STUDY & ANALYSIS OF AI-BASED EXPERT SYSTEM FOR DISASTER RISK REDUCTION SPECIFIC TO ANDHRA PRADESH

A Dissertation Submitted to the Panjab University, Chandigarh for the Award of Master of Philosophy in Social Sciences, in Partial Fulfillment of the Requirement for the Advanced Professional Programme in Public Administration (APPPA)

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UNDER THE GUIDENCE OF

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I have the pleasure to certify that **Commodore Chanti Varanasi,** has pursued his research work and prepared the present dissertation titled ***'Study & Analysis of AI-based Expert System for Disaster Risk Reduction-specific to Andhra Pradesh'*** under my guidance and supervision. The same is result of research done by him and to best of my knowledge; no part of the same has been part of any monograph, dissertation or book earlier. This is being submitted to the Panjab University, Chandigarh, for the purpose of Master of Philosophy in Social Sciences in partial fulfillment of the requirement for the Advanced Professional Programme in Public Administration (APPPA) of Indian Institute of Public Administration (IIPA), New Delhi.

I recommend that the dissertation of **Commodore Chanti Varanasi** is worthy of consideration for the award of M. Phil degree of the Panjab University, Chandigarh.

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III

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IX

LIST OF ABBREVIATIONS

ABBREVIATION	FULL FORM
AI	Artificial intelligence
AIDR	Artificial intelligence for disaster response
ANN	Artificial Neural Networks
AP	Andhra Pradesh
APSDMA	Andhra Pradesh State Disaster Management Authority
ARD	Atmospheric Research Division
ASDMA	Andhra State Disaster Management Authority
ASEB	Andhra State Electricity Board
CCA	Climate Change Adaptation
CDMPs	City Disaster Management Plans
CWC	Central Water Commission
DDMAS	District Disaster Management Authorities
DDMPs	District Disaster Management Plans
DEOCs	District Emergency Operations Centers

DMPs	Departmental Disaster Management Plans
DRR	disaster risk resilience
DRR	Disaster Risk Reduction
EWS	Early Warning Systems
FEMA	Federal Emergency Management Agency
GA	genetic algorithms
GIS	Geographic Information Systems
HRVA	Hazard Risk and Vulnerability Assessment
IMD	Indian Meteorological Department
IOC	Intergovernmental Oceanographic Commission
ML	Machine learning
NDMA	National Disaster Management Agency
NeurIPS	Neural Information Processing Systems
NWM	National Water Model
PSS	Psycho-social Support
RISAP	Risk Information System for Andhra Pradesh

SDGs	Sustainable Development Goals
SDMAs	State Disaster Management Agencies
SEC	State Executive Committee
UNDP	United Nations Development Programme

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Executive Summary

Recent years have seen an increase in the frequency of catastrophic catastrophes, pushing academics to focus heavily on handling disaster information and developing cutting-edge solutions to reduce losses. Microblogging platforms are increasingly being utilised to convey information that must be shared quickly during any disaster, natural or man-made. These platforms have emerged as a key resource in recent years for news on the situation right now, the availability of food and medicine, and keeping tabs on family and friends. Information retrieval systems powered by artificial intelligence (AI) offer a cutting-edge method for organising disaster relief activities and acquiring situational awareness. This paper provides an overview of the AI methods used by professionals to process disaster risk reduction with machine learning when a disaster occurs, specific to the state of India's Andhra State. Case studies of a few recent disasters are given, emphasising how the development of information and communication technologies has greatly facilitated the dissemination and consumption of vital information in times of crisis. This research demonstrates the benefits and drawbacks of using new and developing AI technologies in disaster management.

Keywords: artificial intelligence, machine learning, disaster management, risk reduction, information technologies, drawbacks

CHAPTER 1

INTRODUCTION

1.1 Background

A nation's social and fiscal resources are greatly impacted by disasters. According to a UN research, there were 354 disasters on average every year from 2007 to 2017, affecting 210 million people and claiming 68,000 lives. These catastrophes caused $ 163 billion in damages. Huge social and economic losses have resulted from the increased likelihood and severity of catastrophe risks in recent years, both in India and globally. India is more severely impacted by disaster-related effects than other climate-sensitive nations because of its large vulnerable population, unplanned physical infrastructure development, and weak institutional capability. From 1998 to 2017, disaster-related economic losses in India were assessed to have cost the country $79.5 billion. Natural disasters also contributed to about 3.67 lakh fatalities in India between 2000 and 2018. In its National Disaster Management Plan for 2019, India adopted the Sendai Framework for DRR 2015–2030, Sustainable Development Goals (SDGs) 2015–2030, and Paris Agreement on Climate Change (CoP 21) to encourage a holistic approach to designing strategies for disaster risk resilience (DRR) and fostering community resilience. In order to accomplish the objectives outlined in these accords, science, technology, and innovation will be essential.

Machine learning (ML), a subset of artificial intelligence (AI), is becoming more and more crucial to disaster risk reduction (DRR), from the forecasting of extreme events and the creation of hazard maps to the real-time event recognition, situational awareness, and decision support it offers

1.2 AI and Its Use In DRR

Artificial intelligence (AI) describes systems that can imitate or even outperform human intelligence in some situations. The process of parsing data into algorithms that learn from data to make classifications or predictions is the essence of machine learning (ML), a subset of artificial intelligence that includes supervised (e.g., random forest or decision trees), unsupervised (e.g., K-means), and reinforcement (e.g., Markov decision process) learning. AI techniques open up new possibilities for applications, such as the pre-processing of observational data and the post-processing of prediction model output. New processor technologies that enable robust, parallel data processing increase the methodological possibilities.

In general, the availability of high-quality data and the choice of an appropriate model architecture determine how well ML performs for a given job. Our base of Earth observational data has greatly expanded thanks to crowdsourcing, instrumental networks, remote sensing (from satellites, drones, and seismic stations, for example), and remote sensing. Model designs are also being improved all the time. Consequently, it is reasonable to anticipate that ML will become more prevalent in DRR applications[1]. For example, a preliminary analysis of recent (2018–2021) literature reveals that ML approaches are being used to enhance early warning and alert systems and to assist in the creation of hazard and susceptibility maps through ML-driven detection and forecasting of various natural hazard types (see Figure 1, note that this survey excludes research that is purely focusing on method development but does not target future DRR application).

[1]Sun, W., P. Bocchini, and B.D. Davison, 2020: Applications of artificial intelligence for disaster management. Natural Hazards 103, 2631–2689. doi: https://doi.org/10.1007/s11069-020-04124-3

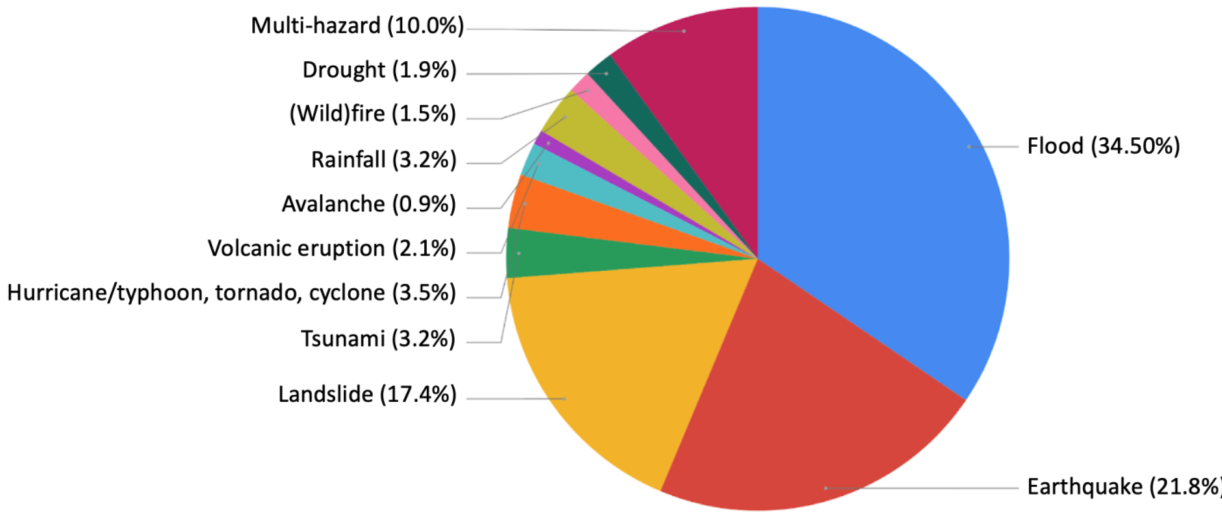

Figure 1. Application of AI to the detection and forecasting of natural hazards and disasters derived from a preliminary literature survey covering articles published between 2018 and 2021 with a focus on (future) DRR applications. These results show an overrepresentation of certain natural hazard types, particularly floods, earthquakes, and landslides.

This preliminary study shows unequivocally how AI-related techniques are being used to assist in better managing the effects of various natural disasters and hazards. We outline four particular instances in which AI is being used to support DRR in the following paragraphs. In general, the availability of high-quality data and the choice of an appropriate model architecture determine how well ML performs for a given job. Our base of Earth observational data has greatly expanded thanks to crowdsourcing, instrumental networks, remote sensing (from satellites, drones, and seismic stations, for example), and remote sensing. Model designs are also being improved all the time. Consequently, it is reasonable to anticipate that ML will become more prevalent in DRR applications[2].For example, a preliminary analysis of recent (2018–2021) literature reveals that ML approaches are being used to enhance early warning and alert systems and to assist in the creation of hazard and susceptibility maps through

[2]Sun, W., P. Bocchini, and B.D. Davison, 2020: Applications of artificial intelligence for disaster management. Natural Hazards 103, 2631–2689. doi: https://doi.org/10.1007/s11069-020-04124-3

ML-driven detection and forecasting of various natural hazard types (see Figure 1, note that this survey excludes research that is purely focusing on method development but does not target future DRR application).

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A national multi-hazard early warning system (MHEWS) is being developed by the United Nations Development Programme (UNDP) to help lessen the risk that communities, livelihoods, and infrastructures will be affected by weather- and climate-related natural disasters. This technology needs precise forecasts and danger maps of severe convective events to function (i.e., hail- and windstorms).

Given the absence of nationwide on-site observation networks, developing these goods is difficult. The chance of witnessing a convective event on a particular day at a specific location under specific meteorological and climatological conditions is therefore being predicted by experts using AI. By combining on-site observations with data from the European Centre for Medium-Range Weather Forecasts' (ECMWF) 5th-generation atmospheric reanalysis dataset and the National Oceanic and Atmospheric Administration's (NOAA) 70-year Storms Events Database, the ML model is able to predict severe convective conditions, that is, the model detects days with a high potential of severe convection resulting in hail- or windstorms (ERA5). The tool uses transfer learning to extrapolate to other areas of the globe with limited data availability from historical data from data-rich regions. Finally, the Weather Research and Forecasting (WRF) numerical weather prediction model is used to simulate and evaluate these events.[3] the ERA5 statistics, etc. This has demonstrated great promise for predicting strong convective storms and creating hazard maps in

[3]Skamarock, W.C., J.B. Klemp, J. Dudhia, D.O. Gill, L. Zhiquan, J. Berner, W. Wang, J.G. Powers, M.G. Duda, D.M. Barker, and X. Y. Huang, 2019: A Description of the Advanced Research WRF Model Version 4. NCAR Technical NoteNCAR/TN-475+STR. doi: http://library.ucar.edu/research/publish-technote

Georgia, a state that presents special difficulties for hail and windstorm forecasting due to its complicated topography.

The second illustration, which deals with flash floods, also makes use of AI to help with small numbers. Due to the fact that there is frequently little to no warning of the impending disaster, flash floods are especially dangerous. It is crucial to have a dense network of sensors to watch and notice changes in discharge or stage throughout the catchment in order to identify such events as they happen. A multi-sensor network made up of weather stations, River Core sensors (for stage and soil moisture), and hydrological stations is used in some river basins, such as that of Colima in Mexico, where elevations vary from 100 to 300 metres (m). These data are used to create machine learning (ML) models that can recognise flash floods. Performance metrics are computed, such as overall accuracy (OA), F1-score, and Intersection Over Union, and results from the ML models are compared with those from hydrological and hydraulic models (IoU). The success of this has led to the expansion of the same techniques to identify flash floods in city tunnels in the other major metropolis.

The third instance demonstrates how AI can be applied to geodesy to predict tsunamis and prevent problems with sensitive data crossing international borders. Tsunami Disaster Early Warning has significantly improved thanks to the use of sophisticated Global Navigation Satellite System (GNSS) real-time processing for positioning and ionospheric imaging. Seismology employs GNSS to investigate ground displacements as well as to track changes in the ionospheric total electron content (TEC), which frequently occur after earthquake events.

AI and ML can be used in conjunction with Earth observations to evaluate threats and make advance preparations.[4] and prepare ahead of time, to evaluate

[4]Iglewicz, B., and D. C. Hoaglin, 1993: Volume 16: How to Detect and Handle Outliers. The ASQC Basic References in Quality Control: Statistical Techniques

impacts as they unfold (as little as 20 min after earthquake occurrence[5]) , and to respond more quickly in the aftermath to save lives during recovery operations[6].

Artificial Intelligence for Natural Catastrophe Management is a priority for the United Nations Environment Programme (UNEP) (FG-AI4NDM). The International Telecommunication Union's (ITU's) expertise in information and communications technology is combined with knowledge of natural disasters and hazards from the World Meteorological Organization (WMO) and United Nations Environment Programme in the Focus Group on AI for Natural Disaster Management (UNEP). The group's objectives include improving modelling at various spatiotemporal scales, facilitating effective communication, and aiding in data gathering and handling. Additionally, it actively involves experts and stakeholders to develop and integrate perspectives and competencies in the development of AI-based technologies into disaster risk management, making means and opening doors to withstand challenges to an open science at the national, regional, and global levels.

The Subject Group on AI for Geodetic Enhancements to Tsunami Monitoring and Detection has begun looking at pertinent best practises in the use of Global Navigation Satellite Systems (GNSS) to improve the accuracy of tsunami monitoring and detection[7].In particular, the experts are investigating the viability of using AI to process GNSS data in nations where exporting real-time data is prohibited by law, as well as establishing protocols for the development and sharing of products derived from AI and related techniques that are permitted for export. The team is also thinking about cutting-edge communication techniques for sending real-time GNSS data to places with little available bandwidth, where using AI for decentralised, data-derived product sharing could allow the transfer of vital information over shoddy network capacity. Such an

[5]Carrano, C., and K. Groves, 2009: Ionospheric Data Processing and Analysis. Workshop on Satellite Navigation Science and Technology for Africa. The Abdus Salam ICTP, Trieste, Italy

[6]Martire, L., V. Constantinou, S. Krishnamoorthy, P. Vergados, A. Komjathy, X. Meng, Y. Bar-Sever, A. Craddock, and B. Wilson, 2021: Near Real-Time Tsunami Early Warning System Using GNSS Ionospheric Measurements. American Geophysical Union, New Orleans, Louisiana, USA

[7]Astafyeva, E., 2019: Ionospheric detection of natural hazards. Reviews of Geophysics, 57, 1265-1288. doi: 10.1029/2019RG000668; Brissaud, Q., and E. Astafyeva, 2021: Near-real-time detection of co-seismic ionospheric disturbances using machine learning, Geophysical Journal International, in review

effort sets the foundation for extending the application of these techniques in developing nations that experience growing tsunami threats in addition to climate change effects like sea level rise[8].

The fourth example looks at how AI can be applied to catastrophe and natural hazard situations to facilitate effective communication. It focuses on how AI can assist first responders to natural disasters in determining the danger level and prioritising when and where to act. Operations Risk Insight (ORI), a platform that uses natural language processing and machine learning, receives structured and unstructured data from risk alert sources, vulnerability, susceptibility and resilience indicators, and news sources. This data is used to visualise and communicate multi-hazard risks in real-time and to aid decision-making. Between Hurricanes Florence and Michael (autumn 2018), IBM made ORI accessible to qualified natural disaster non-profit groups as part of the IBM Call for Code Program. Since then, IBM has collaborated with numerous nongovernmental organisations (NGO) to enhance and alter a platform for leaders in crisis response. For instance, ORI offers Day One Relief, Good360, and Save the Children personalised hurricane and storm warnings in addition to layered data sets that are used to create map overlays that improve situational awareness[9].

More than 98.4 million people were impacted by disasters in 2021 alone, resulting in over 15,000 fatalities and an estimated USD 171.3 billion in economic losses[10].The goal of disaster risk management (DRM) is to assist communities in recovering from disasters as well as in anticipating and lessening the effects of future disasters. By mapping the people and infrastructure that are vulnerable to disasters, identifying high-risk regions, and organising emergency responses, geospatial data play a crucial part in disaster risk management[11]. Remotely

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[8]Meng, X., A. Komjathy, O. P. Verkhoglyadova, Y.-M. Yang, Y. Deng, and A. J. Mannucci, 2015: A new physics-based modeling approach for tsunami-ionosphere coupling. Geophysical Research Letters 42, 4736–4744. doi:10.1002/2015GL064610

[9]Nonprofits and artificial intelligence join forces for COVID-19 relief, EdNC, 2020

[10]CRED & UNDRR . UNDRR); 2021. The Non-COVID Year in Disasters; p. 2020

[11]Kemper H., Kemper G. Sensor fusion, GIS and AI technologies for disaster management. *Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci. ISPRS Arch.* 2020;43:1677–1683. doi: 10.5194/ISPRS-ARCHIVES-XLIII-B3-2020-1677-2020

sensed imagery from satellites or drones can extract proxies to analyze pre-disaster vulnerability and resilience and post-disaster damage and recovery[12]. Similarly to other industries, DRM has seen how artificial intelligence (AI) algorithms can quickly and correctly process data. As a result, DRM is now utilising AI to create more precise risk models and organise the distribution of disaster aid[13].

1.3 Challenges To The Use Of Ai For DRR

When applying AI for DRR, challenges can appear at any stage of the life cycle (Figure 2): at the data, model development or operational implementation stage. The fig simplifies AI lifecycle in DRR.

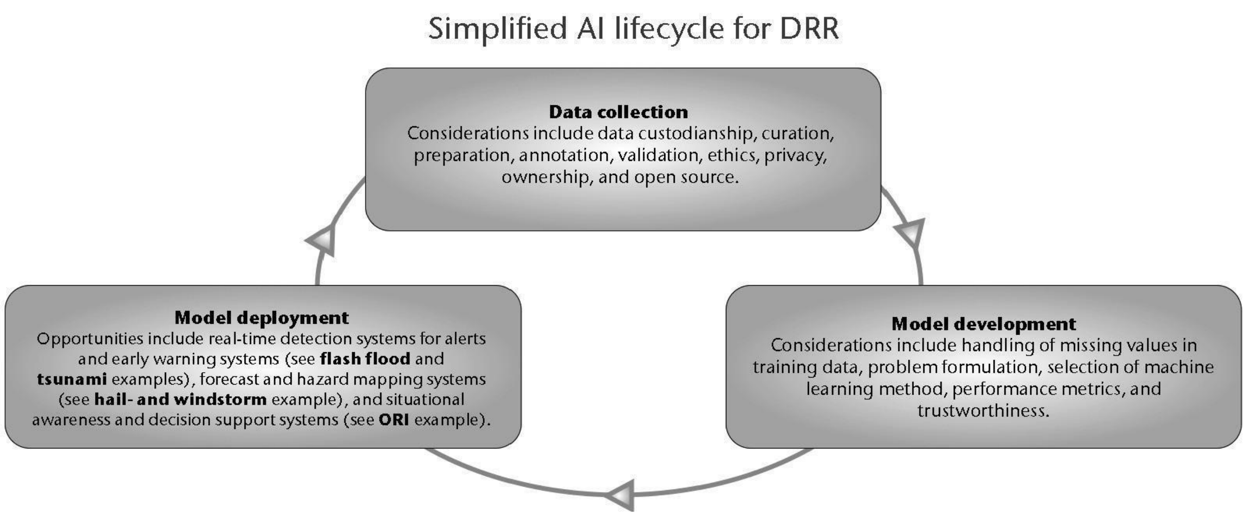

Figure 2. A schematic of key steps in the AI lifecycle for DRR.

It is crucial to take into account the following when collecting and handling data: (a) biases in training and testing datasets; (b) novel distributed AI technologies

[12]Ghaffarian S., Kerle N., Filatova T. Remote sensing-based proxies for urban disaster risk management and resilience: a review. *Remote Sens.* 2018;10:1760. doi: 10.3390/RS10111760.
[13]GFDRR; 2018. Machine Learning for Disaster Risk Management

within the data domain; and (c) ethical concerns. It is crucial to check that data are accurately sampled and that each pattern is sufficiently represented for the given issue in order to avoid biases in training and testing datasets. Think about the difficulty of creating a dataset with examples of extreme occurrences, for instance (which are, by nature, rare). Consider the potential costs of not providing adequate data as well, such as inaccurate forecasts or biassed results.

Once a dataset has been verified to be neutral, we must choose how to incorporate new distributed AI technologies into the data realm. Petabytes of data have been generated as a result of strategic adjustments made to the development of space-based instruments such as numerous small satellites[14] and the introduction of edge computing[15] Centralized data processing and administration can be challenging for AI because it depends on data transmission and the computation of sophisticated machine learning algorithms. On the one hand, effective alliances and international data sharing are necessary for real-time disaster applications. On the other hand, ML algorithms are frequently managed centrally, necessitating the fusion of training data in data centres. The risks to the privacy of personal and national data can be another issue brought on by a centralised strategy. Additionally, centralised data processing and administration may reduce transparency, which may result in end users losing faith in them and make it more difficult to comply with regulations (e.g., GDPR).

The social implications of data pose another problem. These focus on the proper implementation of AI-driven tools, from creation to deployment, for example, making sure that socio-economic biases in the underlying data are not transmitted through the models created by the system. Such principles are promoted in order to mitigate, if not completely eliminate, possible harms connected with AI, such as underrepresentation due to bias (either technical or human-based), and to maximise the benefits of AI

[14] About CubeSat Launch Initiative, NASA

[15] Nikos, K., M. Avgeris, D. Dechouniotis, K. Papadakis-Vlachopapadopoulos, I. Roussaki, and S. Papavassiliou, 2018: Edge Computing in IoT Ecosystems for UAV-Enabled Early Fire Detection. IEEE International Conference on Smart Computing (SMARTCOMP) 106-114. doi: 10.1109/SMARTCOMP.2018.00080

realised for everyone, particularly for those who are more at risk due to the effects of natural disasters.[16].

We also need to take challenges into account during the model creation phase after a dataset has been curated. Here, we emphasise the need for transparency and computational needs. Because AI models frequently depend on intricate structures, training them can be computationally expensive. The VGG16 algorithm, for instance, which is used to classify images, has about 138 million trainable parameters.[17] This size of training model necessitates expensive and big computing resources, which are not always available.

The outcomes of an AI model after development must be comprehensible and suitable to humans. This can be difficult to acquire because there isn't a standard out-of-the-box human-machine interface that explains the reasoning behind the AI model's decisions.

As a result, many researchers are trying to create reliable AI solutions. A precise formulation of the issue, as well as the needs and expectations of the AI-based answer, is crucial when modelling and model evaluation, for example. Then and only then can the problem-solving model and learning strategy be created. Furthermore, selecting and creating appropriate evaluation criteria is aided by being aware of the exact setup.

Data-related problems, such as accessibility, completeness, security, privacy, and ethical concerns, are a major obstacle for useful AI applications in disaster management. When using AI techniques, a large amount of high-quality data is usually needed to build the model. Such information isn't always accessible. For instance, certain infrastructure data cannot be readily available due to concerns about national security and business competition. Another problem is the veracity of the data. For instance, social network raw data frequently contains a variety of biases and errors, necessitating sophisticated information filtering and

[16] In Europe and Central Asia, the Poor Lose More When Disaster Strikes, World Bank 2021
[17] Simonyan, K. and A. Zisserman, 2015: Very Deep Convolutional Networks for Large-Scale Image Recognition. ICLR

verification. Furthermore, gathering and analysing personal data raises important ethical, moral, and human rights concerns. Due to a disaster's dynamically changing environment, data incompleteness is a frequent issue in disaster-related data analyses even when the necessary data are available. To address the aforementioned problems, numerous platforms and databases have been created to gather and exchange disaster-related data in a largely uniform format. ShakeMap and ShakeCast, GeoPlatform (2016, GeoPlatform), I-WASTE (2016, EPA), Lantern Live, and Disaster Response Program (2016, ESRI), among others, are a few instances.

There are three difficult problems in calculation. First, given the growing amount of data and the constrained manpower in the aftermath of a catastrophe, there might not be enough human-labeled training data in time. Applying and enhancing unsupervised learning techniques may be the solution in this case for managing real-world data without the need for manual human labelling. Second, the ability to process, manage, and learn from data within a reasonable response time in the disaster scenario is challenged by the computational complexity, which sharply rises with the size, variety, and update rate of data. Big data needs to be effectively managed, stored, and processed if catastrophe management, and disaster response, are to be successful. To effectively query and keep big data, cloud platforms are useful. This problem can be solved using them. Naturally, it would be beneficial to develop more effective Intelligence techniques. This problem has been addressed through the use of reservoir computing, GPUs, and AI engines, among other strategies. Real-time AI analyses combined with crowdsourcing can help to finish the required computation within the allotted time and eliminate the bulk of the laborious work that has typically required on-site work. Third, it's crucial for professionals to create user-friendly tools for disaster administration. This entails creating AI-based tools with user interfaces that only need rudimentary technological knowledge to operate.

It is crucial to take into account the aforementioned data and model development-related challenges as well as user notification challenges for an

AI-based model that is considered suitable for operational implementation. Using AI-based communication tools, these are investigated. It is necessary to translate and visualise AI model outputs in accordance with end-user requirements in order to enhance and simplify interpretation. The development and evaluation of alert and early warning systems, forecasts, hazards maps, decision support systems, dashboards, chatbots, and other AI-enhanced communications tools must therefore involve all relevant stakeholders, from local communities to emergency system managers and NGO disaster response leaders. Disaster responders must promptly provide input on and evaluate AI model insights in order to raise the accuracy and quality of those insights. To build confidence and improve suggestions based on machine learning, transparency into the data sources ingested, the frequency of data refresh, and the algorithms used for communication tools are crucial. Similar to conventional modelling techniques, it is essential for clear decision-making to communicate the confidence levels, uncertainties, and constraints of an AI-enhanced system. The biggest obstacle to be surmounted is confidence in timely and completely transparent AI-based communications tools. To meet the needs of all stakeholders, this calls for efficient cooperation between seasoned disaster responders, AI developers, geoscientists, regulators, government agencies, NGOs, telecom companies, and others. Every type of disaster is distinct, and every region has varying degrees of vulnerability and resilience.

• To suggest an expert system for timely, accurate, and targeted alert dissemination in view of disasters using the state of Andhra Pradesh, India, as a case study. • To study and analyse the current AI-based solutions for disaster risk reduction.

1.4 Objective Of The Study

- To study and analyze the existing AI-based solutions for disaster risk reduction and

- To propose an expert system for timely, accurate and targeted alert dissemination in view of disasters with the state of Andhra Pradesh, India, as a case in point.

1.5 Rationale Of The Research

Unmanned aerial vehicles (UAVs) for emergency response and AI-based image processing for emergency response and catastrophe detection are just two examples of the many AI-based solutions available for disaster recovery. However, disaster risk reduction is the main emphasis of this dissertation. Although there are a number of AI-based catastrophe risk reduction strategies, this article focuses on risk reduction through the timely and precise distribution of alerts.

Although a framework for an expert system to enhance alert dissemination is put forth, this dissertation does not cover its application. The state of Andhra Pradesh in India is taken into consideration for the creation of the framework because the framework may need to be customised based on the geographical area and demographics.

1.6 Research Questions

The following issues are addressed in this dissertation:

• What are the most recent advances in AI-based catastrophe risk reduction strategies?

• What should the structure be for an expert system that uses targeted alerts to assist in disaster preparedness?

• How can such an expert system be customised for particular geographical areas (for instance, the Indian state of Andhra Pradesh)?

1.7 Research Problem

Disaster risk management (DRM) aims to assist communities with disaster and climate change preparedness, mitigation, and recovery. Disaster risk models, which are at the heart of DRM, heavily depend on geospatial information about the built and natural environments. Artificial intelligence (AI) is being used more and more by developers to raise the calibre of these models. However, little is still known about how the magnitude of covert geospatial biases impacts catastrophe risk models. In many instances, there is also a gulf between the communities conducting the study or using the algorithms and the algorithm designers. This viewpoint draws attention to newly expressed worries about AI's application to DRM. We go over potential issues and show what needs to be taken into account from a data science, ethical, and social viewpoint to guarantee the responsible application of AI in this area. This prompts the following queries: What possibilities does AI offer? What are the difficulties? How can we meet the difficulties and seize the opportunities? And how can AI be used to deliver crucial information to decision-makers, influencers, and the general public to lower the risk of disaster?

CHAPTER 2

LITERATURE REVIEW

AI-based methods for disaster management have been proposed by several researchers in the past. This section covers the most recent and relevant of these methods in the context of risk reduction.

For the prediction of disasters, AI-based methods analyze data either to predict a disaster that is about to occur or to predict that a disaster level is about to escalate. In[18], the authors propose a combination of multi-layer perceptron (MLP) and Genetic Algorithms (GA) for the prediction of landslides. For prediction of floods, uses a deep Neural Network (DNN) architecture. To predict the daily levels of precipitation during typhoons,[19] proposes a Fuzzy Neural Network (FNN)-based method combined with locally linear embedding. Data form Guangxi, China was used for training and testing the model and yielded encouraging results. Vulnerability and risk assessment have also been carried out using AI-based methods.

