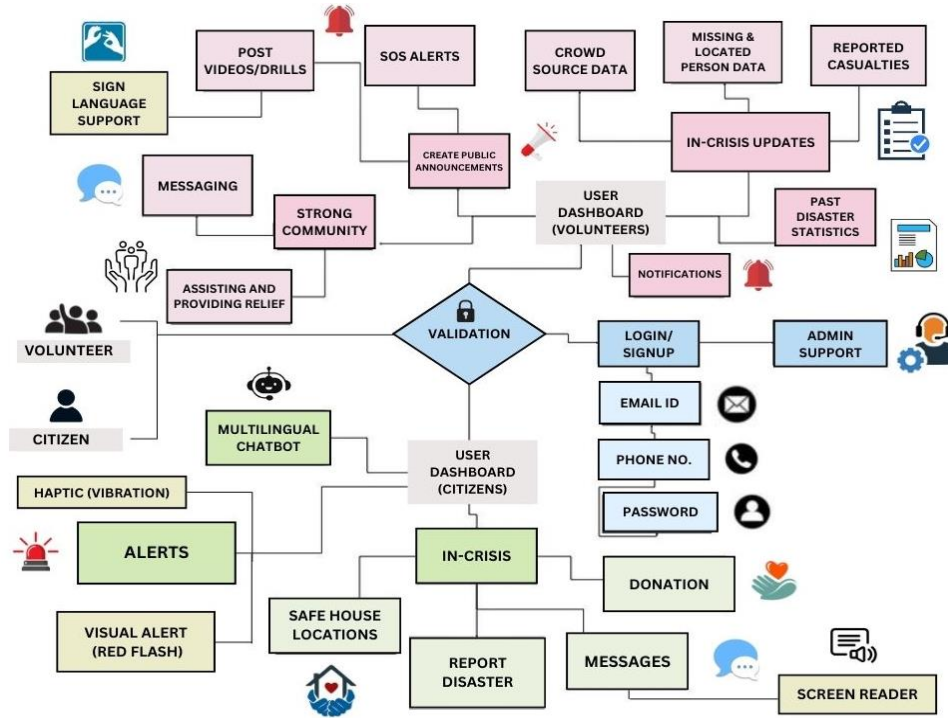


Fig4. Flowchart projecting the functionality of the application

The website enables access to two authorized roles: citizens and volunteers. Each role is equipped with features tailored to the aid and efforts required on the basis of their functions in the disaster management efforts. The user would be able to register through their credentials which will be validated through admin support. The admin functions as a guiding authority to make sure that all the data posted by the users is first validated with the data accessed by the official authorities for data integrity. After registration and login, the users, authenticated as citizens, would have accessibility to the in-crisis features such as safe house locations through smart navigation, hazard updates which will be validated through admin support, and messages. The citizens with limited literacy knowledge would be able to access the data through the screen reader aid equipped in the preferred language of user. They will also be notified through alerts consisting of haptic technology (vibrations varying with the intensity of the crisis) or visual alerts (red flash with frequency based on crisis severity) using a real-time alert system. This would help the users with partial blindness or auditory impaired to receive alerts. Also, the visual alert feature could come in handy when the system having the website is not in touch with the body. Moreover, the interface has been made inclusively intuitive and easily accessible due to the integration of voice, text, and visual aid features. Additionally, the users are accessible to provide the financial aid to the affected community using the blockchain technology in transparency.

The users, registered as volunteers, would be connected to in-crisis updates and resources such as crowd source data, unlocated individual data updates, and reported casualties. The individuals affected during the crisis can gain assistance using these volunteers and help in relocation of missing people. The volunteers would be able to gather the report of places people could be residing in with the access to safe shelter locations to migrate the injured and impacted individuals. They would be able to post public announcements and have access to SOS texts for the nearby affected regions. Also, the users would be able to post videos and drills. The tutorials for all users would consist of sign language aids as well. To enable instant query resolution and reduced delays, a very quick response AI driven assistance mechanism with regional language support will be implemented. This will increase community growth by fostering engagement and trust, encouraging participation from all demographics. AI powered analytics along with predictive features will strengthen manpower allocation which will ultimately lead to optimized

decision making and efficient deployment of services. Also, a user friendly, adaptive interface will allow seamless interaction without considering the user's technical area of expertise.

Further, to highlight the usability of the Surakshit Bharat platform, concept driven distinctions are drawn between the current disaster management solutions and the stipulated framework. Existing systems like Google Crisis Response and Sahana provide valuable disaster management functions but work within particular, predefined scopes. Google Crisis Response mainly concentrates on live alerts by integrating disaster related information from various sources, however the resource allocation mechanisms in it are not direct and it also lacks the future prediction abilities required to predict or hypothesize a future scenario based upon past disaster patterns. Meanwhile Sahana, an open source calamity management system proficiency in the coordination and inter sharing of data among the response teams, prioritizes stakeholder communication and keeping tracks of the resources available. But it does not intrinsically combine or merges the advanced AI powered prediction models or other non-primary security frameworks.

The proposed platform, on the other hand, efficiently adapts itself in different scenarios thereby gathering communities together resulting in its collective growth. The key features have aligned both urban and rural environments in providing reinforcement. Along with integration and bridging the communication gap, the system ensures the access to individuals during crisis for efficient rescue and recovery effects. Since this study is conceptual, insights are sourced from literature rather than direct implementation. Future work in this field would focus more on prototype development, real world testing and comparative analysis to further validate and prove its effectiveness against the already prevailing disaster management systems, providing a base for its further advancements. The evaluation metrics would thus depend upon the implementation of the proposed system in later research. Hence the system is aimed to create a highly responsive, hassle-free, and well-connected digital platform to aid in flood and cyclone disaster management.

4. Conclusion

A natural occurrence that happens regularly, when causes destruction to human lives and property, is referred to as a disaster. The disaster management system hence is the strategic system through which risk mitigation and preparedness for upcoming crises are achieved. The former disaster management systems faced various hurdles such as bridging communication gaps amidst crisis with ineffective responses for disabled, digitally illiterate, and senior citizens. This research paper has a user centered approach to harness progress in the disaster management sector. Analysis in studies marked the lack of resource distribution and delayed response due to limitations in the integration of existing technologies such as GIS and IoT based remote sensing technologies. This platform, thus, would integrate various related government sectors, NGOs, and citizens equipped with diverse features to provide real time data and alerts of upcoming and ongoing crises. The proposed platform would be equipped with some key traits such as support of multilingual, real-time data as well as alerts and safety precautions assisted by AI. This proposed system ensures usage for all diverse groups including disabled, illiterate, and partially literate individuals, elderly people as well as children. By combining IoT, this system has the capability for the collection of data and helps in the process of decision making for response during emergencies. The platform aims to reduce the gaps in the disaster management by combining AI powered prediction models and accountability mechanisms based upon blockchain system. The use of blockchain would ensure a secure and transparent resource allocation along with paving the way to introduce parametric insurance as well. This developed platform aims at minimizing the communication gap, aiding speedy response as well as recovery. This helps in gathering the communities together in turn resulting in collective growth, effective resource and manpower distribution along with a user-friendly platform that is accessible to all. Further advancement in this platform can make disaster management systems more efficient, easy to adapt, and smart in emergency response systems.

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