Prasad et al.(2021)[20] proposed and implemented an ensemble ML algorithm for mapping the flood vulnerability in the west coast of India. This can result in better planning for the areas vulnerable to floods. The authors **Nsengiyumva, J.B (2020),** [21] proposed and evaluated three different ML models for assessing vulnerability of the upper Nyabarongo catchment area, Rwanda, to landslides. For mapping the susceptibility of the Bijar region in the Kurdistan province (Iran)

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[18] Yuan, C.; Moayedi, H. Evaluation and comparison of the advanced metaheuristic and conventional machine learning methods for the prediction of landslide occurrence. Eng. Comput. 2020, 36, 1801–1811.

[19] Huang, Y.; Jin, L.; Zhao, H.S.; Huang, X.Y. Fuzzy neural network and LLE algorithm for forecasting precipitation in tropical cyclones: Comparisons with interpolation method by ECMWF and stepwise regression method. Nat. Hazards 2018, 91, 201–220.

[20] Prasad, P.; Loveson, V.J.; Das, B.; Kotha, M. Novel ensemble machine learning models in flood susceptibility mapping. Geocarto Int. 2021, 26, 1892209.

[21] Nsengiyumva, J.B.; Valentino, R. Predicting landslide susceptibility and risks using GIS-based machine learning simulations, case of upper Nyabarongo catchment. Geomat. Nat. Hazards Risk 2020, 11, 1250–1277.

to landslides,[22] used a hybrid ML-based technique. Sriram et al. proposed a DNN-based causal framework for assessing the effect of extreme weather conditions on the infrastructure in urban regions.[23] Specifically, they assessed the extent of road closures and electricity outages in the event of disastrous weather and proved its efficacy for Hurricane Hermaine (which occurred in the city of Tallahassee, Florida, USA, in 2016).

In another study it was noted that AI-based methods have been employed for effective early warning systems as well. Typically, early warning systems use high-speed computers for sending the alert messages to different locations. Decision algorithms used for this purpose may generate false alarms resulting in unwarranted panic. The authors of[24] proposed Support Vector Machines (SVM), classification tree and KNN (K- Nearest Neighbours algorithm) to reduce such false alarms. In **Li, Z.; Meier (2018)**[25], the authors use a generative adversarial network (GAN) for reducing false alarms based on pressure waves of earthquakes. The number of research publications that focus on AI-based early warning systems is about 7%.[26]

Artificial intelligence is the process by which numerous networked computers imitate human behaviour. AI is concerned with computer-related tasks linked to creating intelligent machines.[27]

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[22] Shirzadi, A.; Bui, D.T.; Pham, B.T.; Solaimani, K.; Chapi, K.; Kavian, A.; Shahabi, H.; Revhaug, I., Shallow landslide susceptibility assessment using a novel hybrid intelligence approach. Environ. Earth Sci. 2017, 76, 60.

[23] Sriram, L.M.K.; Ulak, M.B.; Ozguven, E.E.; Arghandeh, R. Multi-Network Vulnerability Causal Model for Infrastructure CoResilience. IEEE Access 2019, 7, 35344–35358.

[24] 4. Chin, T.-L.; Huang, C.-Y.; Shen, S.-H.; Tsai, Y.-C.; Hu, Y.H.; Wu, Y.-M. Learn to Detect: Improving the Accuracy of Earthquake Detection. IEEE Trans. Geosci. Remote Sens. 2019, 57, 8867–8878.

[25] Li, Z.; Meier, M.A.; Hauksson, E.; Zhan, Z.; Andrews, J. Machine Learning Seismic Wave Discrimination: Application to Earthquake Early Warning. Geophys. Res. Lett. 2018, 45, 4773–4779.

[26] Linardos V, Drakaki M, Tzionas P, Karnavas YL. Machine Learning in Disaster Management: Recent Developments in Methods and Applications. Machine Learning and Knowledge Extraction. 2022; 4(2):446-473. https://doi.org/10.3390/make4020020

[27] Canon, M.J.; Satuito, A.; Sy, C. Determining Disaster Risk Management Priorities through a Neural Network-Based Text Classifier. In Proceedings of the 2018 International Symposium on Computer, Consumer and Control (IS3C), Taichung, Taiwan, 6–8 December 2018; pp. 237–241.

AI developments over the past ten years have significantly improved our ability to predict calamities and offer assistance during emergencies.[28]

Disaster preparation, crowdsourced information systems, rescue, and humanitarian aid can all be seen as applications of AI development..[29]

Despite the fact that AI can take many different forms, this report focuses on using AI in the context of catastrophe prediction and enabling faster rescue and relief activities using robotics, drones, machine learning, deep learning, sensors, and algorithms.

Robotics and robots have existed for many years, but recently, as sensor and compute technology has advanced, they have transformed from nearly nonexistent decision-making devices to fully automatic and artificially intelligent machines..[30]

In contrast to robotics, which has been around for a while, the research emphasises that machine learning is a relatively new field of artificial intelligence. Instead of learning from patterns and conclusions in the data input, machine learning algorithms can complete a task without any instructions, and are thereby classified as AI. By utilising CNN networks, a model for change detection on satellite images can be created, allowing for the coordination of relief efforts and the identification of disaster-prone regions. Airborne robots fly deep into catastrophe areas to survey the damage and deliver aid.[31]

Complicated software that can learn is categorised as machine learning. It analyses patterns in data collected by using words, numbers, images, videos,

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[28] Kumar, T.V.V.; Sud, K. *AI and Robotics in Disaster Studies*; Palgrave Macmillan: Singapore, 2020.

[29] Wheeler, B.J.; Karimi, H.A. Deep Learning-Enabled Semantic Inference of Individual Building Damage Magnitude from Satellite Images. *Algorithms* 2020, *13*, 195.

[30] Park, S.; Oh, Y.; Hong, D. Disaster response and recovery from the perspective of robotics. *Int. J. Precis. Eng. Manuf.* 2017, *18*, 1475–1482

[31] Axel, C.; van Aardt, J.; Axel, C.; van Aardt, J. Building damage assessment using airborne lidar. *J. Appl. Remote Sens.* 2021, *11*, 046024.

and other means, and uses those patterns to forecast results under uncharted conditions.

The disaster management method is being improved and made more effective by artificial intelligence. By enhancing the exchange of information through ontologies, providing information to disaster factors, and providing multi-agent platforms for real-time support and simulated scenarios, AI equipment, such as sensors, helps in crises. In order to handle emergencies effectively, it is necessary to gather data from various sources, combine it, and come to wise decisions.[32]

Artificial intelligence is without a doubt the future of crisis management because it significantly increases our ability to protect civilian populations in the face of disasters. However, in order to ensure that the deployment of AI in crisis management is efficient and practical, governmental organisations must complete a development plan of fundamental requirements.

The general public can disseminate and consume information in a suitable and efficient manner by using social networking sites and digital tools[33].

Millions of people are increasingly using social media during natural or man-made catastrophes to share information.[34]. Additionally, prior study has demonstrated the value of social media activity for a variety of philanthropic duties to increase "situational awareness." While information about social media may be useful to response groups, it can be difficult to comprehend it clearly during a crisis with a limited amount of time[35] Due to the massive amount and

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[32] Erdelj, M.; Natalizio, E.; Chowdhury, K.R.; Akyildiz, I.F. Help from the Sky: Leveraging UAVs for Disaster Management. In *IEEE Pervasive Computing*; Institute of Electrical and Electronics Engineers Inc.: Piscataway, NJ, USA, 2017; Volume 16, pp. 24–32.

[33] Villodre, J.; Criado, J.I. User roles for emergency management in social media: Understanding actors' behavior during the 2018 Majorca Island flash floods. *Gov. Inf. Q.* 2020, *37*, 101521.

[34] Aisha, T.S.; Wok, S.; Manaf, A.M.A.; Ismail, R. Exploring the Use of Social Media during the 2014 Flood in Malaysia. *Procedia-Soc. Behav. Sci.* 2015, *211*, 931–937.

[35] Ali, M.; Zhang, L.; Zhang, Z.; Zada, M.; Begum, A.; Han, H.; Ariza-Montes, A.; Vega-Muñoz, A. Can Leaders' Humility Enhance Project Management Effectiveness? Interactive Effect of Top Management Support. *Sustainability* 2021, *13*, 9526.

rapid pace of social media data streams, manual analysis of dozens of messages, for instance, is very difficult.[36]

During the onset of any natural or man-made disaster in the modern era, people have recently increased their use of social media sites and other platforms to disseminate a variety of data, such as stylistic messages, photographs, and films online.[37] Social media data has proven to be a crucial source of information in earlier natural and social crisis scenarios, such as flooding, earthquakes, wildfires, nuclear disasters, and civil wars. For instance, 177 million tweets about the 2011 Japan earthquake were sent out in a single day.

The analysis of massive amounts of social media data and the conversion of the volume of social media data generated during disasters into understandable, reliable data are both made possible by artificial intelligence, more particularly machine learning (ML). Big data concepts can be emulated by AI applications to mimic human intelligence, greatly enhancing the effectiveness of various tasks, procedures, and pattern finding in enormous amounts of data. Only a few research studies have thoroughly examined recent developments, none of which placed a particular emphasis on AI for social media disaster management with big data analytics, despite the fact that there has been a great deal of research on catastrophes in terms of evaluating social media data using various ML techniques.

Deep learning, which is used in emergency management to reduce the danger of disasters, is one of the most well-known methodologies for prediction systems. Another technique used to address predicting issues is the combination of hierarchy time series with a deep learning algorithm.

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[36] Shaluf, I.M.; Fakharul-razi, A.; Said, A.M.; Sharif, R.; Mustapha, S. Technological man-made disaster precondition phase model for major accidents. *Disaster Prev. Manag. Int. J.* 2002, *11*, 380–388.

[37] Khouj, J.M.M.; López, C.; Sarkaria, S. Disaster management in real time simulation using machine learning. In Proceedings of the 2011 24th Canadian Conference on Electrical and Computer Engineering (CCECE), Niagara Falls, ON, Canada, 8–11 May 2011; pp. 1507–1510.

In order to create the "DHARA" smartphone application, Kumar and Sud used CNN, a long short-term memory AI programme (LSTM). In order to apply early warning preparation and restoration methods before an incident, it was designed to account for the likelihood of flooding.

The study that was suggested used a model to predict rainfall that projected data by analysing environmental factors associated with rainfall.

Regression techniques, including linear, nonlinear, and logistic regression, are used in artificial intelligence to predict dangers and risks and assess their potential effects. Additionally, support vector computers offer accurate forecasting and risk evaluation. Principal component analysis, fuzzy clustering, fuzzy clustering using k means, hierarchical clustering, and k means clustering have all been used to create and compare mitigation strategies, training systems, and emergency evacuation protocols.

Convolutional neural networks, deep neural networks, and multilayer perception are examples of deep learning methods that are used for mapping disasters. Deep Q-networks and genetic algorithms are the most recent AI methods used to evaluate loss and repair costs. Damage assessment, disaster information systems, and interagency cooperation are used in emergencies.

All types of catastrophe management utilise data from numerous sources. The necessary facts must be gathered, prepared, and presented logically. When a catastrophe strikes, having the pertinent information at hand and having it presented logically is crucial for reacting and taking the appropriate action. Disasters may impact all facets of the government or just a few. The dispersal of electricity, the drainage system, and other information are frequently needed by emergency personnel. Using a GIS, all industries can share information via databases on computer-generated mapping in one location. Because without that feature, first responders would have to view the map data of numerous department managers. The majority of catastrophes don't give enough time to get these provisions. Emergency workers are consequently compelled to make decisions based on assumptions, predictions, or incomplete information. As a consequence, time, effort, and, occasionally, lives are lost. GIS offers a method to arrange and visually display important information during disasters.

Information that is accurate, precise, and trustworthy must be available quickly after a catastrophe. The local government and municipal officer first gather information from the danger zone. A description of the area both before and after the disaster is provided in this material. These data help rescue personnel plan their operations in a disaster situation by integrating the data into GIS.

Maps, graphs, and tables are the graphical and visual product that geospatial analysis offers for additional study and forecasting to assess flood alerts. The ability of disaster agencies to take immediate action before a disaster hits under favourable environmental conditions is further strengthened by these maps, which provide a wide range of prediction and mitigation strategies before a disaster occurs.

Early warning systems, which use satellite imagery and remote sensing techniques, offer tools for keeping an eye on the efficiency of disaster preparation efforts. By highlighting the region and identifying the flood-prone location, aerial surveys are used to identify the disaster zone and decide the best course of action to minimise damage.

By using the aforementioned tools, flood disasters are less severe and do less harm to the community and flooded territory. By combining AI and GIS apps, Malaysian institutes for remote sensing have enhanced flood risk mapping.

The most useful tool for data analysis and environmental planning is regarded to be GIS. This is so that advanced features that interpret the relationship between ecological conditions and physical factors, such as the steepness of slopes, vulnerability and risk analysis, crisis mapping, and various environmental parameters and impact analysis, can be provided by the spatial analysis of GIS.

GIS is a conceptualised framework that collects and examines geospatial data. GIS is the combination of various components, and these interconnected components are made up of methods, people, technology, software, and data information. There are additional kinds of GIS software, such as commercial, open-source, and individually licenced programmes, available on the market for various operations. Esri ArcGIS is the software that is most frequently used. Google Earth Pro, Mapinfo Pro, Google Maps API, and BatchGeo are also used by customised applications[38].

[38] Fariza, A.; Rusydi, I.; Hasim, J.A.N.; Basofi, A. Spatial flood risk mapping in east Java, Indonesia, using analytic hierarchy process—Natural breaks classification. In Proceedings of the 2017 2nd International conferences on Information Technology, Information Systems and Electrical Engineering (ICITISEE), Yogyakarta, Indonesia, 1–2 November 2017; pp. 406–411

CHAPTER 3

RESEARCH METHODOLOGIES AND APPROACH

The study will follow the broad design of Content Analysis research method in which the already available data or information on the subject from multiple sector will be analysed incorporating the personal experience to make a critical evaluation of the material management in the disaster. This research is based on both types of data i.e primary and secondary. The survey and focused group discussion method will be used to collect data. The present study will make extensive use of primary data which includes information on different aspects of research problem. The secondary data will be collected from research reports, Govt publications, newspaper articles, research journals, magazines, case studies, website etc. For the purpose of data collection IIPA library, NDMA, ministerial offices, army logistics /medical directorates , State /District Disaster Management Authority and other related places expected to be useful will be visited.

3.1. Research Design

The research design will be descriptive and exploratory as the intention is to assess our emergency response system with specific reference AI in supplementing the efforts of National and State Disaster response system. It will involve fact-finding followed by interpretation.

3.2. Research Methods and Data Sources

The research will be based on both Primary and Secondary sources as follows:-

3.2.2. Primary Research. Primary sources will be explored as under:-

(ii) Interaction and visit will be carried out with the NDRF Battalion located in Andhra Pradesh to get a feel of the ground situation. In addition information will be gathered from service officers of the Army Navy and Airforce especially those who have been involved in relief and rescue operations.

(ii) Interviews with some members of NDMA

(iii) Collecting information relating use of AI in rescue system..

3.2.1. Secondary Research. Secondary sources will be explored as follows:-

(i) Study of disaster management system from AI perspective.

(ii) Books; academic papers; reports; newspaper and magazine articles available on the subject.

The proposed framework differs from the existing work as it focuses on effective alert dissemination. As such, prediction of disasters, risk assessment or reducing false alarms is NOT the focus of this framework. Existing alert dissemination strategies are based on the decisions made by experts (generally from disaster management divisions of the government such as National Disaster Management Agency (NDMA) and State Disaster Management Agencies (SDMAs)). These organizations assess the risk due to an impending disaster and issue alerts to different stakeholders using various channels.

The proposed expert system is based on the fact that different stakeholders may need the alerts at different times and via different channels before (sometimes during) the disaster, to ensure maximum levels of preparedness. For example, disaster response teams may require the information about an impending disaster a few days in advance, while a couple of days of notice may be enough for the general public. Another factor that determines the efficacy of alerts is the type of disaster and its severity. For instance, it may not be possible to predict an earthquake days ahead, but it may be possible to forecast a storm well before it hits. General public in urban regions may react better to ICT-based alerts such as SMS messages and alerts on the Internet, whereas the public in rural areas may not have access to such channels. In essence, there are several factors that determine the effectiveness of alerts for optimal risk reduction.

To design the expert system, the proposed methodology shall majorly use primary data obtained from surveys and questionnaires. Stakeholders such as the general public, fishing communities and disaster management teams shall be given specially tailored questionnaires regarding the type and timing of alerts that work best for them. The sample size shall be between 25 and 75 and the instrument of survey shall be paper-based or digital questionnaires. This information and the various channels through which the alerts can be disseminated are fed to the expert system, which will then suggest the best alert dissemination when a disaster is imminent.

CHAPTER 4

EMERGING TECHNOLOGIES AND INNOVATIONS-

DISASTER RISK MANAGEMENT

The range of information and degree of granularity available, as well as the dependability, affordability, and access to this technology, have all significantly increased as a result of recent advancements in earth observation technologies, which are not new. The price of high-resolution imagery has decreased nearly 50% in the past ten years thanks to technological advancements and increased competition in space projects.[39]

The technology has also benefited from significant advancements in sensor hardware, which have increased the spatial (granularity) and temporal (frequency) resolution of imaging, including through the emergence of "high revisit" satellites; increased coverage and resolution due to an increase in the number of satellites in orbit providing very high-resolution imagery globally;

• better characterization of the built environment through the development and use of hyperspectral, Light Detection and Ranging (LiDAR), and Synthetic Aperture Radar capabilities (LiDAR sensors, for example, can determine the type of building material used in a given structure (e.g., concrete versus asphalt) from hyperspectral images and building heights), which are also able to provide imagery through cloud cover (which had been particularly problematic) Large-scale data analysis software

The analysis of large amounts of data is supported by a number of tools that have been created. These tools enable pattern, trend, and correlation analysis of both organised and (increasingly) unstructured data (such as sensor data, image data, email data, and social network data).

[39] One commercial provider listed archival high-resolution imagery at $10–$20 per square kilometer and tailored new images for $20–$30 per square kilometer.

As an illustration, pattern recognition methods can be used to analyse images and identify objects (or changes) in digital image catalogues. Machine learning techniques (algorithms that can learn from data without relying on rules-based programming) and deep learning techniques are two examples of artificial intelligence techniques that apply algorithms to the analysis of large datasets (a subset of machine learning composed of algorithms that permit software to perform tasks, like image recognition, by exposing multi-layered neural networks to vast amounts of data [40]).

Four different types of analytics can be provided by these technologies:

- descriptive (analysis of current or past situations),
- diagnostic (analysis of the causes of an event),
- predictive (analysis of possible future scenarios),
- prescriptive (recommendations for action) (analysis of actions that should be taken).

Open-source platforms like GitHub offer methods and code that improve access to these kinds of analytical tools.

4.1.1 AI METHODS

By categorising AI techniques into six groups “supervised models, unsupervised models, deep learning, reinforcement learning, and deep reinforcement learning” this study examines the status of research and application of AI in disaster management.

4.1.2 SUPERVISED MODELS

Algorithms that are taught on pre-existing data with human input are referred to as supervised models. supervised models infer a function from input to output using regression/classification techniques to forecast the value or category of the output variable using labelled training data with known input and output pairs[41]. In

[40]Beal, 2019
[41]Russell and Norvig 2016

general, supervised models have been used for speech recognition, pattern recognition, object identification in computer vision, and information extraction.

4.1.3 UNSUPERVISED MODELS

Unsupervised models operate without input and draw latent structure from unlabeled data based on innate properties (Rus- l sell and Norvig 2016). Unsupervised models have many applications to clustering and data aggregation issues and are appropriate for identifying abnormal data and lowering the data dimension. In order to recognise patterns, clustering algorithms divide unlabeled data into numerous groups based on certain similarity characteristics (Maulik and Bandyopadhyay 2002). Principal component analysis (PCA), for example, is a dimension reduction algorithm that can minimise data complexity and prevent overfitting.

4.1.4 DEEP LEARNING

Deep learning is a class of algorithms that employs multiple layers to gradually pull features from the input data, improving learning performance and having a wide range of potential applications[42]. Deep learning algorithms are especially well suited to solve problems of damage assessment, motion detection and facial recognition, transportation prediction, and natural language processing for supporting disaster management, despite the disadvantage of needing a lengthy training period. Recursive and recurrent neural networks, for instance, have been effectively used to analyse natural language.processing[43](NPL) (NPL). Convolutional neural networks (CNN) are appropriate for computer vision and image recognition[44]. Speech synthesis, NPL[45].

4.1.5 REINFORCEMENT LEARNING

Reinforcement learning algorithms are modelled as Markov decision processes to address goal-oriented problems for making decisions in a sequential manner.

[42] Deng and Yu 2014: Pouyanfar et al. 2018
[43] Socher et al. 2011; Graves et al. 2013
[44] Krizhevsky et al. 2017
[45] Dahl et al. 2012

Reinforcement learning algorithms work by learning from a series of reinforcements (using punishment and rewards as positive and negative signals)[46]. Robotics, resource management, and traffic light control are three areas where reinforcement learning has been successfully applied. Reinforcement learning is appropriate for solving problems that require making a series of decisions in a complex and uncertain environment. Creating a training setting that is appropriate and closely linked to the tasks that need to be done is the main challenge in reinforcement learning. A few examples of typical reinforcement learning algorithms are SARSA (State-Action-Reward-State-Action) and Q-learning[47].

4.1.6. REINFORCEMENT LEARNING IN DEPTH

The goal of deep reinforcement learning is to create software agents that can learn on their own to set successful policies for maximising long-term rewards. Deep reinforcement learning combines reinforcement learning and deep neural networks to achieve this goal. For issues involving complicated sequential tasks, such as those in computer vision, robotics, finance, smart grids, etc., deep reinforcement learning performs better. Deep reinforcement learning can occasionally become very computationally costly because it needs a lot of training data and time to perform reasonably.

4.1.7. OPTIMIZATION

While the study's main emphasis is on how AI techniques are used for disaster management, most AI techniques require optimization to identify the best model as determined by an objective function. This research specifically identifies three optimization techniques as example methods and explores how they can be used in disaster management.

[46] Russell and Norvig 2016
[47] Sutton and Barto 2018

4.2. FOUR PHASES OF DISASTER MANAGEMENT: DISASTER MANAGEMENT

Fig. 3 illustrates the four stages of disaster management: mitigation, preparedness, reaction, and recovery. The term "mitigation phase" alludes to management actions taken to prevent or lessen potential emergencies and their effects in the future, with long-term advantages.

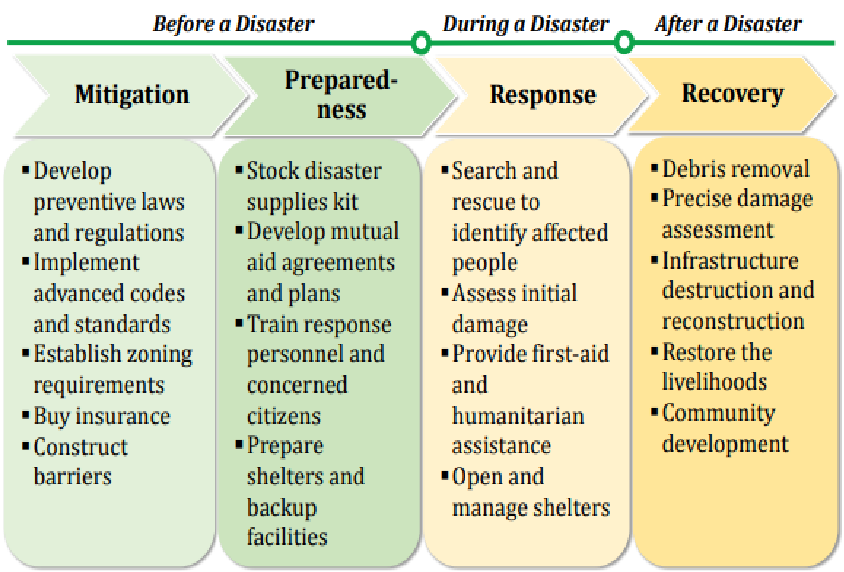

Figure 3: Disaster Handling in Four Phases

Implementing modern building codes and standards, retrofitting hospitals, shelters, and overpasses, and educating the general public and other relevant stakeholders about risks and possible mitigation measures are a few examples of mitigation activities. When an emergency or a calamity is likely to occur, the preparation phase begins. It relates to actions taken in advance of a catastrophe to save lives and aid in response and rescue efforts, such as stocking up on food and water, posting emergency contact information, and planning evacuations. The response phase is primarily where previously developed plans and strategies are put into motion. During a catastrophe, response activities take place and typically involve evacuating dangerous areas, fighting fires, searching for missing people, managing shelters, and providing humanitarian aid. The restoration of functionality to a normal or higher level after a disaster is referred to as the recovery period. Debris removal, accurate damage evaluation, infrastructure reconstruction, and financial support from government and insurance organisations are typical recovery actions.

4.3. DISASTER MANAGEMENT AND DISASTER RESILIENCE

The goals of disaster management are to implement operations and strategies to effectively prepare, rapidly respond and rescue, efficiently allocate resources, quickly correct damage and recover to full functionality, ultimately protect the community and minimize the adverse impact. That is to say that the efficient disaster management should strengthen the disaster resilience of a community. The term "disaster resilience" refers to the ability of an entity to anticipate, resist, absorb, adapt to, and rapidly recover from an unexpected disturbance (DHS 2010). Fig. 2 displays features of disaster resilience in terms of dimensions. stakeholders, disruption types, properties of resilient entities, and benefits. In case of a disaster, such as a hurricane or an earthquake, a resilient community is expected to be able to protect people, infrastructure, and socio-economic environment, with reliable performance and fast recovery capability, as well as a minimal adverse consequences.

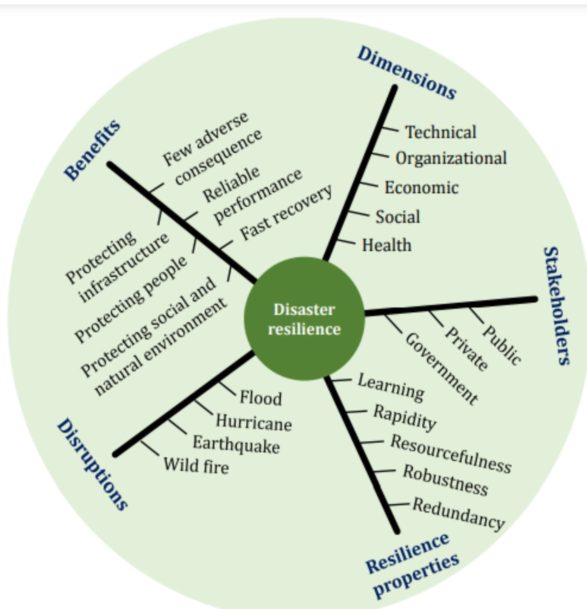

FIGURE 4:Features of Disaster Resilience

The following is a list of some American instances. The Campus Resilience Program, which began in 2013, has produced useful tools and recommendations for assessing the vulnerability of the academic community nationally. The Hazard Mitigation Grant Program (HMGP) assists communities in putting cost-effective hazard mitigation measures in place to reduce the risk of human casualties and property harm from future disasters (FEMA 2018). A six-step process is provided in the Community Resilience Planning Guide to assist local community authorities in identifying gaps, developing resilience plans, and putting strategies into action for increased community resilience against future catastrophes.[48].

Additionally, private businesses and local government agencies have been putting resilience-enhancing practises into effect. For instance, the 100 Resilient Cities initiative helps local governments promote municipal resilience while tackling climate change and equity issues[49].Other nations have concurrently been actively moving in this path. The European Resilience Management Guideline and tools have been created by the Horizon 2020 Research and Innovation Program to support efficient disaster management and increase resilience to disasters and climate change (EU-CIRCLE 2019). The Asia-Pacific region has been making significant changes in creating disaster management policies under the Sendai Framework for Disaster Resilience Network, with growing applications of AI in disaster response. All of these rules and software programmes are intended to assist disaster management and improve disaster resilience[50]. By processing massive amounts of data related to disasters more effectively and efficiently, artificial intelligence (AI) has a great potential to lessen the burden on decision-makers in crisis management. In order to protect the vulnerable community and vital intrastate infrastructure from any catastrophe, disaster management is a strategic and multifaceted procedure for mitigation, preparation, response, and recovery. Working in the field of disaster risk

[48] NIST 2018: Cauffman et al. 2018
[49] The Rockefeller Foundation 2019
[50] UN 2015; Renwick 2017; Pau et al. 2017: Izumi et al. 2019

reduction, researchers, decision-makers, and government representatives have a shared understanding of the crisis and take preventative measures before one happens. However, people must deal with the effects of every disaster. As a result, the planning and execution of efficient crisis management procedures determines success or failure. A primary hazard can also result in a secondary hazard that has a significant effect, such as a tsunami that causes coastal flooding. Therefore, AI is unquestionably the disaster management of the future and a major force multiplier in the ability to protect people and property in the face of catastrophe. Modern geospatial and artificial intelligence technologies are highly developed and have the potential to be very useful in disaster situations. Planning for disaster response is greatly influenced by the morphology of the region, the weather, the ecology, other elements, and the machinery's resources. It is advised to use management science and operations research criteria to improve resilience in emergency relief while taking the population's effect into account[51]. However, a number of academic studies assess the usefulness of artificial intelligence in disaster management[52].Other nations' crisis response environments differ significantly from India's. This necessitates the identification and prioritisation of the information required for strong crises in natural catastrophes[53]. Protecting people and property in the face of disaster is the proper method to lessen the effects of a catastrophe, and this is unquestionably the direction disaster management will take [54].

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[51] Ogie, R.I.; Rho, J.C.; Clarke, R.J. Artificial Intelligence in Disaster Risk Communication: A Systematic Literature Review. In proceedings of the 2018 5th International Conference on Information and Communication Technologies for Disaster Management (ICT-DM), Sendai, Japan, 4–7 December 2018; pp. 1–8

[52] Nunavath, V.; Goodwin, M. The Use of Artificial Intelligence in Disaster Management—A Systematic Literature Review. In proceedings of the 2019 International Conference on Information and Communication Technologies for Disaster Management (ICT-DM), Paris, France, 18–20 December 2019; pp. 1–8

[53] Abid, M.; Isleem, H.F.; Shahzada, K.; Khan, A.U.; Kamal Shah, M.; Saeed, S.; Aslam, F. Seismic Hazard Assessment of Shigo Kas Hydro-Power Project (Khyber Pakhtunkhwa, Pakistan). Buildings 2021, 11, 349

[54] Yang, T.-H.; Liu, W.-C. A General Overview of the Risk-Reduction Strategies for Floods and Droughts. Sustainability 2020, 12, 2687 ; Costache, R.; Bui, D.T. Spatial prediction of flood potential using new ensembles of bivariate statistics and artificial intelligence: A case study at the Putna river catchment of Romania. Sci. Total Environ. 2019, 691, 1098–1118.

Many academics use geographic information systems and artificial intelligence to map the distribution of flood risks and flooding susceptibility[55]. A geographic information system serves as a facilitator, allowing spatial data to be entered, stored, integrated, managed, and delivered for strategic planning and real-time decision-making for flood crisis management and hazard preparation[56]. These systems are competent and complete in terms of managing flood crises. The planning process must take a systematic approach in order to make quicker and more accurate decisions: This essay examines the benefits of artificial intelligence and how it can be used to handle disasters and lessen their effects.

4.4. ARTIFICIAL INTELLIGENCE AND DISASTER MANAGEMENT

In contrast to human intelligence, artificial intelligence is the intelligence demonstrated by computer systems[57]. Artificial intelligence is the process by which numerous networked computers imitate human behaviour. AI is concerned with computer-related tasks linked to creating intelligent machines. AI developments over the past ten years have significantly improved our ability to predict calamities and offer assistance during emergencies[58]. The growth of artificial intelligence is visible in crowdsourced information systems, rescue, and humanitarian aid[59]. Despite the fact that AI can take many different forms, this report focuses on how robotics, drones, machine learning, deep learning, sensors, and algorithms can be used to anticipate disasters and speed up rescue

[55] Arinta, R.R.; Andi, E.W.R. Natural disaster application on big data and machine learning: A review. In Proceedings of the 2019
4th International Conference on Information Technology, Information Systems and Electrical Engineering (ICITISEE), Yogyakarta, Indonesia, 20–21 November 2019; Volume 6, pp. 249–254

[56] Supra Note 34

[57] Kumar, T.V.V.; Sud, K. AI and Robotics in Disaster Studies; Palgrave Macmillan: Singapore, 2020

[58] Canon, M.J.; Satuito, A.; Sy, C. Determining Disaster Risk Management Priorities through a Neural Network-Based Text Classifier. In Proceedings of the 2018 International Symposium on Computer, Consumer and Control (IS3C), Taichung, Taiwan, 6–8 December 2018; pp. 237–241

[59] Park, S.; Park, S.H.; Park, L.W.; Park, S.; Lee, S.; Lee, T.; Lee, S.H.; Jang, H.; Kim, S.M.; Chang, H.; et al. Design and Implementation of a Smart IoT Based Building and Town Disaster Management System in Smart City Infrastructure. Appl. Sci. 2018, 8, 2239.

and relief efforts[60].. Robotics and robots have existed for many years, but recently, as sensor and compute technology has developed, robots have advanced from nearly nonexistent decision-making devices to fully automatic, artificially intelligent machines. Contrary to robotics, which has been around for a while, machine learning is a relatively new field of artificial intelligence[61].

Purpose of the Analysis	AI Algorithm	Input Data
Flood vulnerability mapping and plotting	Artificial neural network	Rainfall data, slope, elevation data, flow accumulation, soil, land use, and geology data layers from the remote sensing technique
Landslide disaster exposure mapping	RFEs and NBT classifiers	Satellite spatial images and field survey data
Landslide and flood disaster risk reduction	CNN	Satellite spatial images
Disaster risk reduction through social media and flood prediction by satellite images	CNN, SVM, RFS, and GVN networks	Social media application and satellite images
Disaster assessment in coordinating relief (flood and fire management)	CNN and semantic segmentation models of satellite images	Satellite images
Earthquake prediction detection	CNN networks	3D point cloud
Classification of building damages (earthquake)	CNN networks	Satellite and UAV images
Near real-time damage mapping	CNN networks	UAV images
Post-earthquake damage mapping	ANN (the backpropagation algorithm) and support vector machines (radial basis function, RBF)	Satellite images

Figure 5:Previous studies that implemented artificial intelligence in disaster management

Figure 5 illustrates the previous studies that implemented intelligence in disaster management. It shows the research previously undertaken for various kinds of disasters and the algorithm used and the data provided.

[60] Mosavi, A.; Ozturk, P.; Chau, K. Flood Prediction Using Machine Learning Models: Literature Review. Water 2018, 10, 1536.

[61] Park, S.; Oh, Y.; Hong, D. Disaster response and recovery from the perspective of robotics. Int. J. Precis. Eng. Manuf. 2017, 18, 1475–1482.

Machine learning algorithms are classified as AI because they can complete a task without being given any instructions and instead learn from patterns and conclusions in the data input[62]. By utilising CNN networks, a model for change detection on satellite images can be created, allowing for the coordination of relief efforts and the identification of disaster-prone regions. Airborne robots fly deep into catastrophe areas to survey the damage and deliver aid.

Complicated software that can learn is categorised as machine learning[63].It analyses patterns in text, numbers, photos, videos, and other types of data to forecast outcomes under previously unanticipated conditions. The disaster management method is being improved and made more effective by artificial intelligence[64]. By enhancing the exchange of information through ontologies, providing information to disaster factors, and providing multi-agent platforms for real-time support and simulated scenarios, AI equipment, such as sensors, helps in crises. Making wise decisions requires gathering data from various sources, combining it, and using it to handle emergencies effectively. Artificial intelligence is without a doubt the future of crisis management because it significantly increases our ability to protect civilian populations in the face of disasters. However, in order to ensure that the deployment of AI in crisis management is efficient and practical, governmental organisations must complete a development plan of fundamental requirements. The general public can disseminate and consume information in a suitable and efficient manner by using social networking sites and digital tools. Millions of people are increasingly using social media during natural or man-made catastrophes to share information. Additionally, prior research has established the value of social media activity for a variety of philanthropic duties to increase "situational awareness." While

[62] Noymanee, J.; Nikitin, N.O.; Kalyuzhnaya, A.V. Urban Pluvial Flood Forecasting using Open Data with Machine Learning Techniques in Pattani Basin. Procedia Comput. Sci. 2017, 119, 288–297

[63] Axel, C.; van Aardt, J.; Axel, C.; van Aardt, J. Building damage assessment using airborne lidar. J. Appl. Remote Sens. 2021, 11, 046024

[64] Sulaiman, N.; Mahmud, N.P.N.; Nazir, U.; Latib, S.K.K.A.; Hafidz, H.F.M.; Abid, S.K. The Role of Autonomous Robots in Fourth Industrial Revolution (4IR) as an Approach of Sustainable Development Goals (SDG9): Industry, Innovation and Infrastructure in Handling the Effect of COVID-19 Outbreak. In IOP Conference Series: Earth and Environmental Science; IOP Publishing: Jaipur, India, 2021; Volume 775, p. 12017

information about social media may be useful to response groups, it can be difficult to comprehend it clearly during a crisis with a limited amount of time. Due to the massive amount and rapid pace of social media data streams, manual analysis of dozens of messages, for instance, is very difficult. During the onset of any natural or man-made disaster in the modern era, people have recently increased their use of social media sites and other platforms to disseminate a variety of data, such as stylistic messages, photographs, and films online. Social media data has proven to be a crucial source of information in earlier natural and social crisis scenarios, such as flooding, earthquakes, wildfires, nuclear disasters, and civil wars. For instance, 177 million tweets about the tragedy were made in a single day following the 2011 Japan earthquake[65].

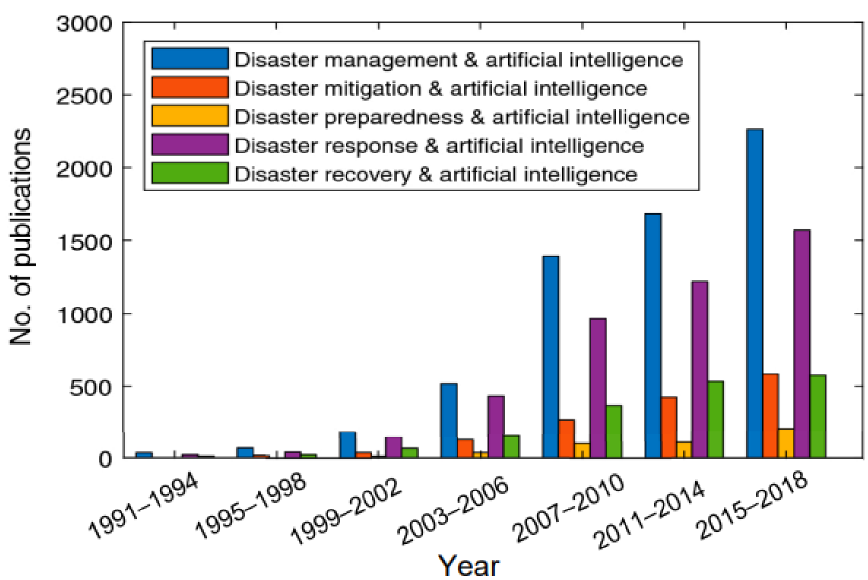

Figure 6: Number of publications from 1991 to 2018

4.5. AI APPLICATIONS IN DISASTER RESPONSE

The disaster response portion of disaster management has seen the most publications over the past few years. Compared to the other stages, the response phase has seen the most widespread application of AI. Applications

[65] Sakurai, M.; Murayama, Y. Information technologies and disaster management–Benefits and issues. Prog. Disaster Sci. 2019, 2.

and techniques in artificial intelligence (AI) analyse big data in crisis response quickly, facilitate wise decision-making, and enhance disaster management in general. **Figure 6 illustrates** growing trends in disaster response while emphasising the value of AI through analysis of publications, such as books, articles, and other downloadable materials[66]. Figure 5 shows articles about the use of AI in disaster management from 1991 to 2018 that can be found in the World CAT database [67].The disaster response portion of disaster management has seen the most publications over the past few years. Compared to the other stages, the response phase has seen the most widespread application of AI. Applications and techniques in artificial intelligence (AI) analyse big data in crisis response quickly, facilitate wise decision-making, and enhance disaster management in general. Figure 5 illustrates growing trends in disaster response while emphasising the value of AI through analysis of publications, such as books, articles, and other downloadable materials[68]. Figure 6 Publications from 1991 to 2018 by number Applications of Intelligence in disaster relief Disaster reaction times are crucial for survival. The ability of decision-makers to comprehend the circumstance and enhance the effectiveness of response efforts must be prioritised[69],In order to ensure disaster relief and attend to people's pressing needs and concerns, this obviously calls for situational awareness for effective decision-making and user-friendly disaster information systems for effective coordination[70].

AI techniques can be used to streamline rescue and response operations. The analysis of massive amounts of social media data and the conversion of the

[66] Munawar, H.S.; Ullah, F.; Qayyum, S.; Khan, S.I.; Mojtahedi, M. UAVs in Disaster Management: Application of Integrated Aerial Imagery and Convolutional Neural Network for Flood Detection. Sustainability 2021, 13, 7547

[67] Oakley, M.; Himmelweit, S.M.; Leinster, P.; Casado, M.R. Protection Motivation Theory: A Proposed Theoretical Extension and Moving beyond Rationality—The Case of Flooding. Water 2020, 12, 1848.

[68] Sulistijono, I.A.; Risnumawan, A. From concrete to abstract: Multilayer neural networks for disaster victims detection. In Proceedings of the 2016 International Electronics Symposium (IES), Denpasar, Indonesia, 29–30 September 2016; pp. 93–98.

[69] Fu, Q.; Sun, E.; Meng, K.; Li, M.; Zhang, Y. Deep Q-Learning for Routing Schemes in SDN-Based Data Center Networks. IEEE Access 2020, 8, 103491–103499.

[70] Polvara, R.; Patacchiola, M.; Hanheide, M.; Neumann, G. Sim-to-Real Quadrotor Landing via Sequential Deep Q-Networks and Domain Randomization. Robotics 2020, 9, 8.

volume of social media data generated during disasters into understandable, reliable data are both made possible by artificial intelligence, more particularly machine learning (ML). Big data concepts can be emulated by AI applications to mimic human intelligence, greatly enhancing the effectiveness of various tasks, procedures, and pattern finding in enormous amounts of data[71]. Only a few research studies have thoroughly examined recent developments, none of which placed a particular emphasis on AI for social media disaster management with big data analytics, despite the fact that there has been a great deal of research on catastrophes in terms of evaluating social media data using various ML techniques. Deep learning, which is used in emergency management to reduce the danger of disasters, is one of the most well-known methodologies for prediction systems. Another approach used to address forecasting issues involves combining hierarchical time series with a deep learning algorithm[72]

Long-short-term memory AI application CNN was used by Kumar and Sud to create the flood-supported smartphone application "DHARA" (LSTM). In order to apply early warning preparation and restoration methods before an incident, it was designed to account for the likelihood of flooding. The study that was suggested used a model to predict rainfall that projected data by analysing environmental factors associated with rainfall. Regression techniques, including linear, nonlinear, and logistic regression, are used in artificial intelligence to predict risks and hazards and assess their potential effects. Additionally, support vector computers offer accurate forecasting and risk evaluation. To create and compare mitigation strategies, training systems, and disaster evacuation procedures, a variety of techniques have been used, including neural networks, hierarchical clustering, k means clustering, fuzzy clustering, and principal component analysis. Convolution neural networks, deep neural networks, and multilayer perception are examples of deep learning methods that are used for

[71] Deshmukh, K.H.; Bamnote, G.R. Role of Deep Learning in Disaster Prediction BT. In Proceedings of the Integrated Intelligence Enable Networks and Computing; Algorithms for Intelligent Systems; Springer: Singapore, 2021; pp. 697–705.

[72] A Collaborative Multi-Agency Platform for Building Resilient Communities. 2019. Available online: https://mobilisesarawak. uthm.edu.my/ (accessed on 20 Nov 2022)

mapping disasters. Deep Q-networks and genetic algorithms are the most recent AI techniques used to evaluate loss and repair costs, while damage assessment, disaster information systems, and interagency cooperation are used in emergencies. Another choice is to use a variety of deep learning algorithms or blend them together to find the forecast that is both quick and precise. High-performance techniques are frequently necessary due to their large dense datasets and nonlinear features in order to predict future outcomes, especially for natural disasters. Table 2 lists the earlier research on disaster management and the part AI plays in effective disaster management techniques. For the purpose of employing multi-agency collaboration in resilient community building, a new AI platform called MOBILISE was created. Disaster management organisations can collaborate on disaster mitigation thanks to MOBILISE's real-time intelligence. The MOBILIZE platform is an intuitive AI that enables agencies to upload and interactively explore data on hazards, exposure, and vulnerability in order to develop a shared knowledge of their local risks and put disaster risk reduction measures into place. An Azure cloud service powers the information server for risks. Additionally, MOBILIZE provides a VR-based user experience. The user can view 3D representations as textured point clouds or meshes taken from aerial sensing devices like drones using this innovative VR interface. The MOBILISE web platform models the impact of disasters and visualises the risks. MOBILIZE's 3D visualisation of real-time data helps with crisis reaction by providing layers of information about flood-prone areas, rainfall forecasts, and drainage systems.

4.6. AI APPLICATIONS IN DISASTER RECOVERY

Recovery from a disaster is a complex process that involves both public and private groups as well as governments. To rapidly comprehend the complexity of the situation, identify operational requirements and recovery plans, and carry out rehabilitation and reconstruction tasks, comprehensive decision-making is required. As disaster recovery typically requires careful damage evaluation, budgeting, planning, obtaining permits, designing, and building, AI can be a crucial module for assisting disaster recovery management in a shorter amount of time. By carefully analysing the catastrophe's effects, creating recovery plans, monitoring the recovery process, and calculating loss and repair costs, AImethods have been applied to disaster recovery management. The rise in publications in recent years suggests that disaster recovery management applications of AI are receiving more focus. For a swift recovery, an accurate and timely evaluation of the disaster's effects is essential. A catastrophe also results in emotional distress and economic disruption in addition to bodily harm. Visual inspection is the main technique used in current practise to evaluate physical harm to structures like buildings, bridges, tunnels, storage tanks, etc. The visual inspection technique is labor- and time-intensive, though, frequently. Based on data from sensor measurements, social media imagery, and aerial images, AI techniques can aid in the elimination of such human efforts. Social media opinion analyses allow for the tracking of human activity patterns over the course of the recovery process when evaluating the effects of disasters on people. Additionally, the economic effects of hazards have been estimated using AI techniques. In these cases, supervised models are frequently used to create quantitative relationships between important factors and the economy and to pinpoint potential growth-stimulating factors.

4.7. PRACTICAL AI-BASED DECISION SUPPORT TOOLS

Many AI-based decision support tools have been created by research institutions and industrial companies over the past few decades to eventually facilitate informed disaster management in practise. We discovered related AI-based tools for decision-making in disaster management by searching on the websites of Google Scholar and Web of Science with the keywords "disaster management," "decision support tool," and "artificial intelligence." A variety of data, including social media data, mobile data, sensor measurements, on-site reports from first responders, and crowdsourced information from volunteers, are used as input by tools that apply various AI techniques to disaster management in order to extract useful information. These tools are applicable to a variety of infrastructures and hazards, fostering the development of AI applications for crisis management at various stages. The disaster response phase tends to have more tools that are relevant than other phases. Only a tiny percentage of tools use sensor measurements, remote sensing, or mobile phone data as input; the majority of tools use social media data. In the stages of disaster preparation and mitigation, some tools concentrate on projecting potential outcomes under a hazard scenario for creating management plans for retrofit and evacuation. For instance, the Optima predict M software simulates and forecasts changes in the demand for emergency medical services and the availability of ambulances in the wake of a disaster, assisting dispatchers and operations staff in determining the best course of action for preparing for unanticipated emergencies. For professional response teams in the disaster response phase, other tools offer comprehensive platforms for effective communications with text, audio, and location services. This is because saving lives is typically the most important concern in the initial days following a disaster and requires communication and situational awareness. For instance, Blueline Grid analyses mobile phone data in real-time to plan effective catastrophe responses. Based on information about the infrastructure and past disasters, One Concern forecasts potential infrastructure losses and their effects. Artificial intelligence for disaster response (AIDR) uses crowdsourced aerial image information and crisis-related tweets to automatically categorise victims' requirements and infrastructure damage for effective disaster response management. SensePlace3 is a geo-visual interface that uses data mining tools from Solr to process real-time Twitter data to visualise time, location, and relationships of occurrences. Deep-Mob simulates how people will act and move during natural disasters by using deep belief networks to learn from millions of users' GPS data. In collaboration with the Federal Emergency Management Agency (FEMA), the Presidential Innovation Fellow Program, the National Geospatial-Intelligence Agency, and other analysts, GeoQ is an open-source tool for crowdsourcing geo-tagged pictures of the disaster-affected regions in order to evaluate damage.

4.7.1. CHALLENGES USING THESE TOOLS

The practical application of these AI-based decision assistance tools currently presents some difficult challenges. First off, the input data for these tools is frequently very big, and dealing with data-related problems can be difficult. For various reasons, including potential legal repercussions and commercial competitiveness, input data may be accessible for some communities but not for others, or it may be available for some communities but not for others. For instance, large cities and urban areas typically have documented data that is sufficiently detailed and large to enable reliable AI predictions, whereas small cities and rural areas may not. Even if all input data are available, some of it may be inaccurate, and using some of these tools may result in data ownership problems. For proper data collection, cleaning, protection, and administration, policies and regulations must be created. Second, communities have various socioeconomic backgrounds and are subjected to various dangers. The AI-based decision support tools may not be appropriate for another community if they were created using data from one community. This inevitably makes it difficult to generalise the use of AI-based decision support tools for a wide range of groups. Third, some tools may be difficult for practitioners to use because they demand a high degree of deployment expertise. Big data analytics often requires specialised software and powerful computers, which may not be accessible to many local governments and emergency services in economically underdeveloped areas.

4.8. GEOGRAPHIC INFORMATION SYSTEMS AND DISASTER MANAGEMENT

All types of catastrophe management utilise data from numerous sources. The necessary data must be gathered, processed, and logically presented[73]. When a catastrophe strikes, having the pertinent information at hand and having it presented logically is crucial for reacting and taking the appropriate action.

[73] Duarte, D.; Nex, F.; Kerle, N.; Vosselman, G. Satellite Image Classification of Building Damages Using Airborne. ISPRS Ann. Photogramm. Remote Sens. Spat. Inf. Sci. 2020, IV, 4–7.

Disasters may impact all facets of the government or just a few. The dispersal of electricity, the drainage system, and other information are frequently needed by emergency personnel. Using a GIS, all industries can share information via databases on computer-generated mapping in one location. Because without that feature, first responders would have to view the map data of numerous department managers. The majority of catastrophes don't give enough time to get these provisions. Emergency workers are consequently compelled to make decisions based on assumptions, predictions, or incomplete information[74].

As a consequence, time, effort, and, occasionally, lives are lost. GIS offers a way to arrange and visually display important information during disasters. Information that is accurate, precise, and trustworthy must be available quickly after a catastrophe. The local authority and municipal officer first gather information from the danger zone. A description of the area both before and after the disaster is provided in this material. These data help rescue personnel plan their operations in a disaster situation by integrating the data into GIS. Maps, graphs, and tables are the graphical and visual product that geospatial analysis offers for additional study and forecasting to assess flood alerts. The ability of disaster agencies to take immediate action before a disaster strikes under favourable environmental conditions is further strengthened by the wide range of prediction and mitigation strategies offered by these maps before a disaster occurs[75]. Early warning systems, which use satellite imagery and remote sensing techniques, offer tools for keeping an eye on the efficiency of disaster preparation efforts. By highlighting the area and identifying the flood-prone location, aerial surveys are used to identify the disaster zone and determine the best course of action to minimise damage[76].By using the aforementioned tools, flood disasters are less severe and do less harm to the community and flooded territory. By

[74] Abid, S.K.; Sulaiman, N.; Mahmud, N.P.; Nazir, U.; Adnan, N.A. A review on the application of remote sensing and geographic information system in flood crisis management. J. Crit. Rev. 2020, 7, 491–496.

[75] Fava, P.R.; Fritz, S.; Castellano, A. The Use of Geographic Information Systems for Disaster Risk Reduction Programmes in Africa. Coop. Internazionale COOPI 2010, 1–93. Available online: https://docplayer.net/7068754-The-use-of-geographic-informationsystems-for-disaster-risk-reduction-programmes-in-africa-user-manual.html (accessed on 20 Nov 2022)

[76] Lai, J.-S.; Tsai, F. Improving GIS-Based Landslide Susceptibility Assessments with Multi-temporal Remote Sensing and Machine Learning. Sensors 2019, 19, 3717

combining AI and GIS apps, Malaysian institutes for remote sensing have enhanced flood risk mapping[77].

The most useful instrument for data analysis and environmental planning is GIS[78]. This is so that advanced features that interpret the relationship between ecological conditions and physical factors, such as the steepness of slopes, vulnerability and risk analysis, crisis mapping, and various environmental parameters and impact analysis, can be provided by the spatial analysis of GIS. GIS is a conceptualised system that collects and analyses geospatial data[79].

GIS is the combination of various components, and these interconnected components are made up of methods, people, technology, software, and data information. There are additional kinds of GIS software, such as commercial, open-source, and individually licenced programmes, available on the market for various operations. Esri ArcGIS is the software that is most frequently used. Google Earth Pro, MapInfo Pro, Google Maps API, and BatchGeo are also used by customised applications[80].

Three main goals of disaster control are: to safeguard human life, critical infrastructure, and a healthy ecosystem. GIS is an invaluable tool for achieving these requirements for the mitigation, preparedness, response, and recovery stages of the disaster management cycle[81].Each stage communicates with the others while utilising GIS to analyse data and create a structure for disaster management. There are three steps in the GIS process for each level of disaster

[77] Sabri, S.; Yeganeh, N. Flood Vulnerability Assessment in Iskandar Malaysia Using Multi-criteria Evaluation and Fuzzy Logic. Res. J. Appl. Sci. Eng. Technol. 2014, 8, 1794–1806

[78] Kankanamge, N.; Yigitcanlar, T.; Goonetilleke, A. How engaging are disaster management related social media channels. The case of Australian state emergency organizations. Int. J. Disaster Risk Reduct. 2002, 48, 101571

[79] Paul, P.K.; Aithal, P.S.; Bhuimali, A.; Tiwary, K.S.; Saavedra, R.; Aremu, B. Geo Information Systems & Remote Sensing: Applications in Environmental Systems & Management Geo Information Systems & Remote Sensing: Applications in Environmental Systems & Management. Int. J. Manag. Technol. Soc. Sci. 2020, 5, 11–18.

[80] Fariza, A.; Rusydi, I.; Hasim, J.A.N.; Basofi, A. Spatial flood risk mapping in east Java, Indonesia, using analytic hierarchy process—Natural breaks classification. In Proceedings of the 2017 2nd International conferences on Information Technology, Information Systems and Electrical Engineering (ICITISEE), Yogyakarta, Indonesia, 1–2 November 2017; pp. 406–411.

[81]Supra Note 70.

management. The first stage involves gathering information from trustworthy sources, and the second involves measuring spatial data and presenting it in readable formats, such as numbers, figures, charts, and graphs. This process is converted using a geographic database (GDB)[82]), which is used in both steps. The data must be finalised and given to the user as a final stage. Lastly, statistical distribution is used to spread the data. These geospatial abilities are useful for enhancing crisis management because they are suitable and reliable for spatial analysis. The data being provided in a layer file is another feature of GIS. provides a broad variety of visuals of various layers, including flood-prone areas, buildings, land, roads, hospitals, schools, and the vulnerable population, in any hazard zone[83].

Researchers and scientists can "sense" Earth by using the satellite imagery method of remote sensing, which uses high-resolution cameras to monitor flood activity and evaluate damage before and after the flood. Geometric and arithmetic analysis can be done using the GIS lens during each stage of crisis management. These reviews of previous flood incidents aid in predicting current patterns[84]. Damage research is carried out using various layers[85].

4.9. GEOGRAPHIC INFORMATION SYSTEMS AND FLOOD MANAGEMENT

Several methods and techniques have been developed to investigate flood hazards and risk assessment. These techniques include the AHP method, logistics regression, the analytic network method, statistical index, random forest, and flood zoning. Hydraulic science techniques are rich in geometric and flood damage assessment through flood zoning maps. These maps identify the

[82] Thomas, C.F. An Introduction to Geographic Information Systems. Libraries 2020, 183–204.
[83]Supra Note 34.
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location of a flood and help to assess the damage incurred[86]. Flood zoning has become vital and emerged as a crucial source of safety and security for humankind. It also strengthens flood reduction strategies and reduces flood-related damage[87] GIS combined with hydrologic engineering models (HEC-RAS) is customized to provide river maps. These models have been successfully applied in Warsaw, Columbia, and Dhaka, as well as many other flood-prone states[88]. In South Asia, Malaysia, Indonesia, and Thailand also use HEC-RAS models for flood zoning and to successfully mitigate flood hazards[89].

GIS has also been proven to identify areas suitable for developing flood mitigation systems and evaluate the effectiveness of the available flood mitigation systems[90]. The research by Puttinaovarat and Horkaew[91] addressed assisting flood disaster mitigation via an internetworking system using remote sensing, GIS, and deep learning (DL). Such approaches enable flood notifications and verification in real-time, thus significantly reducing the time spent on investigations[92] applied ML algorithms to calculate the flood-related region in Amol city, Iran, using geospatial predictor variables. The distance to channel, land use, and run-off generation were identified as the primary causes of flood hazards[93]. The obtained vulnerability map indicates the need for flood mitigation planning in high-risk areas[94].

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CHAPTER 5

AI FRAMEWORK- ALERT DISEMINATION-FOR SPECIFIC LOCATIONS- TYPES OF DISASTER- ANDHRA PRADESH

5.1. DISASTER RISKS IN ANDHRA PRADESH

According to the 2011 census, there were 49386799 people living in the 160205 square kilometre state of Andhra Pradesh. The State is extremely vulnerable to a number of natural hazards because of its location. Out of the 13 districts in the State, 4 in Rayalaseema and 9 in coastal Andhra are particularly vulnerable to cyclones, storm waves, and floods. Tropical storms and other associated hazards are a threat to about 44% of its geographic area. Storm surges can occur anywhere along the Andhra shore, but the area between Nizampatnam and Machilipatnam is the most vulnerable. Additionally susceptible to flash floods caused by the torrential rainfall brought on by the cyclonic depression are the coastal districts of the state. Additionally, flooding in the coastal areas is a frequent occurrence during the monsoon season. In the East Godavari, West Godavari, and Krishna districts, the Godavari and Krishna Rivers also overflow and create floods.

In the past century, the State has been struck by more than 60 cyclones. In recent decades, it appears that the frequency of cyclones has grown to the point where strong cyclones are now a frequent occurrence, occurring every two to three years. Floods, storm surges, and recurrent cyclones all cause loss of life, property, and income. In addition to causing the affected people great suffering and hardship, it also disrupts economic activity. While the Godavari and Krishna Rivers' fertile delta is thought to be the foundation of the State's economy, it also experiences the wrath of floods and storms. Disasters have historically had a negative impact on the state's population, economy, and growth in significant numbers. Disaster risks in the State are expected to increase due to climate change, climate variability, and other factors.

Andhra Pradesh, a state that is vulnerable to multiple hazards, has endured numerous storms, floods, and sporadic droughts over the years. With about 10,000 fatalities, the cyclone in November 1977 is regarded as one of the deadliest cyclones to ever strike the state. The state also experienced severe cyclone and tidal surge damage in 1979, 1990, and 1996.

The state has endured recently as a result of cyclones and floods. One of the strongest and most destructive tropical severe cyclonic storms to ever strike an Indian city, Cyclone Hudhud made landfall in Visakhapatnam on October 12, 2014, with winds exceeding 220 km/h. In the State's Visakhapatnam, Srikakulam, Vijayanagaram, and East Godavari districts, the cyclone had a significant impact on over 300 communities spread across 44 subdistricts. The cyclone Hudhud severely damaged the state's infrastructure, communications, kutcha homes, and means of subsistence while drawing attention to the increasing risks in urban areas.

The Government of Andhra Pradesh is aware that disaster risk management in the State requires a comprehensive, proactive, multi-disciplinary, and multi-stakeholder strategy in order to address disaster risks and ensure sustainable socio-economic development of the State.

5.1.1. A STATE DISASTER MANAGEMENT POLICY IS REQUIRED

The State Disaster Management Policy seeks to enhance the State's disaster prevention, preparation, and reaction, which could aid in disaster mitigation, save lives, and safeguard the livelihoods of those who are most vulnerable. The policy may lead to a shift in strategy from conventional post-disaster response and relief to creative, inclusive prevention, mitigation, and preparedness focused on technology.

The new strategy is the result of the belief that disaster preparedness and mitigation efforts should be integrated into the development process and should be multi-disciplinary in nature, encompassing all development-related fields. A state-specific policy is required that outlines the state's goal and crisis management plan. This policy must emphasise that investments in preparedness, mitigation, and prevention are far more cost-effective than those in relief and rehabilitation.

The State of Andhra Pradesh has embarked on a voyage for accelerated economic growth, the creation of world-class infrastructure, and the promotion of industry in the State following its bifurcation. At the same time, AP is very vulnerable to cyclones, droughts, and food shortages, all of which have the ability to slow down development and have long-term effects on people and infrastructure. The State Disaster Management Policy demonstrates the government's desire to protect all planned expenditures in the public and private sectors as well as the lives, livelihoods, and property of the State's citizens.

5.1.2. POLITICS FOR STATE DISASTER MANAGEMENT

In order to guarantee sustainable socioeconomic development, the State Disaster Management Policy aims to establish mechanisms, systems, and processes for the comprehensive management of disaster risks in the State. For the purpose of managing disaster risk, the Disaster Management policy shall serve as the state's guiding concept. It seeks to establish frameworks, procedures, and systems for handling disasters in the State. Its goal is to make Andhra Pradesh more resilient to disasters by implementing comprehensive, technologically oriented approaches to disaster risk reduction that target multiple hazards risk reduction.

5.1.3. METHODS FOR MANAGING THE STATE'S DISASTER RISK

The State shall implement the following strategies for catastrophe risk management: a comprehensive and integrated technocentric strategy; the community is put front and centre, and cooperation and encouragement are sparked through joint efforts of all governmental agencies, academic institutions, non-governmental organisations, and creative public-private ventures.

Assimilation of civic accessible warning systems, last mile connectivity, and IT-based response systems; Multi-hazard, Multi-Disciplinary, and Multi-Stakeholder Approach leading to Multi-Sectoral Cooperation and Networking for Greater Synergy; Disaster Risk Management Addressing the Underlying Risk Factors Rather Than Just Post Disaster Response, Relief, and Rehabilitation.

Adoption of community-based approaches to disaster preparation and risk reduction; Approach that places vulnerable communities at the centre of all state government policies, plans, and programmes; Formation of a state that is resilient to disasters by enhancing society and stakeholder capacity.

Promote public-private partnerships for risk management and establish interstate, national, and international networks for DRR procedures.

An inclusive approach to addressing the particular requirements of the underprivileged, marginalised, and vulnerable groups in society.

Institutional obligations

The State Government is aware that disaster risk management is a shared duty of numerous stakeholders at various levels rather than a distinct industry or discipline. Therefore, defining the duties and responsibilities of important stakeholder institutions is a crucial component of the policy framework.

In order to create a complete Disaster Management Code that provides a state-specific legal framework for disaster management, the state government must also take into consideration enacting the necessary laws and revising the current relief codes.

The State Government will set up a proper chain of command so that the District Disaster Management Authorities, led by District Collectors at the district level, and the APSDMA at the State level are each given the authority to coordinate disaster management efforts and mobilise resources from all pertinent Departments at their respective levels. At the Taluk and Village levels, similar institutional arrangements defining roles, administrative frameworks, and processes must also be made.

5.1.4. THE STATE DISASTER MANAGEMENT ADMINISTRATION OF ANDHRA PRADESH

The Andhra Pradesh State Disaster Management Authority (APSDMA) was established by the State Executive on November 14, 2007, in accordance with the Disaster Management Act, 2005.

The rights and duties outlined in the Disaster Management Act, 2005, shall be carried out by APSDMA. It will serve as the highest decision-making authority and give state government departments, agencies, and other stakeholders general direction and guidance. Additionally, it will oversee, evaluate, and coordinate all statewide disaster risk management-related activities.

The District Disaster Management Authority (DDMA) and other government offices, agencies, and entities must abide by the State Disaster Management policy and guidelines established by the APSDMA. The State Disaster Management Strategy, Departmental Plans, and District Disaster Management Plans must also be approved by it. The Authority will be given the legal authority to coordinate, facilitate, and oversee disaster management-related activities using the resources and know-how of relevant government agencies, district administrations, local governments, non-governmental organisations, the public sector, international development organisations, donors, and the local community. Additionally, it will perform the duties outlined in the National Emergency Management Act of 2005.

Where required, APSDMA will develop new capabilities while utilising state government departments' and agencies' current resources and capabilities. It will motivate agencies to incorporate disaster risk reduction into their separate core operations. It will give non-governmental and community-based groups a platform. corporations, the private sector, and other groups outside of the formal government framework are members of the UN and other international organisations.

5.2. STATE EXECUTIVE COMMITTEE

In accordance with the terms of the Disaster Management Act of 2005, the State Executive Committee (SEC) has been established by the Government of Andhra Pradesh. The rights and duties outlined in the Disaster Management Act of 2005 shall be carried out by SEC.

Authorities for Local Disaster Management: In accordance with the terms of the Disaster Management Act, 2005, the Government of Andhra Pradesh established District Disaster Management Authorities (DDMAS) in each of the 13 districts. The Disaster Management Act of 2005, National Guidelines issued by the NDMA, and the SDMA guidelines and directives must all be followed by the DDMAS in its capacity as the district's planning, coordinating, and implementing authority for disaster management. The DDMAs will designate particular roles and responsibilities and establish institutional arrangements at the Subdivision, Taluk, and Village levels.

5.2.1. ACTIONS TAKEN BY ANDHRA PRADESH TO REDUCE DISASTER RISK

Among all the Indian states, Andhra Pradesh has always taken the lead in lowering the risks that its residents experience from natural disasters and climate change. Its example has been emulated by other Indian states. Several recent Andhra Pradesh initiatives point to an emerging pattern in India.

First, Vijayawada and Vishakhapatnam in Andhra Pradesh are serving as test sites for Public Private Partnership (PPP) in DRR. This is a welcome pilot project to safeguard the development and prosperity of these two towns, which are Andhra Pradesh's economic growth engines. To ensure that PPP in DRR at the state level becomes a widely accepted reality in India within the next three to five years, it is imperative that this initiative be carefully watched and that lessons learned are shared with other states and coastal cities. to safeguard the coastal cities' economic development in India. This trial could pave the way for more significant developments like enhanced cooperation between various institutions and agencies, the creation of a centre for excellence, and the installation of an urban observatory system that makes it easier to share PPP best practises.

The "Last mile" of Early Warning Systems (EWS), which is essential for quick action and a decrease in the loss of life and livelihood in India, is being invested in by Andhra Pradesh. Most often, the destruction of the last mile of early warning systems is what results in the loss and harm associated with disasters.

It is essential to make sustained, focused efforts to execute policies all the way to the finish line. The first goal is to provide for the needs of Andhra Pradesh's most vulnerable residents, particularly the physically challenged, dalits, kids, and women. For the purpose of providing its people with location-specific hazard warnings, Andhra Pradesh created a lightning alert system, mass messaging system, and EWS dissemination system. These programmes are a positive improvement. To make sure that the systems are equipped to respond, a readiness audit is now required.

Finally, Andhra Pradesh is enhancing the capabilities of its schools to serve as DRR hubs in the neighbourhoods where the schools are located. For school safety, Andhra Pradesh has worked cooperatively with UNICEF, the Education Department, and the Andhra Pradesh State Disaster Management Authority (APSDMA), and this endeavour is succeeding. This programme is targeted at 39000 school children in four coastal districts who are exposed to high cyclone, flood, and tsunami risk. The development of teachers', students', and officials' capacities is ongoing, and efforts are being made to spread the word of behavioural transformation to everyone.

Fourth, compared to other Indian states, Andhra Pradesh pays significantly more attention to subnational processes.

A number of systems, including SEOC, 13 DEOC, EWDS, Lightning alert, and monitoring systems, are in place to effectively handle crises and reduce risk. Additionally, for more than 3.3 million vulnerable citizens, ADR and APSDRF were created. This has one of the broadest public coverages. In 2017–2018, more than 50 national, state, regional, and village-level programmes were created with the goal of enhancing these subnational capabilities. 11,900 parties are thought to be covered. For integrating capacity building at the state level, a capacity building tool and online portal have been created. Construction is currently underway on the Andhra Pradesh Disaster Research Centre, which will include a geospatial laboratory and a chemical emergency management platform.

Fifth, Andhra Pradesh has preparation for a tsunami on its agenda. Although Andhra Pradesh is not particularly at risk for tsunamis, it is still wise to be ready for such a danger given the potential loss of life and property. Andhra Pradesh has taken systematic measures to be ready for a potential tsunami on its coast since the 2004 Indian Ocean earthquake. Andhra Pradesh is conducting mock drills on the coast, which is one of the best methods to accomplish this.

The authorities have the chance to evaluate their level of readiness and reaction time during these mock drills. To synchronise information sharing, operational process flow, and multi stakeholder coordination, NDMA and the Indian National Centre for Ocean Information Services are taking the initiative. In the end, the calibre of those in charge of these procedures for preparation is what counts. The secret to improving such Indian and Andhra Pradeshi individuals' access to resources and influence is to invest more in them.

Andhra Pradesh has strengthened its people' resilience by implementing the aforementioned measures, and in doing so, has also provided examples for other Indian states to follow. Disasters can have devastating effects on people, towns, and entire countries. These effects might result in fatalities, financial losses, or infrastructure devastation. The results of climate change and rising human population density have recently made catastrophes worse. Disaster Risk Reduction (DRR) has consequently grown in significance as a study and policy area. DRR is a multi-sectoral strategy that integrates various data sources and partners in order to lessen the effects of disasters. By increasing the precision and speed of catastrophe forecasting, detection, and response, artificial intelligence (AI), an emerging technology, has the potential to lower the risk of disasters. The potential of AI in DRR, its present applications, and the difficulties that must be overcome in order to realise that potential are all covered in this paper. AI has the ability to be an effective DRR tool. AI algorithms can combine various data sources, including satellite imagery, weather information, and reports from the general public, to produce forecasts and early notification systems that are more precise. AI can also be used to quickly identify catastrophes like landslides and floods. This may make it possible for quicker reactions, which could lessen the effects of catastrophes. AI can also be used to allocate resources in the most efficient way possible to maximise the impact of DRR efforts.

5.2.2. REDUCTION AND PREVENTION

The Government of Andhra Pradesh is aware that reducing disaster risks needs an integrated, comprehensive strategy that addresses every aspect of the various stages of disaster risk management. Strategic interventions would be needed for each stage of disaster management in order to execute the State Disaster Management Policy. As a result, disaster mitigation and prevention will be important strategies used to execute the Policy. In this situation, APSDMA will direct and oversee prevention, readiness, and capacity-building efforts. For the prevention and mitigation of disasters as well as preparedness and capacity building, APSDMA will work with State Government Departments, DDMAS, local authorities, NGOs/CBOs, the private sector, and national and international organisations.

5.2.3. ENSURING THE STATE'S GROWTH IS RISE-SENSITIVE:

The Andhra Pradesh government is aware of the connections between disaster risk reduction and growth planning. Developing projects may increase or decrease the likelihood of disasters. Therefore, disaster risk mitigation strategies should be incorporated into all development planning efforts. The Andhra Pradesh government will see to it that disaster risks are considered in planning efforts by state government agencies as well as municipal self-government, along with mitigation and prevention strategies.

Giving strategic direction

State government organisations will receive strategic instruction and advice from the APSDMA for disaster risk management. It will create and publish guidelines and policies on particular catastrophe risk management-related topics.

5.2.4. DISASTER RISK MANAGEMENT TECHNO-LEGAL FRAMEWORKS STRENGTHENING

The State Government will increase the vigilance with which laws, bylaws, and rules that contribute to disaster risk reduction are enforced. The State Government will examine the current building codes, bylaws, and zonal regulations and make changes as needed. To strengthen the techno-legal framework in the state, the following actions will be taken in particular: Periodic review and amendment of municipal regulations, such as building bye-laws and development control regulations; Review of land use plans in major cities and urban settlements based on scientific hazard risk assessments; Strengthening the techno-legal compliance regime; Training of engineers, architects, masons, and construction workers.

5.2.5. RISK ANALYSIS

According to the State Government, risk assessment is a requirement for risk-informed growth. In order to direct risk mitigation, preventive, and preparedness measures by various stakeholders at the state, district, and sub-district levels, scientific hazard risk assessment will be carried out in the state. The fundamental requirement of risk-informed planning will be met by creating a Risk Information System for Andhra Pradesh (RISAP) that includes risk profiles of hydro-meteorological hazards, geological hazards, hazards, and industrial hazards.

5.3. DISASTER MANAGEMENT PLANNING

Plans for disaster management will be created and updated on a frequent basis at the State, District, and Sub-District levels. City disaster management plans will be developed for each of the state's main cities. The APSDMA, DDMAS, State Government Departments, ULBS, and other pertinent authorities will be able to implement preparedness and mitigation steps thanks to these disaster management plans. These Plans will also aid in the systematic and efficient response to catastrophes and the implementation of relief, reconstruction, and recovery measures.

Under the general direction of the APSDMA, current manuals and codes, such as the Relief Code, will also be evaluated and updated. As required by the Disaster Management Act of 2005, it will be made sure that crisis management plans are reviewed and updated.

5.3.1. DISASTER RISK REDUCTION IS MAINSTREAMED INTO DEVELOPMENT PLANS AND SCHEMES

In order to integrate risk reduction into development in a variety of development schemes, projects, and programmes, the APSDMA will create the necessary tools and methodologies. The APSDMA will develop the capacity of individuals working for both the government and non-governmental organisations who execute various programmes, projects, and schemes.

5.3.1.1. REDUCTION OF DISASTER RISK IN URBAN AREA

The State Government will put an emphasis on danger mitigation in cities. All municipal corporations and councils will work together to reduce and prevent the danger of disaster. Plans for managing disasters in the city will be created, and disaster-specific actions will be done. Action plans for risk mitigation through development initiatives will be created by the Municipal Corporation and councils. Municipal representatives will receive training.

5.3.2. DESIGNING AND ENACTING PARTICULAR HAZARD MITIGATION PROJECTS

With help from the World Bank, the State Government is putting its National Cyclone Risk Mitigation Initiative into action. The Government will give the APSDMA financial support for planning and carrying out particular hazard mitigation initiatives.

5.3.3. STRATEGIZE RISK TRANSFER METHODS

The government will promote risk transfer tools like insurance as part of risk mitigation measures and in an effort to lessen the burden on both the government and victims.

5.3.4. ADAPTATION TO CLIMATE CHANGE (CCA)

Andhra Pradesh is particularly vulnerable to hydro-meteorological risks. The frequency and severity of these catastrophes are likely to increase in the future, according to numerous studies on the effects of climate change. As a result, the APSDMA will work to strengthen the capacity of the state's river plains and coastal towns to withstand disasters and extreme weather events. It will encourage integrated water management, the building of risk-resistant structures and shelters, and the development of alternative means of subsistence.

5.3.5. CONTROL OF CYCLONE AND FLOODS RISK

Being a state that is particularly vulnerable to flood and cyclone catastrophes, APSDMA will place a high priority on improving risk management and mitigation strategies for flood and cyclone events. Vulnerable areas of the state will have access to critical infrastructure development and human capacity enhancement.

Building community, government, and institution preparation for disasters aids in a swift and efficient response. The State Government must immediately take the necessary precautions and enhance tactical readiness. The state will adopt the following actions to be prepared for disasters:

Create an incident response system.

The Andhra Pradesh government understands the importance of having prepared teams of officials to handle catastrophes. In accordance with the National Guidelines on Incident Response System published by NDMA, the Government has already informed Incident Response Teams at the State and District levels. At the district and state levels, it will create and carry out a training programme for incident reaction teams.

5.3.6. CONSTRUCT A DECISION SUPPORT SYSTEM

The government will build a database of essential resources, infrastructure, and facilities on the GIS platform to aid decision-making by the authorities in the wake of a catastrophe.

5.3.7. INCREASE THE EOCS NETWORK

For the timely gathering of hazard-related information and the swift dissemination of pertinent information and cautions, a network of EOCs at the State and District levels with a strong communication network will be essential. The condition of the EOCS and communication network will determine how successfully the state manages post-disaster reaction and relief efforts. In order to guarantee fail-safe communication, APSDMA will ensure strengthening of the EOCS and communication network at the State and district levels.

5.3.8. IMPLEMENTING EARLY WARNING SYSTEMS THAT CAN REACH THE LAST MILE

Early warning systems will assist the APSDMA and DDMAs in taking prompt preventive action, minimising the harm and losses brought on by catastrophes. Therefore, APSDMA and DDMAS will improve the early warning systems to provide prior notice of hazards like cyclones and floods to the last mile. Increasing search and recovery capacity: Building local level search and rescue skills is essential for the state, especially for cyclone and flood preparedness. The state government will establish a State Disaster Response Force, strengthen fire and emergency services as multi-hazard response groups, and train home guards in order to achieve this.

Building health, trauma, and psychosocial care capabilities

Trauma, psychosocial, and post-disaster treatment are highly specialised and essential. Consequently, the state needs to develop specialised skills. By building facilities, infrastructure, and a cadre of skilled workers, APSDMA will work to create these capabilities in the state through the Health & Family Welfare Department, Medical Colleges, and other organisations.

5.3.9. LEVELS OF THE STATE, COUNTY, AND SUB-DISTRICT FOR TRAINING AND CAPACITY DEVELOPMENT

For the state, APSDMA will create a thorough training and capacity development strategy. In order to strengthen the capacities of all pertinent stakeholders in the state, it will network with training facilities for line departments, universities, crisis management experts, NGOs, community groups, and other stakeholders. The newly established Vijayawada South Campus of the National Institute of Disaster Management (NIDM) will participate in training initiatives and support the development of a cadre of specialised management experts in the region. The

APSDMA will support upgrading the training facilities, conducting training needs assessments, reviewing and developing training modules, course curricula, and training materials, as well as supporting the design and delivery of Training of Trainer's Programs on various facets of disaster risk management.

5.4. DEVELOP PARTNERSHIPS AND NETWORKS AMONG NGOS, CSOS ETC

The APSDMA and DDMAs will form alliances with different NGOs and CSOs that could offer assistance with post-disaster reaction, relief, and recovery. To actively engage NGOs and CSOs, inter-agency groups should be established at the state and district levels.

5.4.1. IMPROVE PARTICIPATION IN THE PRIVATE SECTOR

The private sector should take precautions not only to safeguard their assets but also to guarantee business continuity in the aftermath of a catastrophe. By using CSR funds, private sector organisations could also help to risk reduction efforts in the neighbourhood. By encouraging systems for the creation and timely updating of crisis management plans and risk mitigation measures, these organisations' business continuity is also guaranteed.

5.4.2. PUBLIC COMMERCIAL DISASTER MANAGEMENT OF VIJAYAWADA CITY, ANDHRA PRADESH: PRIVATE ENGAGEMENT FOR DRR

In India, the private sector and business organisations have historically supported post-disaster operations. Business and philanthropic goals have primarily influenced the subjects and types of activities. Private sector investments following disasters have been greatly influenced by public policies that regulate their investment through Corporate Sector Responsibility (CSR) programmes. Many corporate organisations and media outlets have collaborated with regional officials, NGOs, and local groups to immediately support the affected communities by distributing relief supplies. They have engaged in village-based projects like the construction or repair of long-term social infrastructure (drinking water facilities, schools, Anganwadi, community canters); individual housing; and supporting livelihood generation through skill development during the early or midterm recovery phase. Associations like CII, ASSOCHAM, HCC, and FICCI have encouraged awareness and learning by organising conferences, exhibitions, and workshops. Businesses have begun to handle disaster risk by using business continuity planning as a tool.

5.4.3. REQUIREMENT FOR PUBLIC-PRIVATE PARTICIPATION IN REDUCING DISASTER RISK

Businesses play an important role in the societies in which they function. They perform a variety of roles, including those of employers, service providers, managers of vital assets, customers of public and other private sector services, payers, and many more. Major financial losses can result from interruptions in business activity, which can also have a negative effect on the long-term expansion of the local, regional, and national economies.

Disasters can harm exposed and vulnerable offices, factories, and other resources, disrupting and paralysing company operations. But the danger of a catastrophe does not end at the factory gate. Infrastructure and urban networks managed by utilities and the public sector are essential to businesses. Because of their extensive interdependence and interconnection, critical infrastructures like those in the areas of transportation, communications, and electricity are especially susceptible to shocks and disturbances. As a result, a single failure can set off a chain reaction that affects numerous industries and locations. Business operations are disrupted and incur additional costs when ports, airports, energy and transportation networks, or neighbourhoods where employees reside, are damaged. When operations are disrupted, skilled workers might depart, market share might be lost to rivals, relationships with important suppliers and partners might be broken, and confidence and reputation might be lost.

However, there is a need to further strengthen these practises in the region through the incorporation of knowledge about disaster risk into investment choices, the development of public-private risk governance, and the disclosure of disaster risks and costs on company balance sheets. Businesses are starting to take steps in this direction by finding disaster hot spots in their supply chains, disclosing risk-reduction strategies, and forming partnerships with local municipal governments.

5.4.4. PRIVATE SECTOR INVOLVEMENT IN ANDHRA PRADESH DISASTER RISK REDUCTION

Many private businesses and the government are currently working together in the fields of energy, waste management, education, health, water and sanitation, etc. Similar collaborations are required in rapidly urbanising regions, especially in Smart City initiatives. There are numerous possibilities now that Visakhapatnam and Amaravathi have been designated as Smart Cities in the State. These communities are expanding quickly and even somewhat haphazardly, undermining environmental and ecological principles and making them vulnerable and unsustainable. There are therefore many opportunities for the private sector to work in collaboration with the government and contribute to development projects while also incorporating DRR and CCA for sustainability and developing infrastructure and infrastructure resilience.

Support for and encouragement of PPP engagement in the city by VIJAYAWADA MUNICIPAL CORPORATION: PROFILE OF CITY RISK

• In Vijayawada City, the Krishna floodwaters can affect 8 divisions, the Budameru floods can affect 17, and the Rock slides can affect 10 divisions.

• A Zone-III Earthquake with a Richter scale impact of between 5 and 6.9 is possible.

• Five steep hills in the metropolis are a threat to the populace.

• 33 cyclones with a radius of 100 to 150 km passed through the region.

• Extreme temperatures [between 46 and 49 degrees] during every summer season.

• High levels of emissions (CO, NOX, SOX, PM) in the ambient atmosphere.

• A low-lying region with a subpar drainage system.

• Upcoming health risks brought on by elevated levels of vehicle emissions

The project's goals are to decrease disaster risk in urban areas by enhancing institutional capacity, and it is supported by UNDP-USAID. • To improve community resilience in Andhra Pradesh cities and manage climate risk in urban areas by improving preparedness. • To incorporate climate risk reduction measures into development initiatives as well as to carry out mitigation actions based on scientific analyses.

Heavy rains, floods, storm surges, and heat waves are just a few examples of the hydro-meteorological hazards that put human lives in peril, disrupt livelihood systems, and halt social and economic growth. Climate change and variability have increased risks in urban areas in recent decades because they are anticipated to affect the frequency and complexity of climate hazards. The initiative seeks to promote adaptation to climate change and manage climate risks while also enhancing the resilience of institutions and city dwellers.

The GOI-UNDP Disaster Management Project has been implementing VMC in the City since 2014, and the following key initiatives have been finished as part of the project:

• Prepared Municipal Disaster Management Plan (CDMP).

• A study was performed on the Hazard Risk and Vulnerability Assessment (HRVA).

• Increasing the community's and important officers' capacity through training.

• Conducting a study to strengthen the Early Warning System (EWS) (based on suggestions from the Early Warning System).

• Prepared sector strategy for mainstreaming disaster risk reduction.

• Knowledge Management for Adaptation to Climate Change and Catastrophe Risk Reduction.

With a river running through the city, the Indrakeeladri hills on the west, the Budameru river in the north, and a series of hills covering the northern, north-western, and southern portions of the city, Vijayawada's climate is heavily influenced by its topography. Additionally, the city has a tropical environment overall, with hot, muggy summers and mild winters. The South-West and North-East Monsoons bring heavy rain to the metropolis.

5.4.5. CONSULTATION WORKSHOP ON PPP

In the month of August 2017, VMC-UNDP organised a half-day consultation meeting with key public and private agencies based in Vijayawada City and Krishna District in particular. The meeting's objectives were to raise awareness of the risk, vulnerability, and hazard profile of Vijayawada city, the state of disaster management initiatives in the city, and to continue discussions on DRR initiatives, best practises, and interventions for fostering resilience among businesses and agencies, as well as potential area development. The workshop has not only made the PPP aware of the value of DRR, but it has also helped them identify and comprehend the area(s) that need to be intervened in order to increase Vijayawada City's resilience by reducing the effects of both natural and man-made catastrophes.

5.4.6. AREAS THAT COULD BE INTERRUPTED

In order to involve players in disaster risk reduction and climate adaptation, the following categories have been identified:

5.4.6.1 KRISHNA UNIVERSITY, MACHILIPATNAM ESTABLISHES A CENTRE OF EXCELLENCE (COE) IN DISASTER MANAGEMENT

For the purpose of creating real-time hazard measures and sharing them with city and district authorities for preparedness and building strong responses, this Center (COE) may have partnerships with NASA, ISRO, IMD, and ANDHRA PRADESH State Remote Sensing Agency. The Center also encourages local risk/hazard research, with an emphasis on urban floods, heat waves, storm surge, etc. in coastal/cities in the state of Andhra Pradesh (1st Priority of SFDRR).

5.4.6.2 UOS, BASED AT VMC, IS AN URBAN OBSERVATORY SYSTEM

The main goal of the UOS is to create a platform for Public and Private Partnership [PPP] to work on urban problems, bolstering the cities of Andhra Pradesh for better governance, and establishing early warning systems. These PPPs can aid in maximising the contribution of private players to risk management and enhancing urban resilience. Along with a number of other for-profit and charitable organisations like the Reliance Foundation, TATA Trusts, Apollo Hospitals, the IT Association, Hyderabad and Local NGOs, among others, the UOS has also facilitated knowledge management and sharing of best practises with municipal corporations and town administrations in the state (2nd Priority of SFDRR).

A centre of excellence for disaster management is located at the Jawaharlal Nehru Technology University in Hyderabad.

With the goal of monitoring landslides and rockslides and providing early alerts for both, this centre has been working on a pilot project. The centre is working in Andhra Pradesh's vulnerable hill regions to provide local people there with early warnings against landslides (pilot project for EWS).

Waste Handling and Minimization in Collaboration with the Pollution Control Board of Andhra Pradesh, Vijayawada The plan for reducing risk associated with heavy downpour and inundation due to heavy rains and floods in the city was first discussed with Pollution Control Board officials. The city's low-lying areas and vulnerable position will be crucial to efforts to reduce water logging and manage contamination because the topography is largely flat.

5.4.6.3 BUDGET PROPOSED UNDP

budgeted Rs. 15 lakh for Vijayawada city to start PPP engagement with key potential players in the city; based on the firms'/agencies' expressions of interest, the money will be used for DRR and CCA initiatives by the Vijayawada Municipal Corporation. The team will tour the city during the second week of May 2018 to finalise any potential initiatives following a final consultation meeting with TERI and The Energy and Resource Institute with VMC and USAID. The Indian Institute of Human Settlements (IIHS), based in Bangalore, and TERI will provide the necessary technical assistance.

5.4.7. TSUNAMI MOCK DRILL IN ANDHRA PRADESH MEASURES ANDHRA PRADESH'S PREPAREDNESS

All ocean basins have experienced localised tsunami devastation. Over the previous 4,000 years, more than 2,000 tsunamis have been recorded, with 1,100 of those being supported by scientific evidence. The Pacific Ocean has seen 73% of the verified tsunamis, 16% in the Mediterranean and Black Seas, 6% in the Caribbean Sea and Atlantic Ocean, and 5% in the Indian Ocean. Of these, 85% of the tsunamis and 14% of the landslides were brought on by tremors.

The fact that local and regional tsunamis, which have affected shores within minutes to several hours, have been responsible for more than 99% of all fatalities, emphasises the importance of local and national preparedness in minimising tsunami-related losses.

The 2004 Indian Ocean tsunami emphasised the fact that tsunamis can (and will) occur in all ocean basins and can happen at any time, killing about 230,000 people in 14 countries, with nearly 170,000 deaths estimated in northern

Sumatra, Indonesia alone. Following the disaster, three new Intergovernmental Coordination Groups (ICG) for tsunami warning and mitigation systems were established in the Indian Ocean (ICG/IOTWS), the Caribbean and surrounding areas (ICG/CARIBE EWS), and the North-eastern Atlantic, the Mediterranean, and connected seas (ICG/NEAMTWS), all under the auspices of the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific, and Cultural Organization (UNESCO). These were created using lessons learned from the oldest system, ICG/PTWS, which was founded in 1965.

Because of their quick onset and unpredictable nature, tsunamis stand out from other dangers; we never know where or when the next one will strike, and when it does, we have little warning and therefore little opportunity to prepare. This places a great deal of responsibility on nations to plan ahead, create agreed-upon standard operating procedures, and train through exercises.

On November 24, 2017, along India's eastern coast, the National Disaster Management Authority and Indian National Centre for Ocean Information Services (INCOIS) jointly performed the Multi-State Tsunami Mega Mock Exercise (in the States of Andhra Pradesh, Odisha, Tamil Nadu and West Bengal). Prior to the mock exercise, multistakeholder coordination meetings and tabletop drills were organised at the national and state levels to coordinate information exchange and the operations process flow.

All concerned State/UT and District level officials replied to the mock bulletins within the allotted response times after INCOIS issued them in accordance with the scenarios created by NDMA. The relevant States turned on their State Emergency Operation Centers and District Emergency Operation Centers, and the incident was closely watched until it was deemed "normal." People from the forewarned villages were evacuated and housed in cyclone shelters or community facilities that were accessible. The fake drill saw an evacuation of roughly 1,53,712 people to safe locations, and it was noted as having excellent involvement compared to the previous tsunami mock drills.

The exercise gave the State and District crisis management authorities a chance to put their SOPs to the test and improve communication between emergency support function departments.

The Indian Ocean Wave Exercise (IOWave18) will take place on September 4-5, 2018, according to the Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System (ICG/IOTWMS). The planned international practise will help India's attempts to prepare for a tsunami and build community resilience to disasters in coastal areas.

Improvements in the Flood Forecasting Process: Conventional flood forecasting models utilising statistical correlation and regression equations were used to create flood forecasts during the early era of flood forecasting activity up until 1958 to the 1990s. Using data processing tools like spreadsheets and Tables, data entry methods were updated in the 1990s. Equations for regression and association were also created on spreadsheets. Tools like the Mike-11 software were adopted for the establishment of telemetry modelling centres during the X Plan era. All of the newly operationalized flood forecasting sites were subjected to mathematical modelling during the XII Plan. During the XII Plan, new Mike-2016 software was utilised. Since 2017, there have been three-day flood warnings, which are now accessible for all 325 flood forecasting stations. In order to obtain their data easily, CWC and IMD have an agreement in this respect. From 2017 onward, IMD will also offer map-based sub-basin-wise Quantitative Precipitation Forecasts (QPFs) based on the results of the Numerical Weather Prediction (NWP) model. It is necessary to create a flash flood forecasting and early warning system in light of the numerous instances of flash floods that have occurred recently in the nation. Flash floods are ascribed to a favourable confluence of hydrologic and meteorological conditions as well as catchment area characteristics. Focusing on scientific research will help create a model-based system that can predict flash floods with enough advance time, reducing the threat of flash floods.

Indian NWM: With the aid of some scalable models, the details of which are provided in graphical format, an attempt at a comparable type of national water model may be made in India. Together, these models can be used to input data into a decision-support system that can assist the nation by anticipating and forecasting floods and other water-related occurrences.

5.4.8 NATIONAL WATER MODEL DEVELOPMENT FOR ANDHRA PRADESH

The National Water Model (NWM) is an American hydrologic modelling framework that simulates observed and anticipated streamflow across the full continental United States (CONUS). The NWM uses mathematical representations of the various processes and how they interact to mimic the water cycle. This intricate depiction of physical processes, including snowmelt, infiltration, and water movement through the soil layers, changes greatly with shifting elevations, soils, vegetation types, and a wide range of other factors. Additionally, very rapid changes in response on rivers and streams can be brought on by extremely variable precipitation over brief distances and times. Overall, the process is so intricate that simulating it mathematically requires a supercomputer or extremely powerful computer in order to operate quickly enough to assist decision-makers when flooding is a threat.

There are four operating modes for the NWM:

A snapshot of the most recent hydrologic circumstances is provided by analysis and assimilation.

Short-Range predicts streamflow and hydrologic conditions at the hourly level out to 15 hours; Medium-Range forecasts at the 3-hourly level out to 10 days; and Long-Range forecasts at the 30-day ensemble level.

By giving "street level" water information and guidance (such as flood maps), the NWM enhances the National Weather Service's capacity to provide impact-based decision support services across the country. It also serves as the basis for additional private sector water services.

5.5. USING INTERNET OF THINGS (IOT) SENSORS

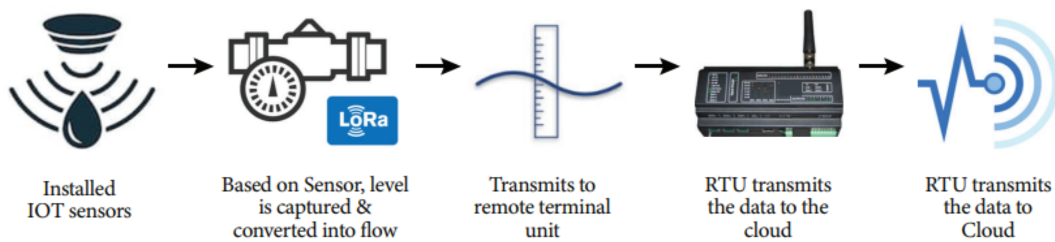


Figure 7- IoT Sensors

5.6. ADVANTAGES OF THE MODEL

i. In addition to recording rainfall, temperature, levels, and flow, cloud-based storing makes data accessible from anywhere and secure.

iii. Computing in the cloud.

5.6.1. FLOOD FORECASTING BASED ON HYDROLOGICAL MODELS

Precipitation turning into channel flow is a very complicated physical process. The representation of watershed processes through a hydrological model is a widespread practise. Governmental organisations, academic institutions, and commercial businesses have created a wide range of hydrological models. They provide a broad variety of options for process simulation, varying degrees of complexity and data requirements, as well as varying levels of technical support and training. Their use is also influenced by institutional skills, geographic and environmental variables, and forecasting objectives. As a result, choosing a "best option" flood forecasting model requires a methodical approach.

5.6.2. SUCCESS FACTORS OF THE MODEL

Utilizes near real-time and historical info for computation.

ii. Employs a wide range of cutting-edge methods, such as GPS

iii. The model only needs a few instruments installed.

5.6.3. AI-BASED FORECASTING OF FLOODS

For scientists studying flood risk management, the need for dependable, simple-to-use hydrological forecasting systems is an appealing task. At the moment, powerful methods for modelling hydrological processes have been made available to water engineering thanks to advancements in computing technology, including Artificial Neural Networks (ANN) and genetic algorithms (GA). These have been used with varying degrees of effectiveness in numerous case studies. These AI and ML-based models take input from data like temporal flow or rainfall to forecast the flow at a place of interest.

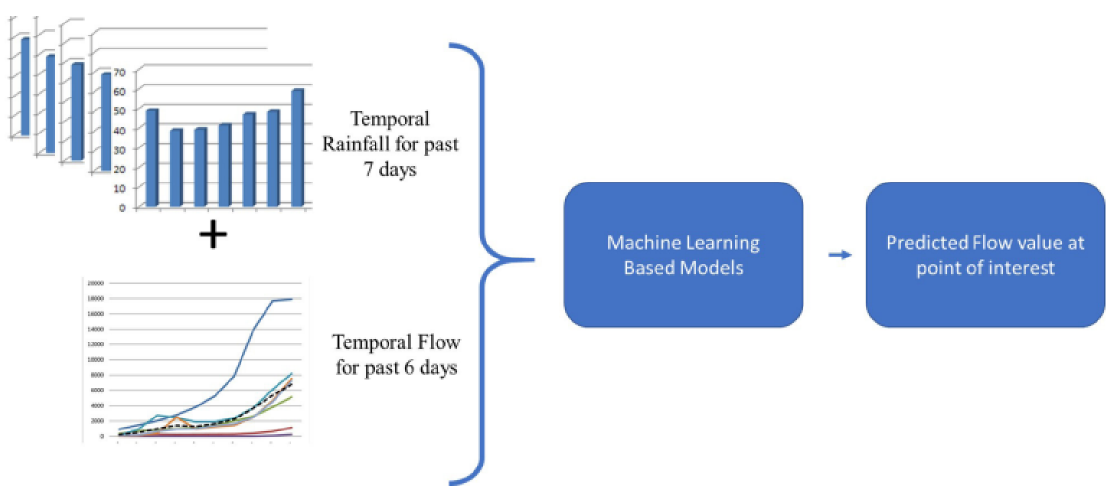


Figure 8 - AI Based Flood Forecasting

5.7 <u>ADVANTAGES OF THE MODEL</u>

i. Utilizes historical data for computation;

ii. uses current rainfall and related flow to represent reality;

iii. and, over time, improves accuracy of results. Using the aforementioned theories,

For the nation, a national water model can be created. The NWM India will be able to predict floods for the near future, the middle term, and the long term. The alert can be sent out in the case of flooding using SMS or mobile applications. Through satellite images or other tools like drones or unmanned aerial systems, post-flood assessments can be performed.

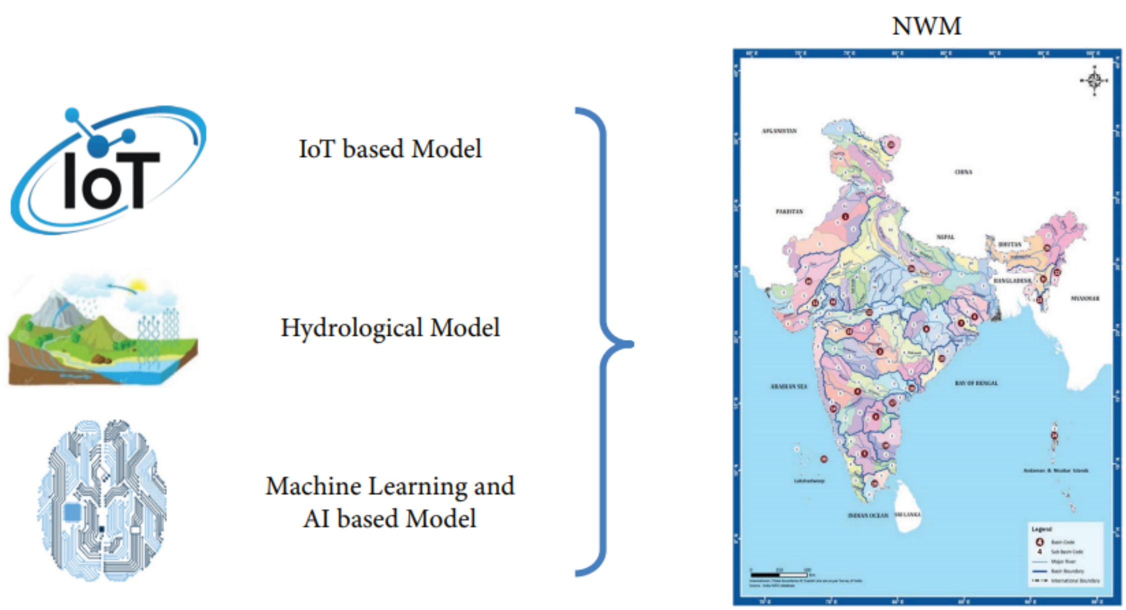


Figure 9- National Water Model for India

5.8. DRR AT LOCAL LEVEL: DISASTER RISK REDUCTION AT SUB NATIONAL LEVEL IN ANDHRA PRADESH

Cyclones, storm swells, floods, heat waves, and droughts can all affect Andhra Pradesh. The populace in 9 districts is exposed to the dangers of nature due to

Andhra Pradesh's 974 km long coastline. When cyclones form in the pre-monsoon (April to May) and post-monsoon seasons, about 44 percent of the state is susceptible to tropical storms and associated hazards (October to December). A moderate to high intensity cyclone could be anticipated to make landfall in Andhra Pradesh every two to three years. It appears that the frequency of cyclones has increased over the past few decades to the point where strong cyclones are now a regular occurrence, occurring every two to three years and repeatedly and severely impacting the state's economy while placing a strain on its institutional and financial resources.

In coastal Andhra Pradesh, nearly 29 million people are at risk from cyclones and their impacts; 3.3 million of them live in communities that are less than five kilometres from the ocean. About 10,000 persons were killed in November 1977 by the twentieth-deadliest cyclone. In May 1990, a powerful cyclone struck the coast, causing 817 fatalities and a state loss of Rs 2,137 crores. During the cyclone in May 1979, over 700 persons died. When Cyclone Laila made landfall in the coastal districts of Guntur district on May 20 just before monsoon, seven persons were slain. Farmers in Krishna, Guntur, and the West and East Godavari regions were devastated by the severe damage to their harvested paddy.

For Andhra Pradesh, having multiple cyclones in a single season is not uncommon. A severe cyclonic cyclone struck the state in November of 1996, resulting in 1,077 fatalities. The damage to the state was Rs 6,129.25 crores. One more powerful cyclone struck the province in December. There were 27 fatalities this time.

Although drought poses a serious danger to the Rayalaseema region and Prakasam district, drought conditions are also present in many other interior coastal belt areas due to changing weather patterns. 2016 saw the declaration of a drought condition in 245 mandals across 7 districts in the state. In the state, the heat wave in 2014, 2015, and 2016 resulted in a significant number of deaths.

The Andhra Pradesh Disaster Management Rules were published and went into force on August 1st, 2007, in accordance with the provisions of the Disaster Management Act of 2005. In order to mitigate, manage, and lower the risk of disasters and create a disaster-resilient Andhra Pradesh, the Andhra Pradesh State Disaster Management Authority (APSDMA) was established in 2007 and is presided over by the Chief Minister.

A modern State Emergency Operation Center (SEOC), 13 District Emergency Operations Centers (DEOCs), Early Warning Dissemination System, Lightning Alert and Monitoring Systems, Atmospheric Research Division (ARD) at APSDMA, and Andhra Pradesh State Disaster Response Force (APSDRF) were established for dealing with emergencies in an effective manner. To improve disaster risk governance and make Andhra Pradesh more disaster-resilient, numerous programmes and projects were also adopted.

Along with the aforementioned creative programmes, the agency ran more than 50 other initiatives at the national, state, regional, district, and village levels in the years 2017–2018, involving more than 11,900 participants. The programmes covered a variety of topics and included trainings, mockdrills, and exercises as well as meetings, conferences, and workshops spread out across the state to increase the state's capacity to manage and mitigate disasters.

THE FOLLOWING GIVES A GLIMPSE OF SOME OF THE INNOVATIVE INITIATIVES TAKEN UP BY APSDMA.

1. LIGHTNING WARNING SYSTEM

The state-of-the-art lightning alerting system installed in the SEOC has a thorough working procedure to monitor lightning and thunderstorm activity effectively and issue warnings in advance. After a lightning strike, an e-mail alert is received within 5 minutes, starting the detailed observation and close monitoring of the action using a visualisation tool on screen. The system uses mobile phones in the identified lightning sites to send real-time text messages.

2. SYSTEMS FOR DISSEMINATING EARLY WARNING

The public living in the regions that are likely to be affected by disasters will receive advance warning alerts under this initiative. In SEOC, DEOCs, and MEOCs, electronic equipment is being put, including routers, servers, digital mobile radios, workstations, satellite phones, and electronic sirens.

3. SYSTEM FOR MASS MESSAGING

All residents of an area likely to experience a catastrophe are sent SMS and voice alerts. This is known as LBAS (Location Based Alert System).

4. DISTRICT EMERGENCY OPERATION CENTRE (DEOC)

Nine of Andhra Pradesh's coastal districts have created District Emergency Operation Centers. For all crisis management-related tasks, the DEOCs will be directly supervised by the SEOC.

5. CENTRE FOR MANDAL EMERGENCY OPERATIONS (MEOC)

In each of the 77 Mandals within the nine coastal districts, MEOCs are being created. The DMR Antenna will be housed in a 30-meter structure that will be built at each MEOC.

6. MASS WARNING SYSTEMS

Cyclone shelter with multiple uses: The alert sirens are located on top of the structure in 138 MPCS. The neighbouring community is forewarned of any disaster using these sirens. In times of danger, members of the public will seek refuge inside the MPCS.

7. FISH LANDING CORPORATIONS (FLC)

There are 16 different FLC numbers, and each FLC has a 30-meter tower for DMR communication. Fishermen using analogue VHF sets on the open seas can communicate with fixed stations using DMR.

8. TOURISTY PLACES

Ten tourism destinations (sea beaches) have been selected for the distribution of early warnings. These locations have warning sirens placed to alert visitors to potential dangers.

9. THE FOUNDATION OF ANDHRA PRADESH CENTRE FOR DISASTER RESEARCH WITH A GEOSPATIAL LAB

The Andhra Pradesh Disaster Response Center (APDRC) is intended to serve as the state's central location for all crisis management-related geospatial services. Advanced geospatial functionalities and analytical skills would form the foundation of the APDRC.

10. TOOL FOR BUILDING CAPACITY

For the purpose of integrating capacity development initiatives in the state, the APSDMA has created an online platform. The web-based capacity development tool gathers and compiles training sessions, workshops, and courses provided by both national and state-level organisations.

PLATFORM FOR CHEMICAL EMERGENCY CONTROL

a platform that allows MAH Units, Response Forces, and the State Department to track, evaluate, and gather data on hazardous chemicals used in particular sectors and to have a comprehensive, usable database of the same.

5.9. DISASTER MANAGEMENT PLANNING IN ANDHRA PRADESH: GOVERNANCE AND DRR

Due to its unique geographic location, India is susceptible to a number of natural disasters, making disaster management a top priority for all tiers of government. The Government of India passed the Disaster Management Act in 2005 in response to the severe catastrophe experiences of the 2004 Tsunami, Bhuj Earthquake, and Odisha Super Cyclone (DM Act). It offered a framework for the DDMP's planning as well as general standards for disaster management that were to be followed by all districts and states across the nation.

The Indian state of Andhra Pradesh, which has a variety of physiographic characteristics including high hills, plains, coastal environments, and deltaic environments, is situated in the country's southern peninsula. Because of its diverse natural and environmental environment, Andhra Pradesh is a territory that is vulnerable to both natural and man-made hazards. Cyclones particularly impact Andhra Pradesh because of storms that produce high surges in addition to high wind speeds. To a lesser degree, it is vulnerable to tsunamis, torrential downpours, and high winds, which can cause floods in some areas and result in significant loss of life, property, and livelihood. Andhra Pradesh has also experienced a number of man-made disasters, including chemical industrial catastrophes, which have increased the state's vulnerabilities.

Actors at all levels must take action, not just those at the national level. States and districts must strive to increase their ability to withstand disasters. The neighbourhood and the building must be conscious of the risks it is vulnerable to, the effects that could occur, and the best ways to prepare for, avoid, and manage natural disasters. According to Section 31 of the Disaster Management Act of 2005 (DM Act), the Disaster Management Authority (DMA) at each level of government in the nation is responsible for creating Departmental Disaster Management Plans (DMPs), City Disaster Management Plans (CDMPs), and District Disaster Management Plans (DDMPs) (SDMA). Every year, it needs to be examined and updated. The DM Act also stipulates that the DDMP must include, among other things, the district's disaster-prone regions and the precautions that should be taken for preparedness, mitigation, and prevention. The DDMP shall also include response plans and procedures that, in the event of a disaster, allocate duties to government departments at all levels for quick response to disasters and their relief, the procurement of resources necessary for this response, the establishment of communication links, and the dissemination of information to the general public in order to prepare for any potential disaster situation or disaster (NDMA).

State Disaster Management Authority (SDMA), State Emergency Committee (SEC), and DM Rules were all created by the Government of Andhra Pradesh in 2007. With the assistance of foreign organisations and multilateral bodies like the World Bank, the government has started a number of capacity building and mitigation initiatives.

The All India Disaster Mitigation Institute (AIDMI) joined forces with the United Nations Development Program (UNDP) and the Government of Andhra Pradesh to create 13 district disaster management plans, 11 city disaster management plans, and 17 departmental disaster management plans.

It was crucial to distinguish between a catastrophe and a natural phenomenon when creating the disaster management plan: "A natural phenomenon, but not a natural danger, is a physical occurrence, like an earthquake, that does not have an impact on people. A natural disaster is a dangerous occurrence that results in unacceptably high numbers of fatalities and/or massive property destruction ". Mapped was the spectrum between a natural occurrence and a natural catastrophe, which was linked to the socioeconomic and regional economic structures. The more vulnerable it is, the lower the growth indicators. In order to connect disaster risk reduction to development plans and projects, the disaster management plan takes into consideration all tangible and intangible, structural and non-structural, elements at all levels. As a result, the district, city, or department is now more resilient to natural catastrophes and vulnerabilities of all kinds. Additionally, adequate attention was given to involving the local actors through participatory in the preparation of the DMPs.

The following are the crucial elements of DMPs that were taken into consideration during the manufacturing process:

1. The DMPs ensure that the concerns of the marginalised groups, in particular women, dalits, children, minorities, and other disadvantaged groups, as well as their vulnerabilities, are included because the entire project is predicated on creating DMPs through inclusive, community-centered, and responsive to the needs of vulnerable groups.

2. The departments at the state level, the district level, and the municipal officials must take the proper actions for disaster prevention and mitigation.

3. The Departments at the state level, at the district level, and at local authorities are required to adopt the capacity building and readiness measures.

4. The disaster response plans and procedures, including the division of duties among the Departments, prompt disaster response and relief, the acquisition of necessary resources, the creation of communication links, and the dissemination of information to the public.

5. Improving the early warning systems for various catastrophes.

6. The inclusion of important Flagship Programs and development schemes into the DMP, such as initiatives to create jobs, micro irrigation projects that could boost agricultural output, the Skill Development Initiative Program, initiatives to support the development of women and children, and programmes for the elderly and disabled.

7. Connecting the DMP to the development plan.

8. Environmental factors like climate, eco-systems, and other factors should be considered and incorporated into the designs.

5.10. IMPLEMENTING SCHOOL SAFETY AND HYGIENE FOR CHILDREN AND DRR

Andhra Pradesh, an Indian state, is particularly delicate and susceptible to hazards like droughts, floods, storm surges, and cyclones. There may not have been a single year without a danger in the state in the previous 42 years. Due to their negative effects on child survival, growth, and development, as well as child safety, these hazards have evolved into disasters. Compared to adults, children are more susceptible to the negative effects of disasters on both a bodily and emotional level. They require specialised security and assistance during emergencies and disasters due to their vulnerabilities. Giving kids the knowledge and abilities to defend themselves and other kids is the best method to lessen their vulnerability.

In this situation, it is thought that combining disaster risk reduction (DRR) and school safety offers an efficient strategic solution. Disaster risk reduction (DRR) is a methodical strategy to identifying, evaluating, and reducing risks of all kinds related to disasters. Therefore, preparedness, prevention, and mitigation are the main foci of DRR efforts. The goal of school safety is to equip and allow students to lessen the negative effects of disasters and increase the resilience of their schools.

In collaboration and assistance with UNICEF, the SUCCESS programme was launched in Andhra Pradesh for the first time in April 2016. It lasted a year and was a pilot initiative (1 year). The Department of Education, Government of Andhra Pradesh, and five CADME network partners implemented the initiative, which was funded by UNICEF Andhra Pradesh. In Andhra Pradesh's coastal districts of Nellore, Prakasam, East Godavari, and Srikakulam, the initiative was launched in 300 government schools across 16 mandals (Blocks), serving about 39,000 students.

THE PROGRAM'S KEY ACHIEVEMENTS INCLUDE

• Ensuring that 39 000 schoolchildren are knowledgeable about school safety and cleanliness procedures.

• Implement hygiene and safety steps in 60% of the project area's schools.

• In the project districts, 1200 people were trained in extensive school safety and hygiene steps.

THE FOLLOWING INTERVENTIONS MAKE UP THE PROGRAM'S MAJOR STAGES.

1. Exposure and orientation for the core staff and Department of Education officials.

2. Education and orientation of the project's core personnel

3. Identifying institutions that are at risk for disaster.

4. Identification FPT and HMS and sensitization of education department staff.

5. Orientation and raising of consciousness among students.

6. The establishment and development of school disaster management committees.

7. District-level discussions with representatives of the division departments.

8. Hazard hunting—finding threats and weaknesses and creating a plan for school safety.

9. Community-level stakeholders and support providers should receive training and orientation.

10. Spreading awareness by commemorating unique occasions.

11. Evaluation and supervision.

This project was founded on the fundamental tenet that village-level stakeholders and the vast capacity and resources of the education department and line departments can produce better results with modest but essential interventions. The education department's focus on school safety would increase with the creation and strengthening of a core committee for implementing a comprehensive programme for school safety at different levels. It would also give the committee a platform and an opportunity to spread the key messages of behavioural change and community resilience to a large audience. Children participate meaningfully in the programme to foster a culture of safety and resilience, taking the lead in their schools and neighbourhoods to lessen the negative effects of disasters. Using a DRR and school safety framework, an integrated implementation strategy was used to carry out the initiative.

5.11. DRR CASE STUDY: Getting to the final mile

Through thorough and focused endeavours, as well as the effective implementation of projects and policies all the way to the end, a safe and secure environment can be achieved.

This research assesses the Strategic Support in Comprehensive Coastal Environment for Education Department of Andhra Pradesh in Implementing School Safety and Hygiene (SUCCESS) program's efficacy, efficiency, influence, and sustainability.

Andhra Pradesh is particularly susceptible to frequent natural catastrophes like cyclones, storm surges, floods, and droughts in its coastal districts. Every year for the past 42 years, the state has been hit by a natural catastrophe.

Children are the worst victims of catastrophic events, especially those with physical disabilities. In the worst instances, these events can have a negative impact on a child's survival, growth, development, health, and safety. They require special protection and assistance during natural catastrophes due to these vulnerabilities. Building children's capacity to be self-reliant in terms of knowledge and skills is one method to lessen these vulnerabilities.

Across four coastal districts of Andhra Pradesh “Nellore, Prakasam, East Godavari, and Srikakulam” in 300 public schools dispersed over 16 mandals (Blocks), the initiative was implemented by five network partners of CADME and served 39,000 students.

From November 10 to November 18, 2017, seven members of the AIDMI team toured the sampled schools to gather data with assistance from the district coordinators of NGOs/CADME.

Due to a recent rotation of government officials and instructors in Andhra Pradesh who had received training from or had taken part in the programme, the team had few problems gathering the right data and information. Therefore, the initiative was only partially acknowledged by many current officials. The evaluation team used this chance to educate the current officials, instructors, and headmasters about the SUCCESS Program, though.

It is quite commendable how local NGOs and their field organisers engaged students in activities, helped them comprehend such complex ideas, and carried out this programme. The fundamental idea of school safety, its severity, and the risks that they currently face are all understood by students. With the skills they have gained through this programme, the students are becoming more resilient and disaster-ready, as are the communities where they reside.

In general, the SUCCESS project has been effective in meeting most of its stated objectives. Reaching the last mile will now guarantee the viability and sustainability of the successful results.

5.12. REDUCTION OF DISASTER RISK THROUGH THE USE OF ARTIFICIAL INTELLIGENCE

Technological developments and innovations are opening up possibilities for enhancing catastrophe resilience and promoting risk reduction. The field of disaster risk mitigation and management is changing on a global scale as a result of advancements in disruptive technologies like the internet of things (IoT), artificial intelligence (AI), drone technology, predictive analytics, risk modelling, and remote sensing. With the development of digital infrastructure, including wireless broadband networks, cloud computing, smartphones, and mesh networks, the application of these technologies has increased. However, there are differences in how widely used and accessible these new technologies are in established and developing countries, which are further divided into low- and high-income regions. This affects the technology's accessibility and suitability for a range of disaster control scenarios (pre, during and post). In the developed countries, there is a growing implementation of new and modern technology in the field of disaster risk reduction (DRR). However, due to some major issues with information asymmetry (specifically, the applicability and usage of technology for DRR), inadequate financing, and low technical capability, the application of new innovations for DRR in developing countries remains constrained. The Realtime Beneficiary Identity System (RBIS), which will be powered by artificial intelligence (AI), will go live in Andhra Pradesh in October 2020. The action is a part of the nine promises, or Navarathnalu, made by the YSRCP during the election, as part of which the government will pay pensions to more than 61 lakh members of vulnerable and underprivileged groups, including senior citizens, widows, single women, people with disabilities, and many other people. The use of artificial intelligence for catastrophe risk reduction has also started in Andhra. After being successfully tried in the East and West Godavaris and Krishna districts as pilot projects, the new AI-based authentication system is now being implemented throughout the state.

The International Telecommunication Union's (ITU's) expertise in information and communications technology is combined with knowledge of natural disasters and hazards from the World Meteorological Organization (WMO) and United Nations Environment Programme in the Focus Group on AI for Natural Disaster Management (UNEP). The group's objectives include improving modelling at various spatiotemporal scales, facilitating effective communication, and aiding in data gathering and handling. Additionally, it actively involves experts and stakeholders to develop and integrate perspectives and competencies in the development of AI-based technologies into disaster risk management, making means and opening doors to withstand challenges to an open science at the national, regional, and global levels.

It is important to explain where artificial intelligence (AI) can be used in pills before moving on to the three major themes of artificial intelligence, namely communication, modelling, and detecting. Artificial intelligence, or AI, replicates human intellect through computer system processes. AI has the potential to improve proactive rather than reactive actions for disaster risk reduction, as Andrew Harper, Special Advisor on Climate Action of the United Nations High Commissioner for Refugees (UNHCR), reminded us. AI can speed up our understanding of natural hazards by analysing large volumes of data (and images) from different sources (DRR).

Countries are now able to successfully respond to disasters in all scenarios thanks to disruptive technologies (pre, during and post). Understanding the causes of disasters, improving predictive analytics and forecasting to enable early warning systems, assessing pre- and post-disaster physical damages, ensuring the accuracy and promptness of response strategies and information dissemination, and increasing knowledge of the economic impact and social behaviours post-disaster are all aided by them. Instead, these DRR-focused innovations and technologies are assisting strategic interventions during all three phases of the crisis response process: preparation, mitigation, and recovery.

Drones make remote sensing possible before and after disasters; they keep an eye on geophysical structures to lessen the effects of catastrophes and support relief efforts by broadcasting real-time images and video from disaster-affected areas. The use of AI-driven computational models and cloud-based data integration outcomes for predicting and detecting extreme events as well as creating catastrophe early warning systems has increased. Monitoring sensors that are embedded to provide real-time information and transmit alerts in case of catastrophic occurrences power IoT for disaster management. Ground sensors can identify earth movements, and river level tracking can help with flood control.

When it comes to natural disasters, the year 2019 has been among the worst in India's annals. Over 13 Indian states have been affected by floods (Kerala, Gujarat, Karnataka, Maharashtra, Madhya Pradesh, Andhra Pradesh, and Odisha), prompting the deployment of IoT-based early warning systems that include solar-powered sensors to monitor air temperature and water levels with cloud storage for data and mesh networks for information dissemination, albeit selectively across the nation in the states of Andhra Pradesh and Google deploying solutions.

Some relief organisations also take donations using cryptocurrencies. For instance, in Vanuatu's islands that were vulnerable to natural disasters in 2019, Oxfam gave "Dai" (stable coin) to distribute assistance to 200 people and 30 vendors. Mesh network-enabled information dissemination ensures connectivity after a catastrophe and aids in information sharing during a crisis. International institutions and organisations are constantly conducting research and development on cutting-edge innovations that can support DRR. Robotics and blockchains are examples of this. The ability of a blockchain distributed ledger system to verify data and documents has been confirmed by the scientific community. This will facilitate a quicker reaction to disasters. The United States of America Centre for Disease Control and Prevention is testing this technology to allow trustworthy and quick data collection during a disease outbreak. This may be important for crisis management during the relief and rehabilitation phases, as it necessitates the timely exchange of reliable information and data to support coordinated efforts by various agencies.

When it comes to robotics, the Human- Robot Informatics Laboratory at Tohoku University in Japan is developing various kinds of robots with cameras, wireless communication, infrared sensors, and GPS that can be used in crisis response. Authorities responsible for Andhra disaster risk reduction have used these technologies to find people in areas that have been harmed. India, a nation vulnerable to natural disasters, is also serving as a testing ground for a variety of technologies that will make it possible to execute the Sendai Framework on Disaster Risk Reduction in its proper spirit.

The state of Andhra serves as an illustration of how ongoing, sustained advances combined with the use of appropriate technologies can help save lives. In order to reduce information gaps during disasters between federal and state agencies, the government of India has also decided to set up an integrated control centre.

5.13. COMMUNICATION WITH AI

According to Adam Fysh, Coordinator of Global Risk Analysis and Reporting Section, United Nations Office for Disaster Risk Reduction (UNISDR), dialogue in DRR entails asking the appropriate questions regarding who poses risks and who bears the costs of those risks. To strengthen the understanding and reaction to multiple risks, stakeholders' participation is therefore essential. However, this is only true if key informants are included rather than persuaded and a two-way trust-based communication is established.

Ioannis Andredakis, a Senior Analyst on Disaster for the European Commission's Department for Civil Protection and Humanitarian Affairs, offered one ideal illustration. As it does during disasters in Andhra Pradesh like floods and tsunamis among others, the first job of AI was to understand the degree of risk in terms of the number of people involved as well as how quickly and in which direction the fire was spreading. The second concern was how to successfully implement an emergency evacuation plan while avoiding fear-related actions that might have exposed additional people in addition to those already engaged. This included both removing the people from danger and considering all potential evacuation measures. He added, "With AI, the situation is quickly understood and communicated, potentially reducing the amount of people engaged.

Recent experiences with natural disasters demonstrate that we continue to face difficulties with information's accuracy, dependability, and modality as well as with people's capacity to elicit the right reaction and accept its unpredictability. "The danger of being wrong" remains a significant obstacle, and recent advances in technology might introduce additional uncertainty that has not yet been considered. However, technology continues to be a partner in disaster risk analysis and a crucial tool for researchers, businesses, and decision-makers engaged in DRR. AI is a tool for quick analysis, but it has not yet been fully utilised in the aftermath of catastrophes. Andredakins points out that it hasn't been used, for instance, to categorise the losses (humans still do it). Deploying AI to improve our comprehension of all phases of disasters is therefore of the utmost importance. This can be accomplished by speeding up the creation of algorithms that are trustworthy for our safety.

5.15. FORECASTING AND PROJECTING WITH AI FOR MODELLING

The use of predictive models in weather predictions is something we are all quite accustomed to. AI can assist experts in predicting a variety of natural disasters, though. As Feyera Hirpa, a Senior Data Scientist at One Concern Inc., showed by testing his predicting models during the 2019 flood in Japan's Chikuma River following Typhoon Hagibis, it is a useful compound and scalable flood prediction tool. The observer came to the conclusion that AI has the potential to anticipate floods. There is no guarantee that a model will perform similarly well in real-world scenarios even if it perfectly fits the training dataset. According to Helen Li, Senior AI Researcher at the China Academy of Information and Communication Technology, promising prediction applications are also seen in wildfire-prone regions (CAICT). For computer-based modellers, real-time predicting is still a challenge.

According to Corentin Caudron, Research Officer, Research Center for Development, "forecasting the onset, size, duration and danger of [volcanic] eruptions by integrating observation with quantitative models of magma dynamics" is another difficult case (IRD). However, the characteristics of earthquakes and tremors can aid in a better understanding of eruption manifestations and their development. All due to machine learning (ML), which aided in organising and extrapolating enormous volcanic-seismic data to achieve high forecast and projection accuracy. The fact that each volcano acts a little bit differently from the others complicates matters, but machine learning has proven to offer a promising volcano-independent forecasting method. It appears that AI speeds up data collection and analysis while accounting for the range of heterogeneity held by each natural disaster and circumstance in Andhra Pradesh.

Monitoring and detection using AI for data

The difficulty of dealing with extreme weather shifts is related to global food insecurity. The Joint Research Centre (JRC) of the European Commission in Italy, where Andrea Toreti is a Senior Scientist/Scientific Officer, demonstrated how AI can help track weather-related risks to food security. With the aid of climate variability models, he developed the "Climate Service," a system intended to support informed choices able to reduce risks and disaster-related risks to agriculture. The Climate Service is a tool for the agricultural industry to identify extreme events, such as droughts, in connection to crop productivity, for instance. He is adamant that for technology to have an effect, it must be computationally scalable and sustainable.

The presence or overabundance of locusts poses a threat to food security, particularly in West Africa, where crop damage is believed to have cost $2.5 billion between 2003 and 2005 alone. According to Hadia Samil, a researcher at the MILA Quebec Artificial Intelligence Institute, these statistics are concerning. By analysing remote sensing images, AI can be used to identify locust attacks in "real time" and somewhat predict their movements.

Nicolas Longépé, Earth Observation Data Scientist, Phi-lab Explore Office, European Space Agency (ESA/ESRIN), concludes by pointing out the drawbacks of AI while highlighting how, due to the associated unpredictability of the models, it can identify circumstances that are occurring "near real time." One of the primary study goals of the European Space Agency is the detection of tropical cyclones using a visual pattern analyst on satellite images and atmosphere clouds. The Agency also concentrates on the use of hyperspectral data for wildfire monitoring. AI at the edge, also known as "AI@edge," is one of the technologies currently in use. With this technology, AI is deployed directly on the spacecraft, increasing its security, versatility, responsiveness, and minimal data exchange requirements with the user. There are new possibilities for AI in space and related technologies, which could also have practical applications in the identification, evaluation, and eventual mitigation of disaster risk.

Modernization of the system for data collection and transmission

968 stations in different river basins were to have real-time data acquisition systems installed, according to CWC's plans. Work is currently underway on a plan to expand the coverage under the 14th Finance Commission period by an additional 125 stations. By 2025, an additional 100 stations will be added, bringing the total number of automated sensor-based data acquisition and satellite-based data transmission stations to approximately 1193. IMD plans to expand its Automatic Weather Station (AWS)/Automatic Rain Gauge (ARG) Network, which can also be used by mutual sharing for use in Mathematical models for flood forecasting, in addition to the 1193 stations that CWC will create by 2025. In addition, many State Governments are placing automatic telemetry-based water level/reservoir level and rain gauge sensors in different river basins within their State as part of the National Hydrology Project (NHP). The National Water Information Center (NWIC)/Water Information Management System (WIMS) portal may also have access to these statistics. For use in mathematical modelling for flood predictions, all of these stations can be used in real time. In the ensuing years, this will greatly expand the country's hydro-meteorological data network coverage for use in real-time flood predictions. It is also necessary to develop a straightforward data dissemination policy for the States to use when using data, especially when it comes to trans-boundary rivers.

5.16. MODERNIZATION OF PREDICTION RELEASE

Since 2006, CWC has been updating and improving its user-friendly flood warning website, which has been in use ever since. The Water Information Management System (WIMS) is being used to further improve this, and improved data entry, report generation, and user-friendly web functions are all anticipated outcomes. Additionally, CWC and M/s Google are collaborating to create the Common Alerting Protocol (CAP), which will be used starting in 2015 to distribute flood forecasting information from CWC to the general public in the affected regions via Google-enabled Android smartphones or other Google platforms. The National Disaster Management Authority is creating its own CAP warning systems through the MoCIT's Centre for Development of Telematics (C-DoT), which will allow priority call routing from the relevant mobile towers. Alerts may also be aired on radio and television. Tamil Nadu has started testing the method as a pilot since March 2020. Additionally, CWC and M/s Google Inc. are working together to offer flood warnings based on the flood forecast provided by the CAP platform using high-quality digital terrain models that Google has access to using artificial intelligence and machine learning. When inundation warnings were made available to the forecast sites at Patna Gandhighat in 2018, the system officially began operation. Ayodhya in Uttar Pradesh, Neamatighat, Tezpur, Guwahati, and Goalpara in Assam, and Patna Gandhighat and Kahalgaon in Bihar have all been added to this in 2019. It has also been extended to approximately 11,000 sq.km. in total, covering 7 FF stations. Over the following few years, it is probable that all level forecast stations will be covered.

CHAPTER 6

DATA ANALYSIS, ASSESSMENTS AND FINDINGS

Chapter 6 empirical study

In this research the researcher conducted a survey by formulating a questionnaire containing a total of 15-20 questions relating to AI, disaster management, from 3 set of people coming from different backgrounds. The 1st questionnaire was for the people working different authorities like government employee and others. A total of 63 responses were collected over a period of 20 days where 68.3% are people working as a government employee and renaming people worked under different authorities.

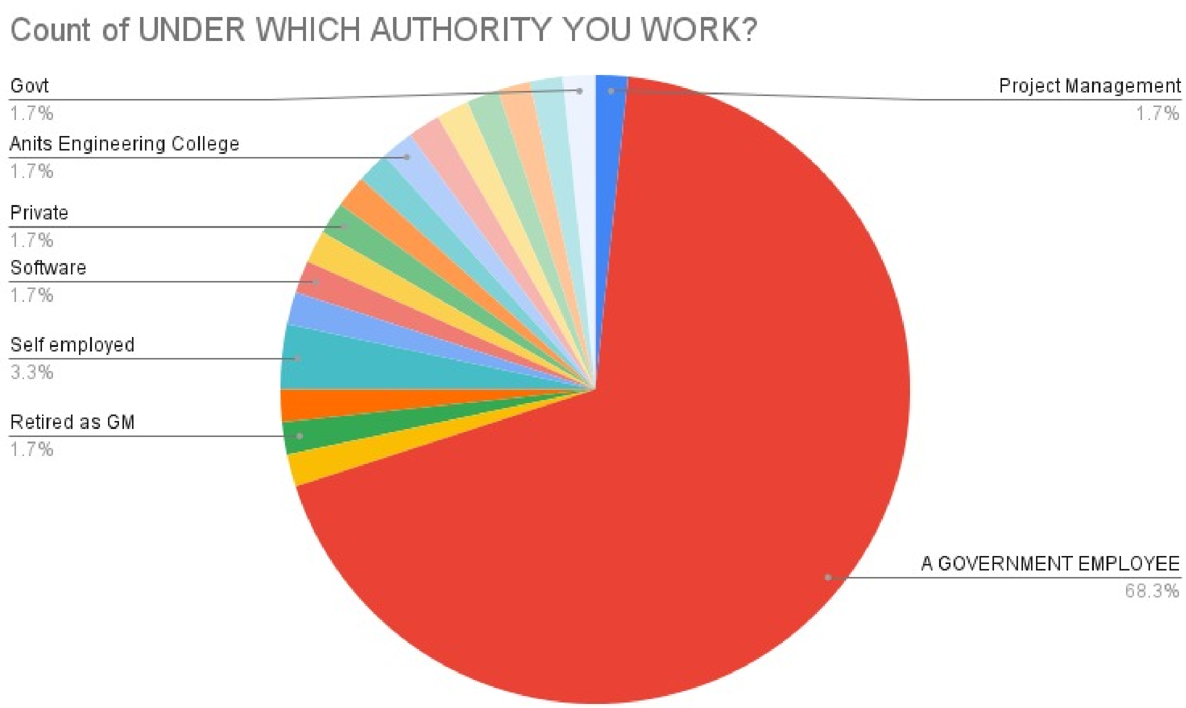
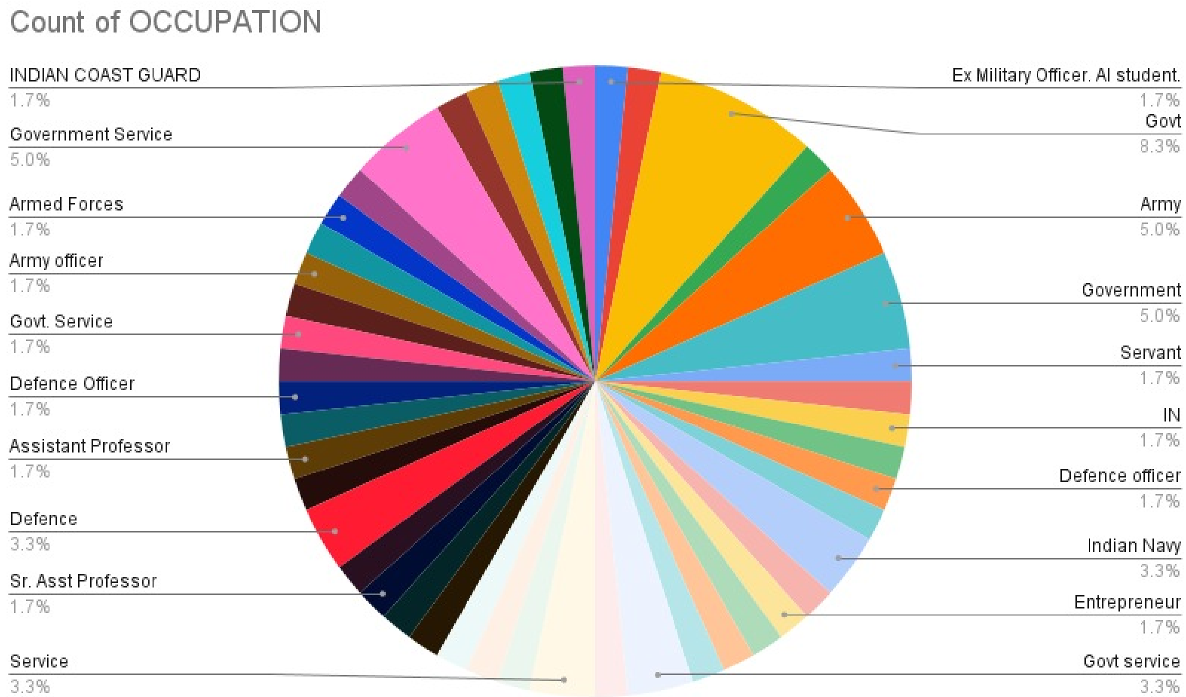


Fig: Authorities people work under



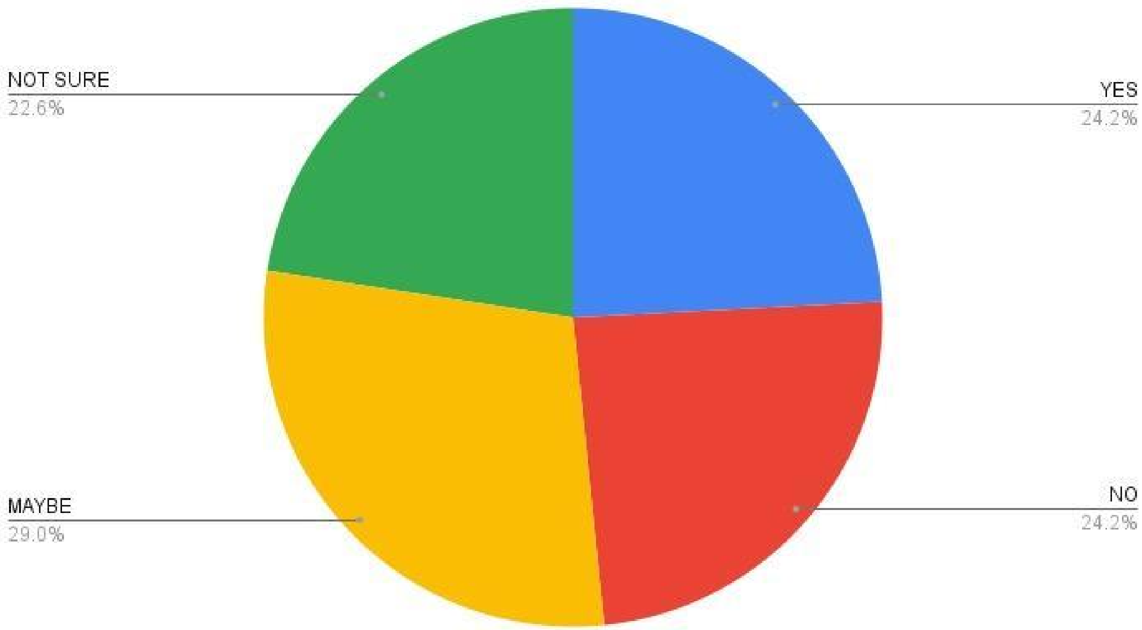
Questionnaire 1

Q1. Are there artificial intelligence based system in disaster risk reduction strategies?

From Graph/figure we can infer that artificial intelligence based system in disaster risk reduction strategies may or may not be there in India, since the number of people who have given their response indicates the same. The graph shows that people have disagreed and somewhat agreed with the question posed with the options provided as to yes, no, maybe, not sure. Amongst the responses 24.2 % people voted for yes, 24.2% people for no, 29% people for maybe, 22.6% people for not sure. Out of 63 people surveyed, 15 said the yes 15 have said no, 18 said maybe, 14 were not sure.

It can be inferred that most of the people are either confused and not sure about the AI bases system available for disaster risk reduction strategies. It is clear that more such systems must be brought into action to curb the disaster.

Q1. FIG1. Are there artificial intelligence based system in disaster risk reduction strategies?

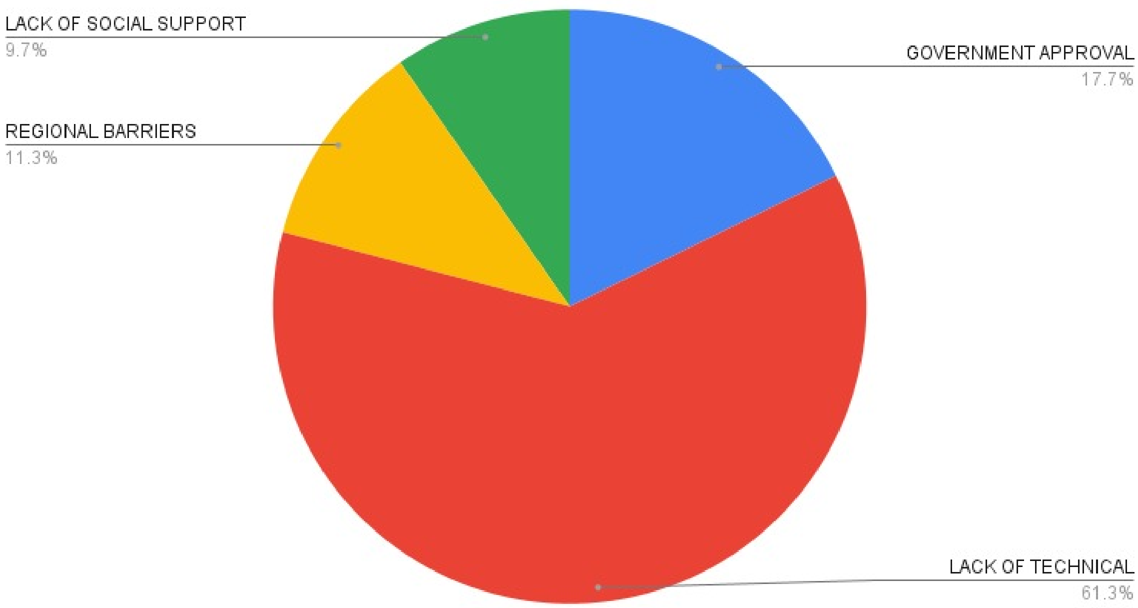


Q2. In your opinion, what are the hindrances in preparing proper expert system of target alert framework system which aims to aid disaster management?

From Graph/figure we can infer that lack of technical support is the major hindrances in preparing a proper expert system of target alert framework system which aims to aid disaster management, since the number of people who have given their response indicates the same. The graph shows that people have given mixed responses to the question posed with the options provided as to lack of social support, government approval, regional barrier, lack of technical support. Amongst the responses 61 % people voted for lack of technical support as the reason for the hinderance, 17.7% people for government approval, 11.3% people for regional barriers, 9.7% people for lack of social support.

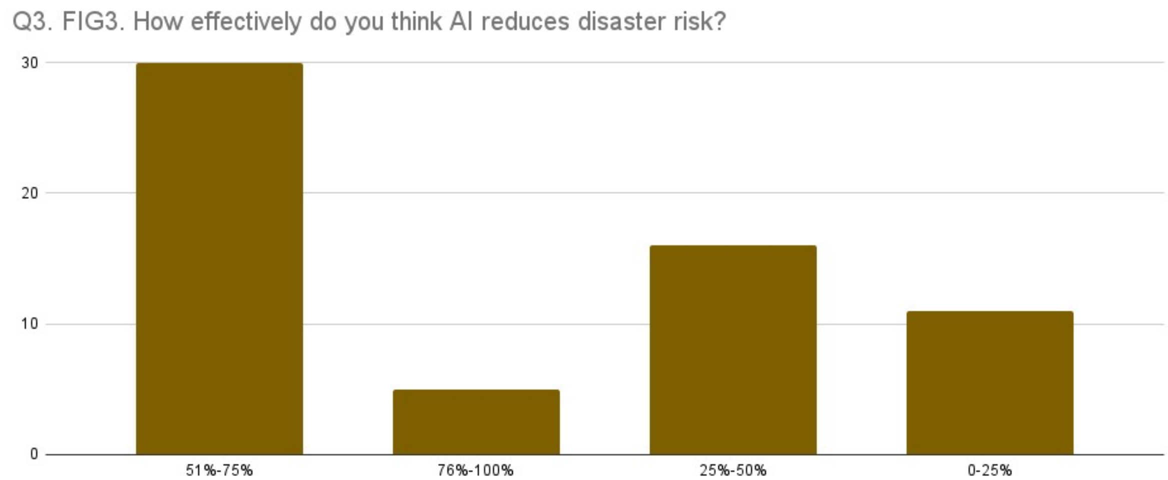
It can be inferred that most of the people agree to the lack of technical support in constructing a suitable expert system for the target alert framework system intended to assist disaster management.

Q2. FIG.2 In your opinion, what are the hindrances in preparing proper expert system of target alert framework system which aims to aid disaster management?



Q3. How effectively do you think AI reduces disaster risk?

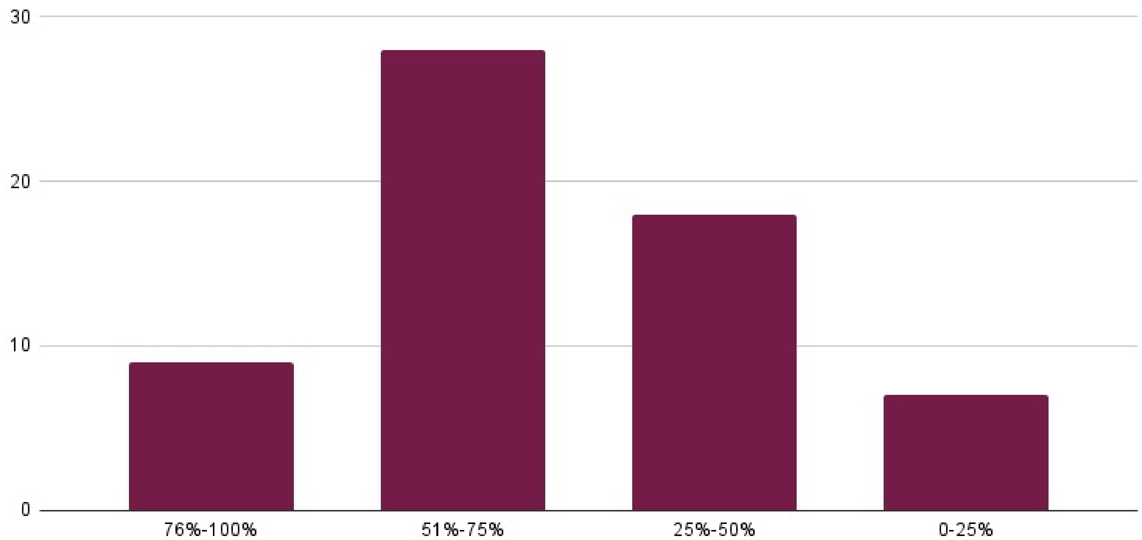
From Graph/figure we can infer that AI is useful to reduce disaster risk, since the number of people who have given their response indicates the same. The graph shows that people have given mixed responses to the question posed with the options provided as to the % of effectiveness on a scale of 0-25%, 25-50%, 51-75%, 76-100%, where 0-25% means effective to some extent and it goes to 76-100% in a increasing order which means AI is most effective to reduce disaster risk. Amongst the responses, 11 people voted for 0-25%, 16 people for 25%-50%, 30 people for 51%-75%, 6 people for 75-100%.



Q4. How effectively machine learning approaches improve forecasting of various natural disasters?

From Graph/figure we can infer that machine learning approaches improve forecasting of various natural disasters, since the number of people who have given their response indicates the same. The graph shows that people have given mixed responses to the question posed with the options provided as to the % of effectiveness on a scale of 0-25%, 25-50%, 51-75%, 76-100%, where 0-25% means effective to some extent and it goes to 76-100% in a increasing order which means machine learning approaches improve forecasting of various natural disaster to a great extent. Amongst the responses, 9 people voted for 0-25%, 18 people for 25%-50%, 28 people for 51%-75%, 8 people for 75-100%.

Q4. FIG 4. How effectively machine learning approaches improve forecasting of various natural disasters?

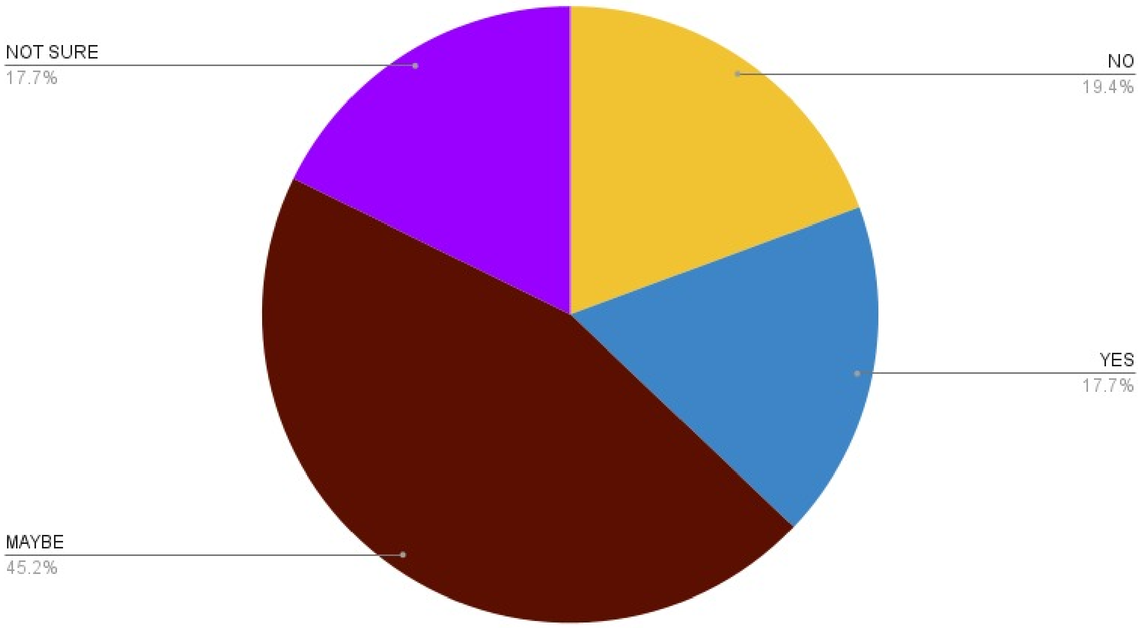


Q5. Are there drawbacks of detecting any disaster through AI ?

From Graph/figure we can infer that there maybe drawbacks of detecting any disaster through AI, since the number of people who have given their response indicates the same. The graph shows that people have disagreed and somewhat agreed with the question posed with the options provided as to yes, no, maybe, not sure. Amongst the responses 17% people voted for yes, 19.4% people for no, 45.2% people for maybe, 17.7% people for not sure. Out of 63 people surveyed, 11 said yes, 28 responded to maybe, 12 for No and 12 for not sure.

It can be inferred that most of the people are either confused and not sure about drawbacks of detecting any disaster through AI. It is clear that more such awareness program must be carried to make people aware of such drawbacks.

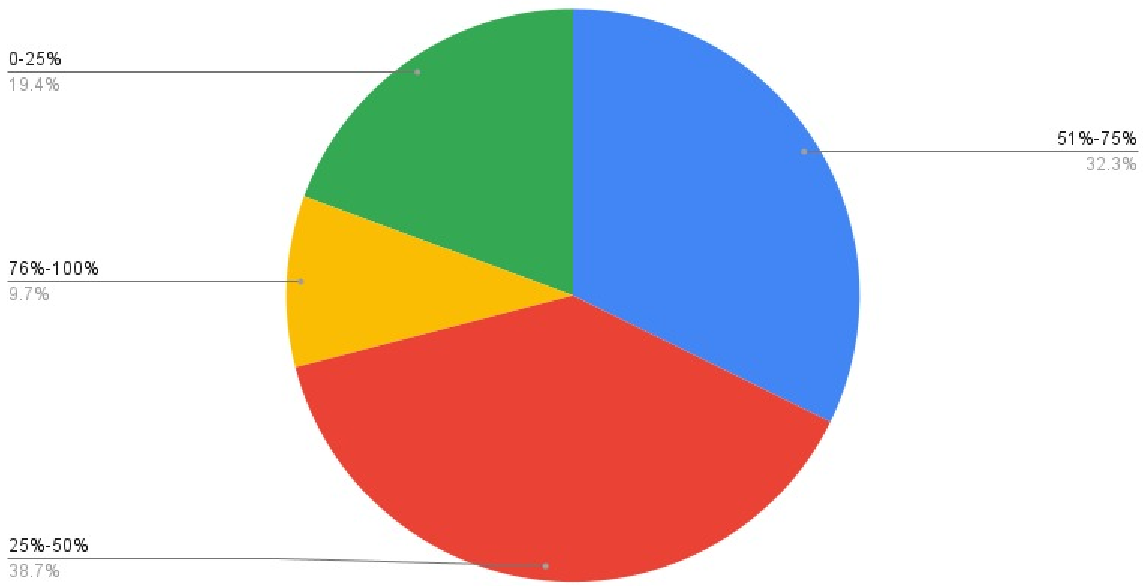
Q5. FIG.5 Are there drawbacks of detecting any disaster through AI ?



Q6. Up to what extent, it forewarns about the impending disasters detection through AI?

From Graph/figure we can infer that it forewarns about the impending disasters detection through AI to a good extent, since the number of people who have given their response indicates the same. The graph shows that people have given mixed responses to the question posed with the options provided as to the % of effectiveness on a scale of 0-25%, 25-50%, 51-75%, 76-100%, where 0-25% means effective to some extent and it goes to 76-100% in a increasing order which means machine learning approaches improve forecasting of various natural disaster to a great extent. Amongst the responses, 19.4% people voted for 0-25%, 38.7% people for 25%-50%, 32.3% people for 51%-75%, 9.7% people for 75-100%.

Q6. FIG 6. Up to what extent, it forewarns about the impending disasters detection through AI?

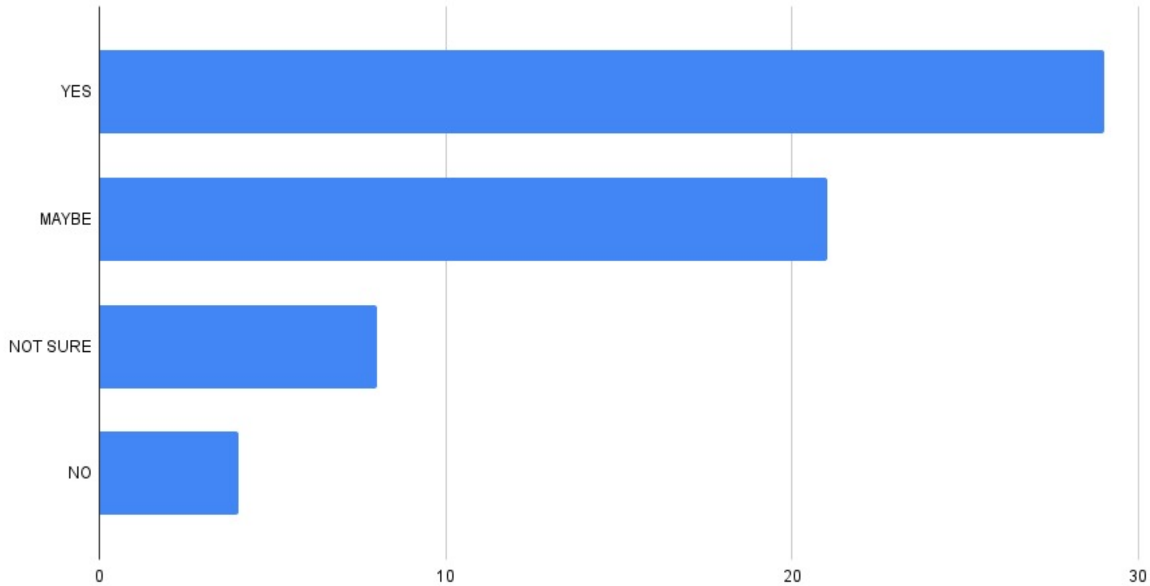


Q7. Are there any fallacies or limitations of AI? {flash floods} {network inaccessible areas}

From Graph/figure we can infer that there are fallacies or limitations of AI, since the number of people who have given their response indicates the same. The graph shows that most of the people have agreed and somewhat have disagreed with the question posed with the options provided as to yes, no, maybe, not sure. Amongst the responses 29 people voted for yes, 4 people for no, 21 people for maybe, 9 people for not sure.

It can be inferred that most of the people have voted for yes that shows there are allacies or limitations of AI in flash floods cases and network inaccessible areas.

Q7. FIG 7. Are there any fallacies or limitations of AI? {flash floods} {network inaccessible areas}

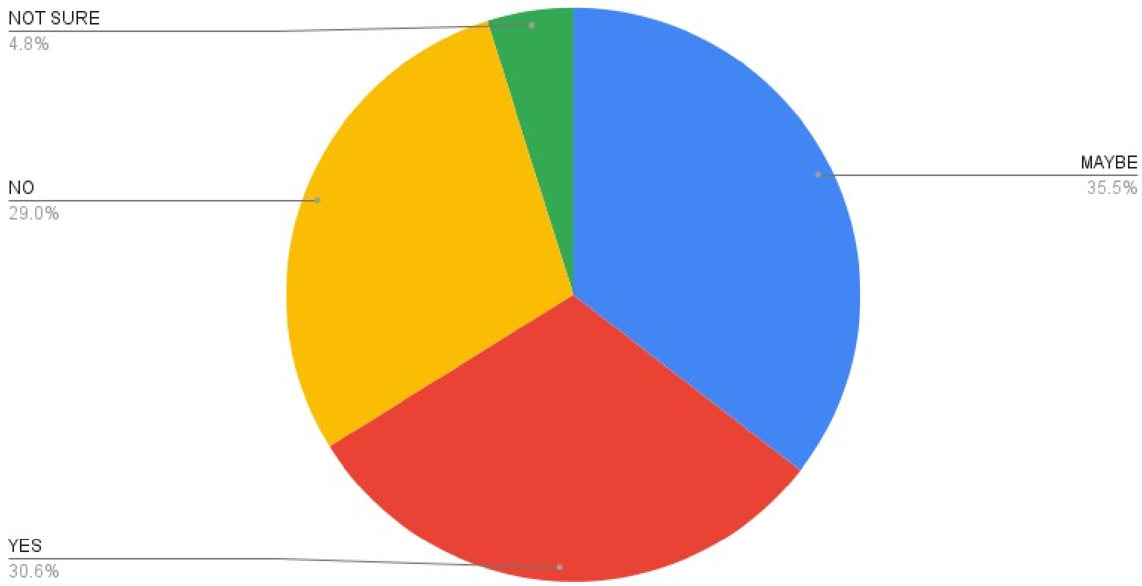


Q8. Does lessening of human intervention due to AI and ML causes inadequate on-site observation networks?

From Graph/figure we can infer that lessening of human intervention due to AI and ML causes inadequate on-site observation networks, since the number of people who have given their response indicates the same. The graph shows that most of the people have agreed and somewhat have disagreed with the question posed with the options provided as to yes, no, maybe, not sure. Amongst the responses 30.6% people voted for yes, 35.5% people for maybe, 29% people for no, 4.8% people for not sure. Out of 63 people surveyed, 19 said yes, 22 responded to maybe, 18 for No and 4 for not sure.

It can be inferred that most of the people are mostly sure about the lessening of human intervention due to AI and ML causes inadequate on-site observation networks. It is clear that a balance must be maintained between the two.

Q8. FIG 8. Does lessening of human intervention due to AI and ML causes inadequate on-site observation networks?

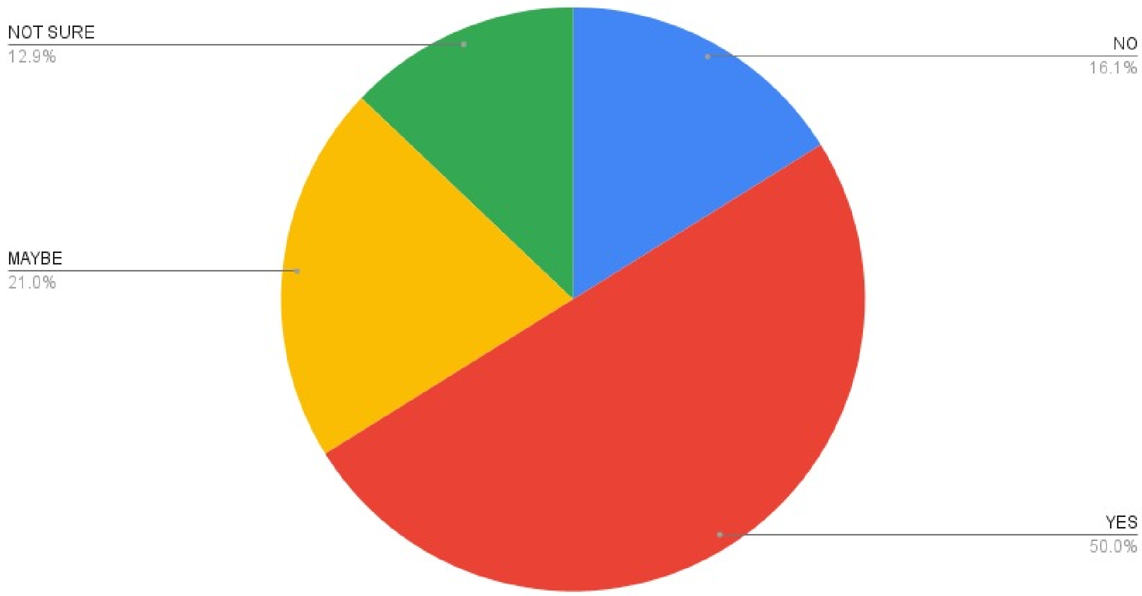


Q9. Does data collection and handling of AI data requires some prerequisite considerations such as ethical issues, biasness etc.?

From Graph/figure we can infer that data collection and handling of AI data requires some prerequisite considerations such as ethical issues, biasness etc, since the number of people who have given their response indicates the same. The graph shows that most of the people have agreed and somewhat have disagreed with the question posed with the options provided as to yes, no, maybe, not sure. Amongst the responses 50% people voted for yes, 21% people for maybe, 16.1% people for no, 12.9% people for not sure. Out of 63 people surveyed, 31 said yes, 13 responded to maybe, 10 for No and 9 for not sure.

It can be inferred that data collection and handling of AI data requires some prerequisite considerations such as ethical issues, biasness etc.

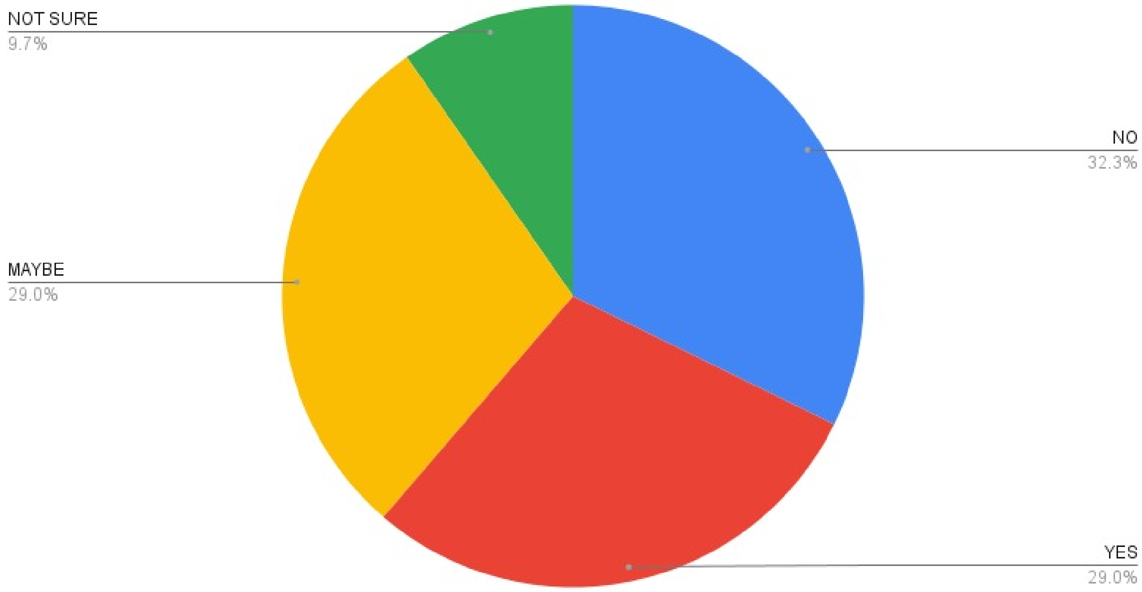
Q9. FIG 9. Does data collection and handling of AI data requires some prerequisite considerations such as ethical issues, biasness etc.?



Q10. Does underrepresentation of humans in this AI based expert system ((in disaster risk reduction)), causes any potential harm?

From Graph/figure we can infer that underrepresentation of humans in this AI based expert system ((in disaster risk reduction)), may cause potential harm, biasness etc, since the number of people who have given their response indicates the same. The graph shows that most of the people have agreed and somewhat have disagreed with the question posed with the options provided as to yes, no, maybe, not sure. Amongst the responses 29% people voted for yes, 29% people for maybe, 32.3% people for no, 9.7% people for not sure. Out of 63 people surveyed, 18 said yes, 18 responded to maybe, 20 for No and 7 for not sure.

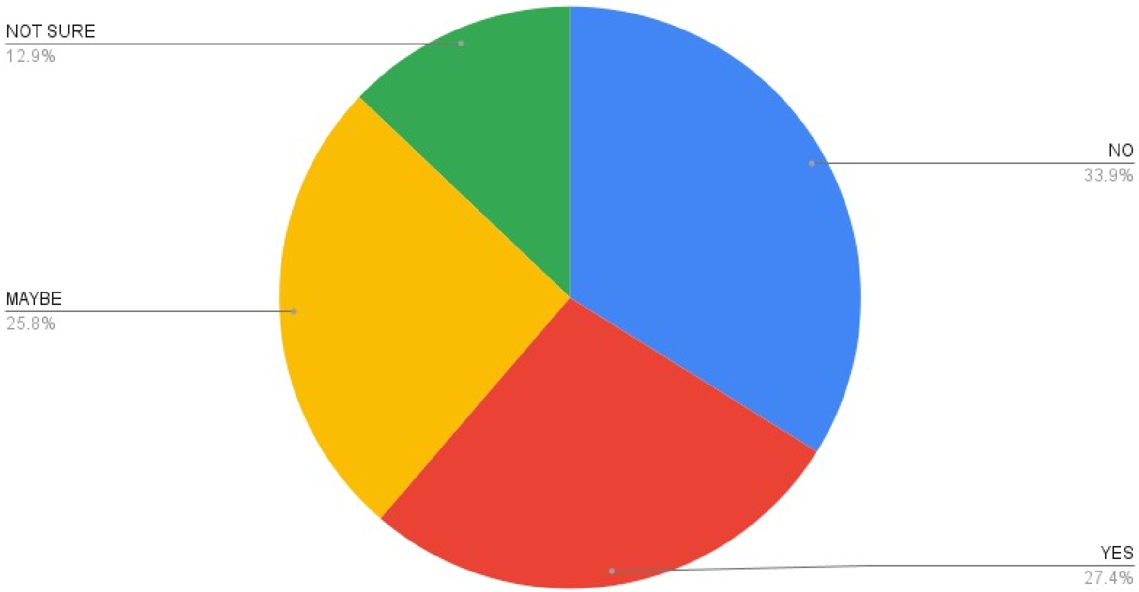
Q10. FIG 10 Does underrepresentation of humans in this AI based expert system (in disaster risk reduction), causes any potential harm?



Q11. Whether the Sensor Networks for Flood Detection are sufficient in providing early signals relating to flood?

From Graph/figure we can infer that the Sensor Networks for Flood Detection are to somewhat extent sufficient in providing early signals relating to flood, since the number of people who have given their response indicates the same. The graph shows that most of the people have agreed and somewhat have disagreed with the question posed with the options provided as to yes, no, maybe, not sure. Amongst the responses 27.4% people voted for yes, 25.8% people for maybe, 33.9% people for no, 12.9% people for not sure. Out of 63 people surveyed, 17 said yes, 16 responded to maybe, 22 for No and 8 for not sure.

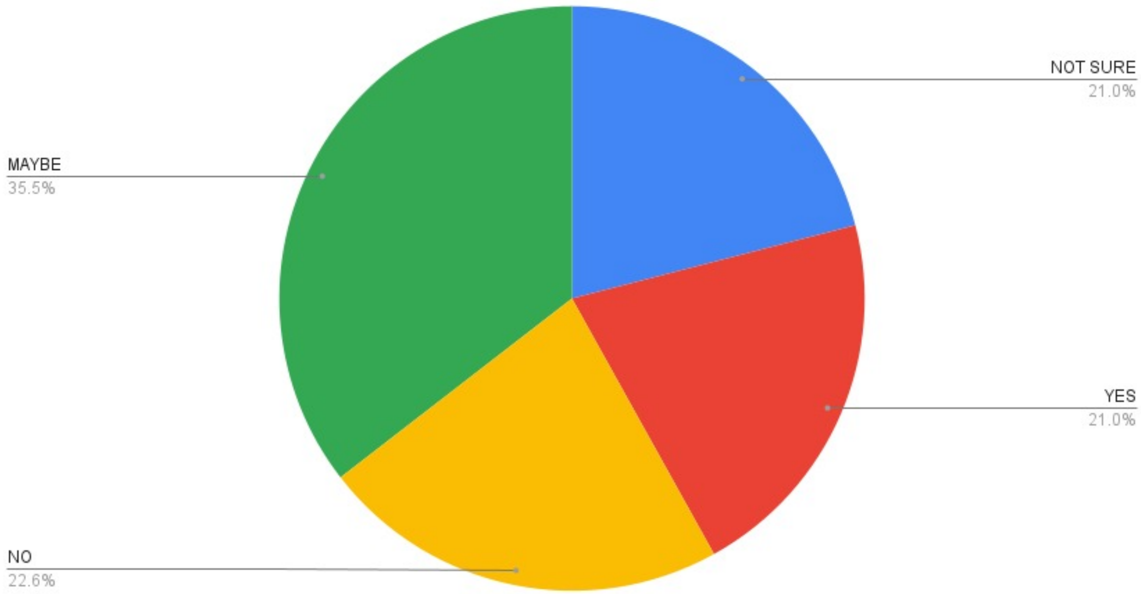
Q11. FIG 11. Whether the Sensor Networks for Flood Detection are sufficient in providing early signals relating to flood?



Q12. What do you think the application of advanced global navigation satellite system (GNSS) have any impediments as well?

From Graph/figure we can infer that most of the people are unsure about the application of advanced global navigation satellite system (GNSS) have any impediments as well, since the number of people who have given their response indicates the same. The graph shows that most of the people have agreed and somewhat have disagreed with the question posed with the options provided as to yes, no, maybe, not sure. Amongst the responses 21% people voted for yes, 35.5% people for maybe, 22.6% people for no, 21% people for not sure. Out of 63 people surveyed, 13 said yes, 22 responded to maybe, 15 for No and 13 for not sure.

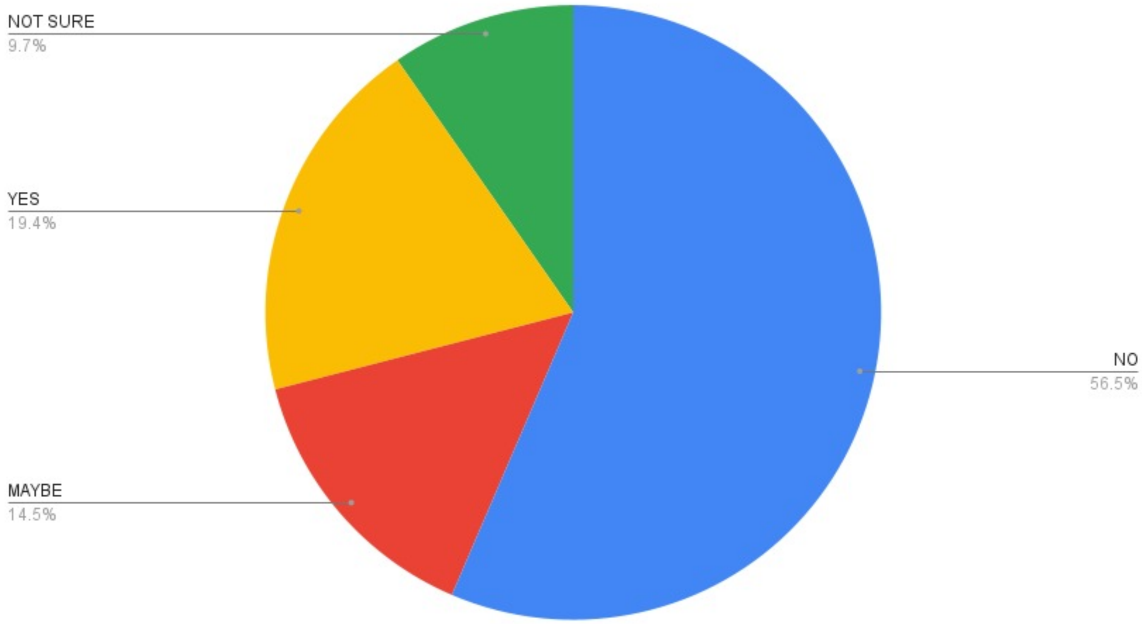
Q12. FIG 12 What do you think the application of advanced global navigation satellite system (GNSS) have any impediments as well?



Q13. Whether the existing National resources are sufficient to combat disasters?

From Graph/figure we can infer that no the existing National resources are not sufficient to combat disasters, since the number of people who have given their response indicates the same. The graph shows that most of the people have agreed and somewhat have disagreed with the question posed with the options provided as to yes, no, maybe, not sure. Amongst the responses 19.4% people voted for yes, 14.5% people for maybe, 56% people for no, 9.7% people for not sure.

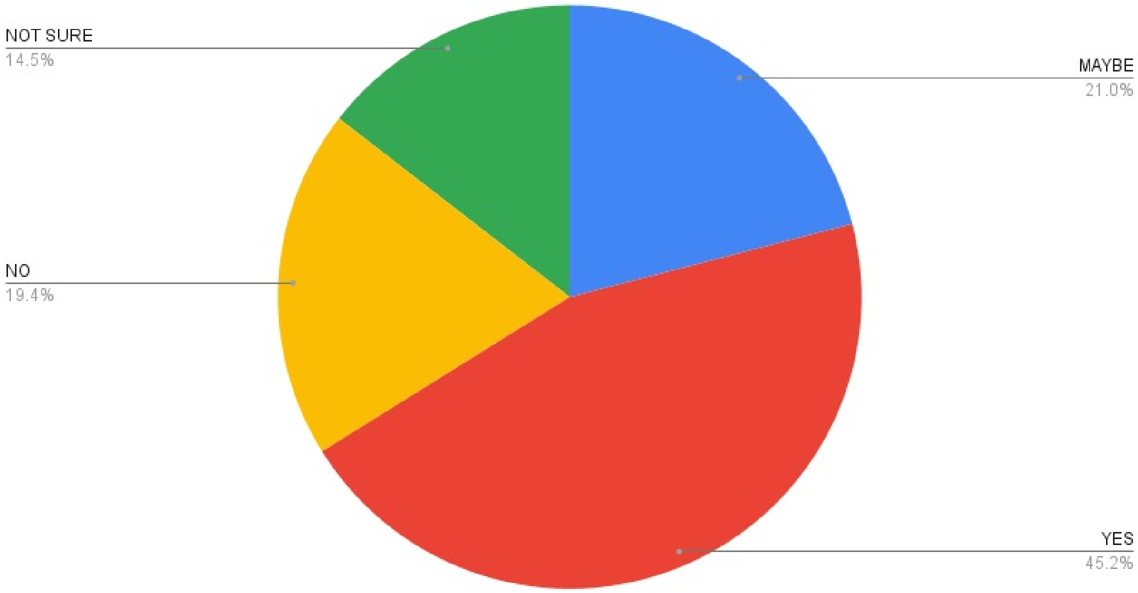
Q13. FIG 13 Whether the existing National resources are sufficient to combat disasters?



Q14. Whether the organizational characteristics enable an organization to effectively and efficiently alleviate human suffering in the event of a natural disaster?

From Graph/figure we can infer that yes the organizational characteristics enable an organization to effectively and efficiently alleviate human suffering in the event of a natural disaster, since the number of people who have given their response indicates the same. The graph shows that most of the people have agreed and somewhat have disagreed with the question posed with the options provided as to yes, no, maybe, not sure. Amongst the responses 45.2% people voted for yes, 21% people for maybe, 19.4% people for no, 14.5% people for not sure.

Q14. FIG 14. Whether the organizational characteristics enable an organization to effectively and efficiently alleviate human suffering in the event of a natural disaster?



Q15. What are the consequences if one fails to provide data without use of appropriate prerequisites such as giving wrong predictions or biased outcomes?

The responses collected by the people have been analyzed and the following consequences may come up if one fails to provide data without use of appropriate prerequisites such as giving wrong predictions or biased outcomes:

- In reliability will lead to lack of trust on the system
- To avert a disaster we require data of last 10 years or more to predict any disaster
- It will not give fruitful result
- System will be trained with old data
- Lack of accurate data or inaccurate predictions may delay in response
- Reliability
- Wrong predictions
- Lack of faith in the system
- Failure to detect, catastrophic consequences
- Catastrophic
- Consequences are huge loss of life
- Inaccurate responses from the system denting its credibility.
- False alarms and panic resulting in confidence level.
- Let us hope for the best. Prepare a better model for our future generations also
- Systems such framed would go Non-reliable
- Correct suggestion or predictions will not come
- Will unnecessarily initiate actions as per the SOP in the case of disasters.
- Inadequate or incorrect warnings, likely increase in adverse impact of disasters.
- It is a learning procedure in AI and ML and the inputs need rectification nothing else.
- Infidelity of data will lead to incorrect analysis leading to not achieving the desired outcomes

Q16. What is your opinion on this method of trusting machine learning and artificial intelligence that sometimes results in uncertainty in the disaster occurrence patterns of specific geographic regions?

The responses collected by the people have been analyzed and the following opinion on the method of trusting machine learning and artificial intelligence that sometimes results in uncertainty in the disaster occurrence patterns of specific geographic regions.

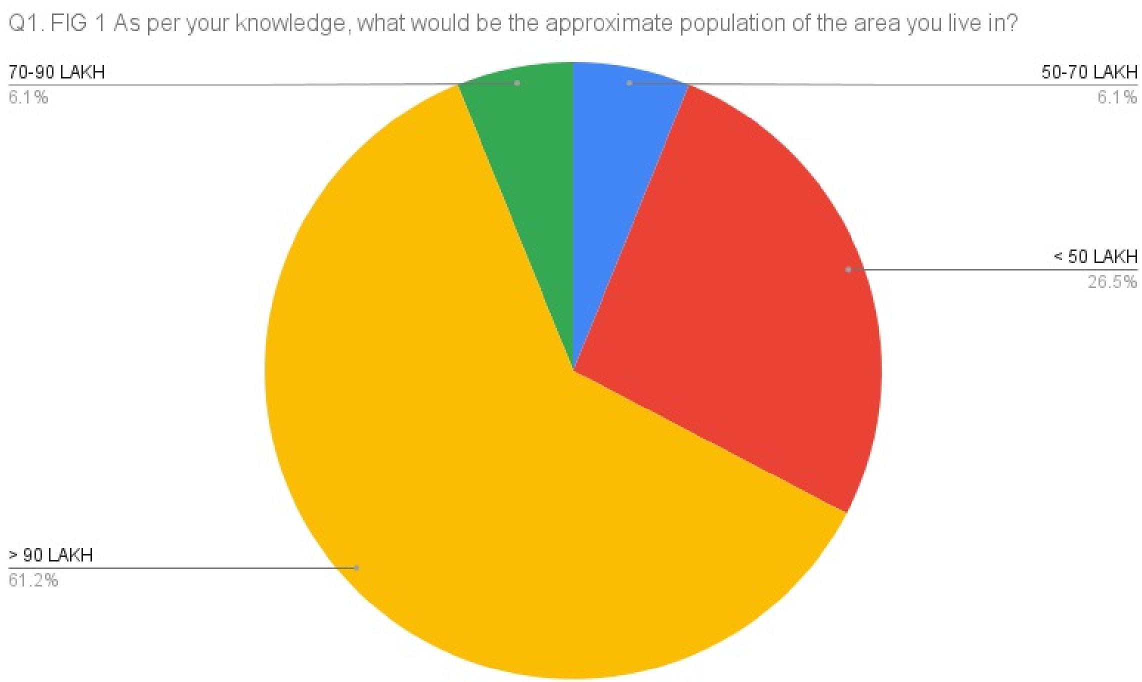
- That is where humans come to asses the details of data and predict accurately
- That has to be used as the expert system tool only , human presence is mandatory
- AI & ML can aid up to certain circumstances. Considering all aspects of natural and manmade consequences need to be incorporated in AI for getting fairly accurate results or predictions.
- Human intervention is essential
- This method will be much better than human monitoring because it will be less prone to errors and negligence
- It is definitely worth trying in a situation bereft of a credible forecasting system. With regular usage and data generation, I am confident that the reliability and accuracy can be incrementally imroved.

- It needs to be continually upgraded and improved
- Sensor/ Data based interpretation /reliability which often leads to false alarms in the seismic areas of Himalayas.
- Improve the systems before trusting them
- We should trust in this method. It is very useful to predict in disaster management. Take some remedial action before damage takes place.
- Cannot totally rely on AI based systems. Need human intervention
- AI and ML should be rigorously checked before putting out for actual use.
- It may still be of some value if correlated with other factors manually
- Modern day AI driven machines are generally dependable. However some kind of cross validation will also help to warn people about disasters.
- There will always be some amount of uncertainity when dealing with AI & ML
- Human interface is a must
- It is better to depend and imptove upon the system by ptoviding more data.
- Need to be monitored by human being, at least in the initial stages in order to prevent wrong predictions.
- AI is way forward
- Even humans err , our effort is to maximise predictions
- AI and ML should supplement other efforts
- Man and machine should work together

Questionnaire 2

The 2nd questionnaire was prepared to people living in earthquake prone areas. The responses were and collected and based on the same graphs and figures were made and the analysis has been done accordingly. A total of 50 responses were collected.

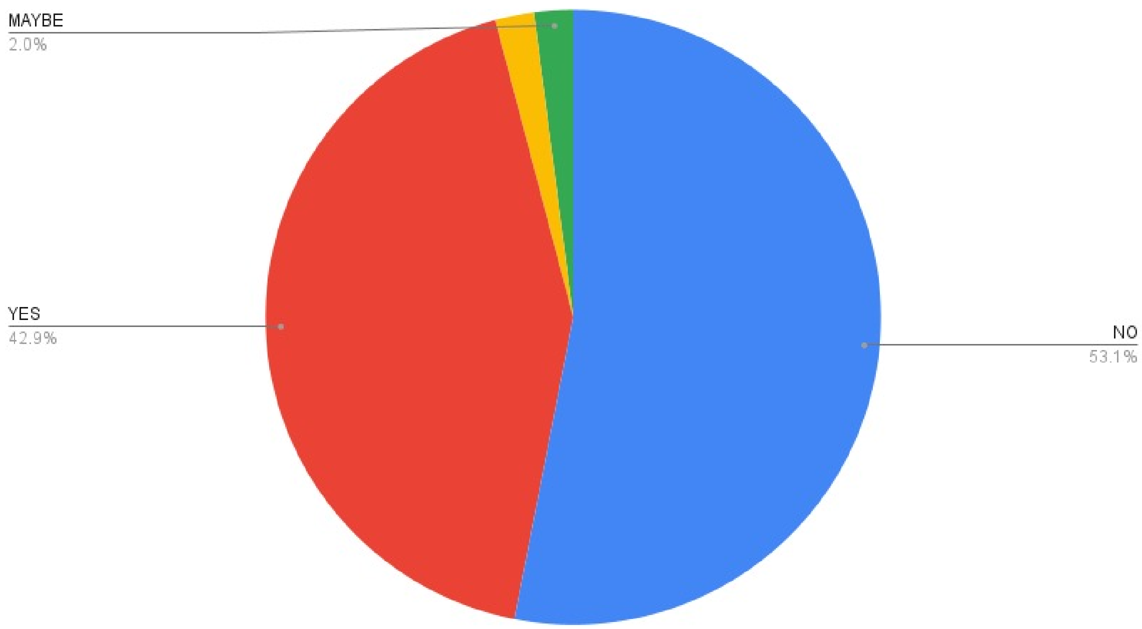
Q1. As per your knowledge, what would be the approximate population of the area you live in?



Q2. Have you experienced any (earthquake) disaster in this region?

From Graph/figure we can infer that yes almost half of the population who were interviewed did experience a (earthquake) disaster in their region, since the number of people who have given their response indicates the same. The graph shows that most of the people have agreed and somewhat have disagreed with the question posed with the options provided as to yes, no, maybe, not sure. Amongst the responses 42.9% people voted for yes, 2% people for maybe, 53.1% people for no, remaining people for not sure.

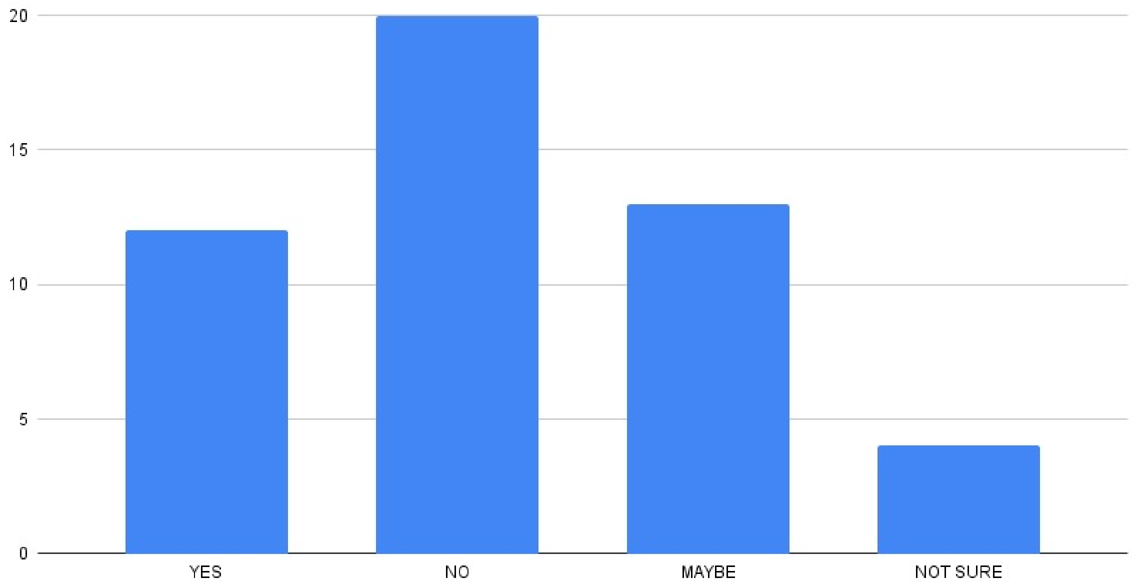
Q2. FIG 2. Have you experienced any (earthquake) disaster in this region?



Q3. Are you able to prepare yourself for a sudden occurrence of such disaster (earthquake)?

From Graph/figure we can infer that most of the population who were interviewed were not able to prepare himself for sudden occurrence of such a disaster (earthquake), since the number of people who have given their response indicates the same. The graph shows that most of the people have disagreed and somewhat have agreed with the question posed with the options provided as to yes, no, maybe, not sure. Amongst the responses 12 people said yes, 21 people said no, 13 people said may be and the remaining 4 people said they are not sure.

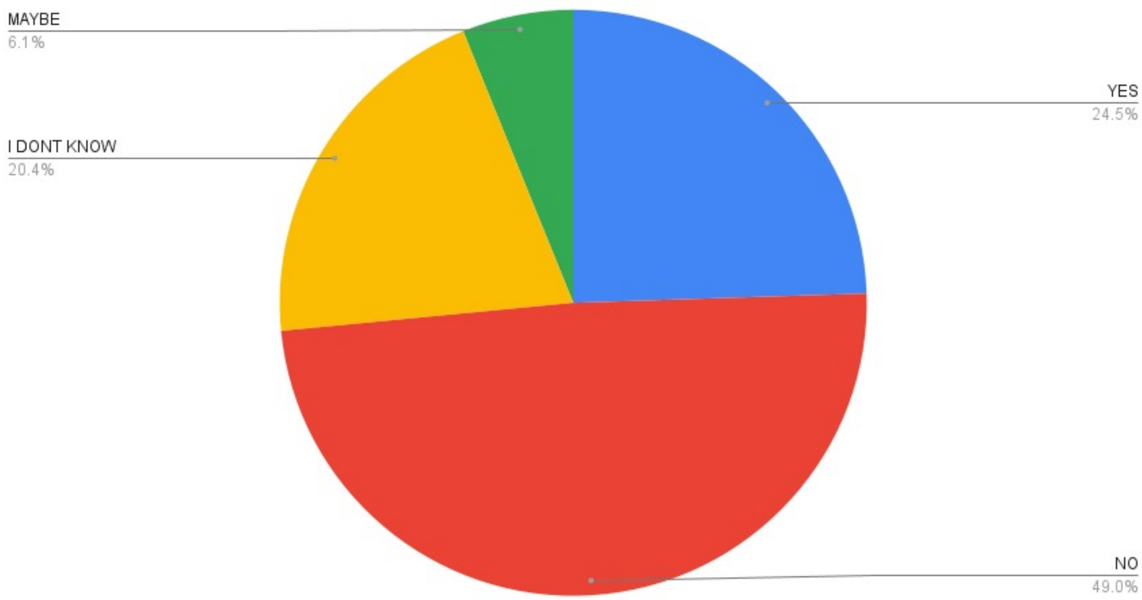
Q3. FIG 3. Are you able to prepare yourself for sudden occurrence of such disaster (earthquake)?



Q4. Is there any emergency assembly point during (earthquake) occurrence of any natural calamity in your area?

From Graph/figure we can infer that most of the population who were interviewed responded that there is no emergency assembly point during (earthquake) occurrence of any natural calamity in their area, since the number of people who have given their response indicates the same. The graph shows that most of the people have disagreed and somewhat have dagreed with the question posed with the options provided as to yes, no, maybe, i dont know. Amongst the responses 49% people voted for no, 6.1% people for maybe, 24.5% people for yes, 20.4% people for don't know

Q4. FIG 4. Is there any emergency assembly point during (earthquake) occurrence of any natural calamity in your area?



Q5. Is there any emergency assembly point during (earthquake) occurrence of any natural calamity in your area? (IF YOU KNOW THEN MENTION NAME)

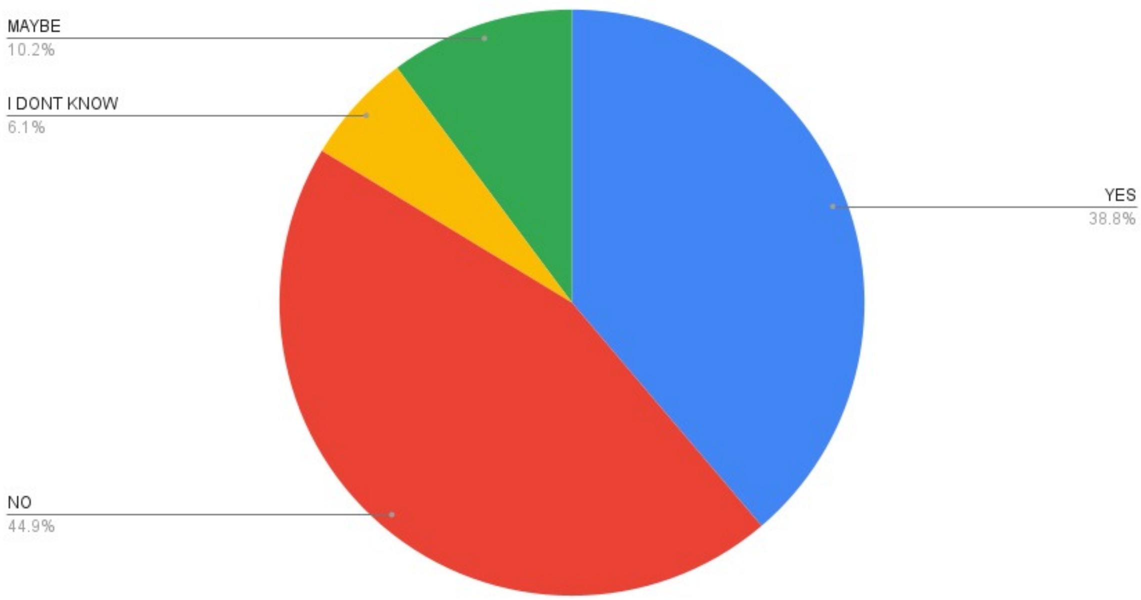
From the responses it can be inferred that most of the peopled responded to emergency assembly point during (earthquake) occurrence of any natural calamity in their area as Sports ground, Open parks, Front of building, Central park in the colony, Open ground. Most of the people even responded to dont know, no idea and all.

Q6. As this is the DISASTER prone area, are you people properly trained for (earthquake) disaster management skill? Do you think it really helps?

From Graph/figure we can infer that most of the population who were interviewed responded that they don't find the training provided to them for earthquake disaster management skills helpful, since the number of people who have given their response indicates the same. The graph shows that most of the people have disagreed and somewhat have dagreed with the question posed with the options provided as to yes, no, maybe, i dont know. Amongst the responses

44.9% people voted for no, 98.8% people for yes, 10.2% people for maybe, 6.1% people for don't know.

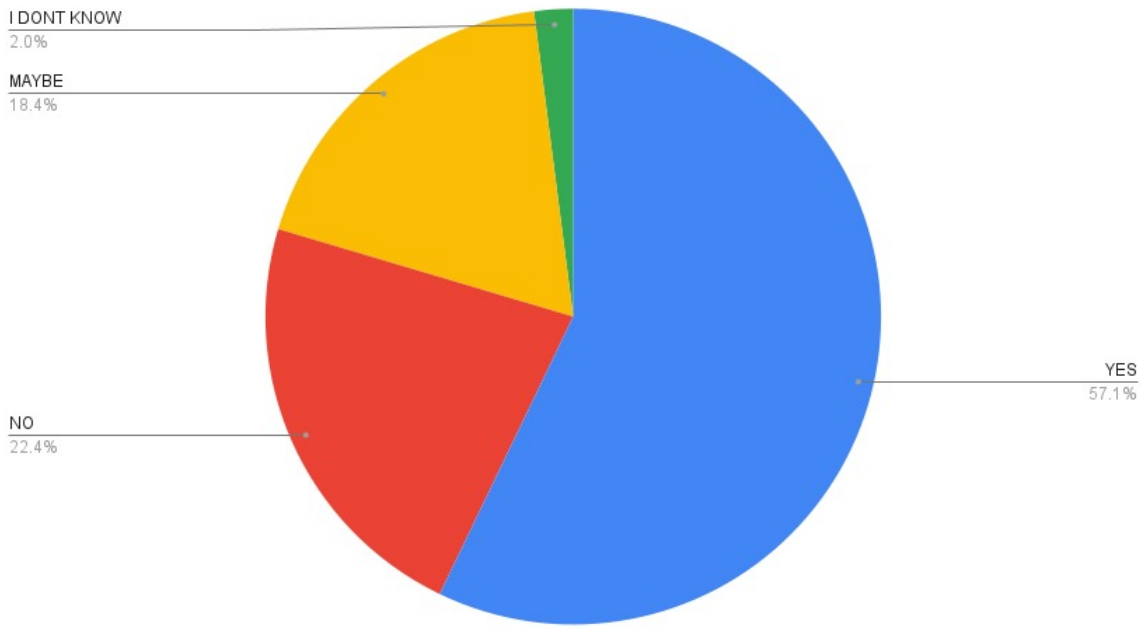
Q6. FIG 6. As this is the DISASTER prone area, are you people properly trained for (earthquake) disaster management skill? Do you think it really helps?



Q7. Are you aware of earthquake safe building technology and practices?

From Graph/figure we can infer that most of the population who were interviewed responded that they are not aware of earthquake safe building technology and practices, since the number of people who have given their response indicates the same. The graph shows that most of the people have agreed and somewhat have disagreed with the question posed with the options provided as to yes, no, maybe, i dont know. Amongst the responses 22.4% people voted for no, 57.1% people for yes, 18.4% people for maybe, 2% people for don't know.

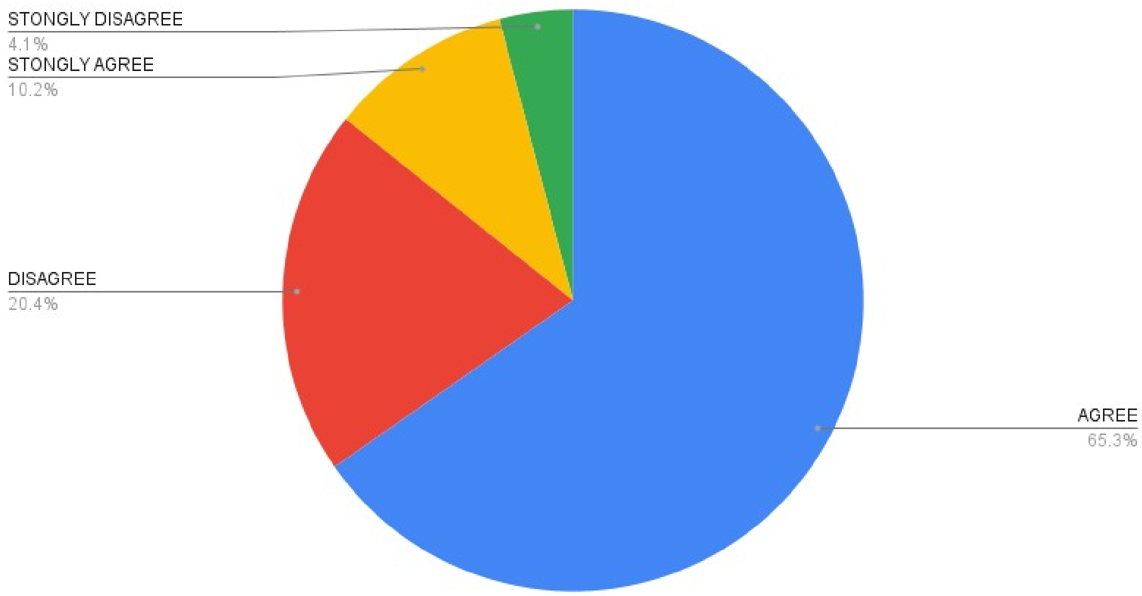
Q7. FIG 7. Are you aware of earthquake safe building technology and practices?



Q8. Do you think that there is non-competency of government and other organization in releasing funds to meet the full material requirement in any disaster?

From Graph/figure we can infer that most of the population who were interviewed responded that they are of the opinion that there is non-competency of government and other organization in releasing funds to meet the full material requirement in any disaster, since the number of people who have given their response indicates the same. The graph shows that people have agreed and somewhat disagreed with the question posed where the options are strongly disagree, disagree, agree, strongly agree. Amongst the responses 65.3% people voted for agree, 20.4% people for disagree, 10.2% people for strongly agree, 4.1% people for strongly disagree.

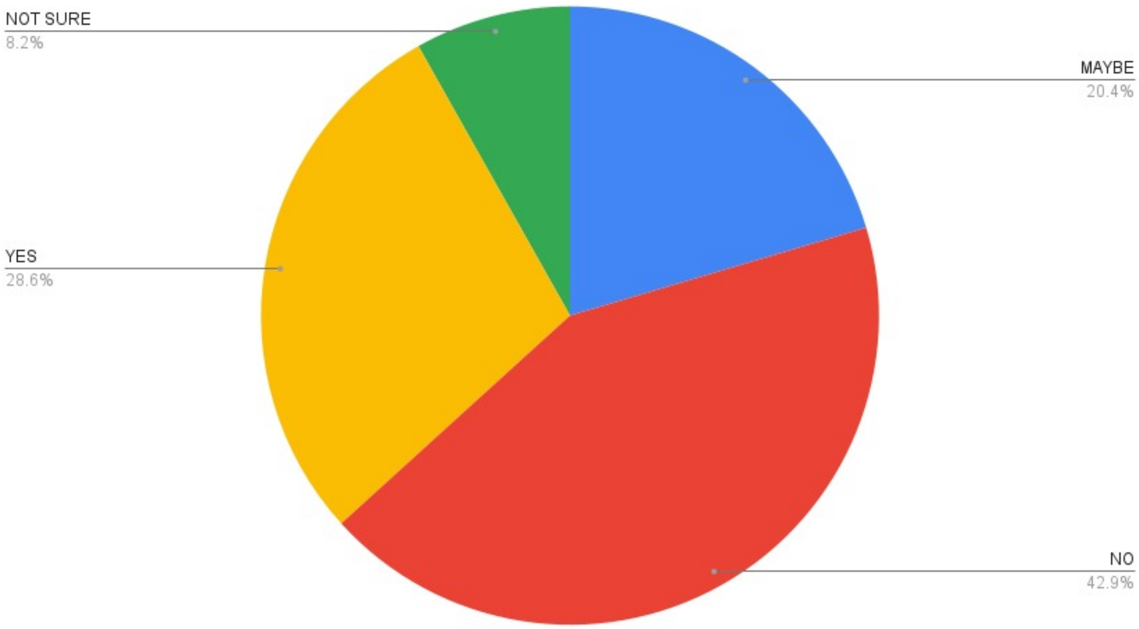
Q8. FIG 8. Do you think that there is non-competency of government and other organization in releasing funds to meet the full material requirement in any disaster?



Q 9. Whether the existing National resources are sufficient to combat disasters?

From Graph/figure we can infer that most of the population who were interviewed responded that the existing national resources are not sufficient to combat disasters, since the number of people who have given their response indicates the same. The graph shows that most of the people have disagreed and somewhat have agreed with the question posed with the options provided as to yes, no, maybe, not sure. Amongst the responses 42.9% people voted for no, 28.6% people for yes, 20.4% people for maybe, 8.2% people for not sure.

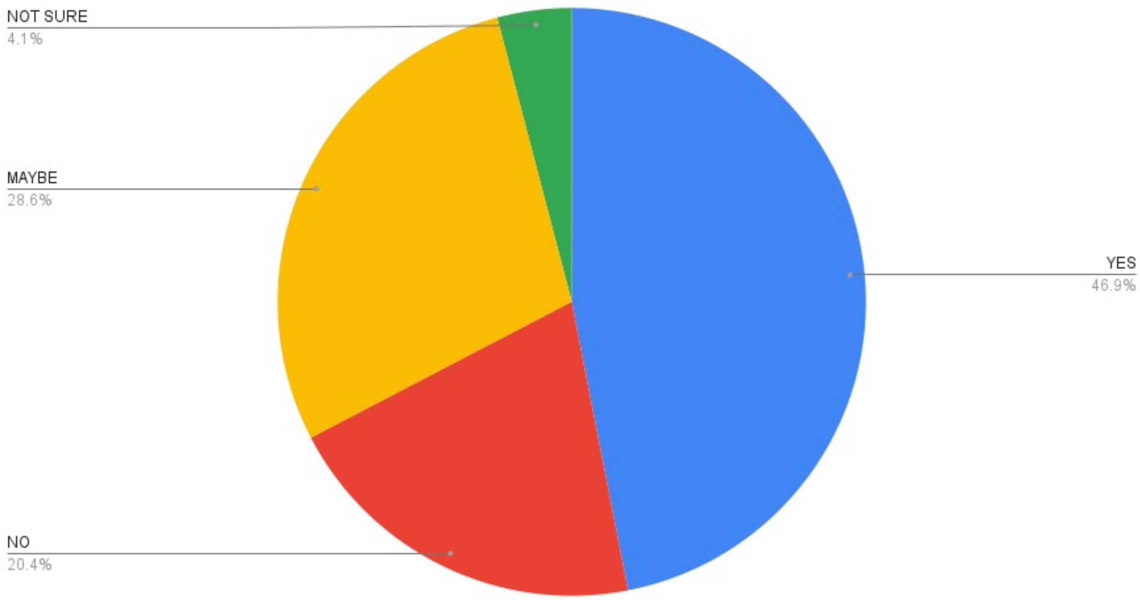
Q9. FIG 9. Whether the existing National resources are sufficient to combat disasters?



Q10. Whether the organizational characteristics enable an organization to effectively and efficiently alleviate human suffering in the event of a natural disaster?

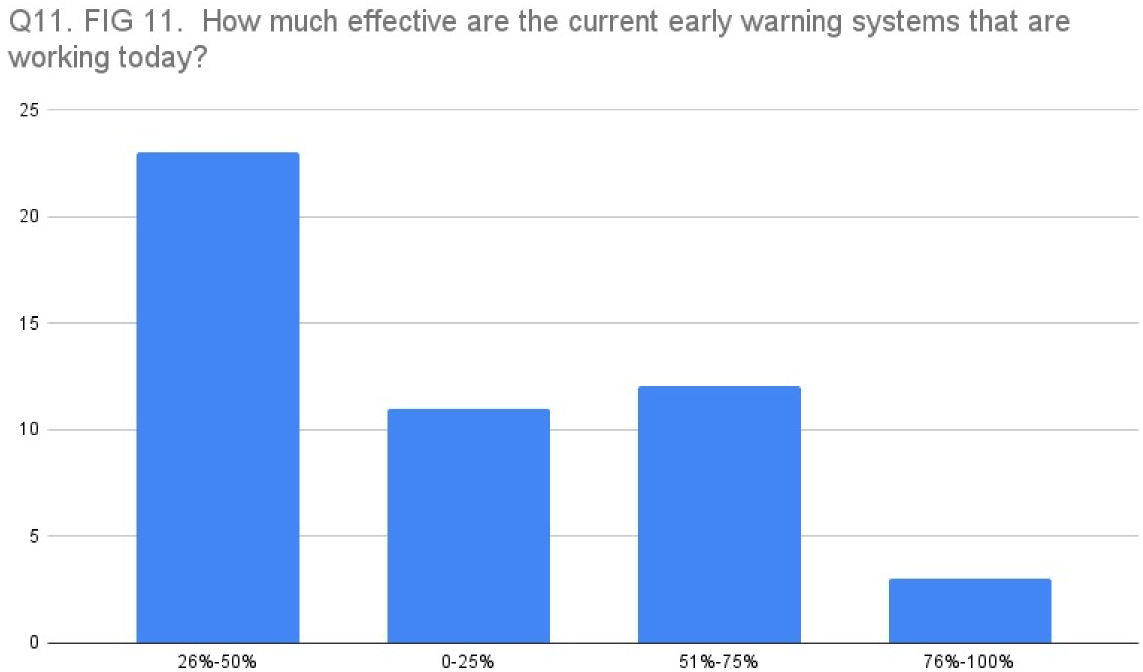
From Graph/figure we can infer that most of the population who were interviewed responded that yes **the organizational characteristics enable an organization to effectively and efficiently alleviate human suffering in the event of a natural disaste**, since the number of people who have given their response indicates the same. The graph shows that most of the people have disagreed and somewhat have agreed with the question posed with the options provided as to yes, no, maybe, not sure. Amongst the responses 46.9% people voted for yes, 20.4% people for no, 28.6% people for maybe, 4.1% people for not sure.

Q10. FIG 10. Whether the organizational characteristics enable an organization to effectively and efficiently alleviate human suffering in the event of a natural disaster?



Q11. How much effective are the current early warning systems that are working today?

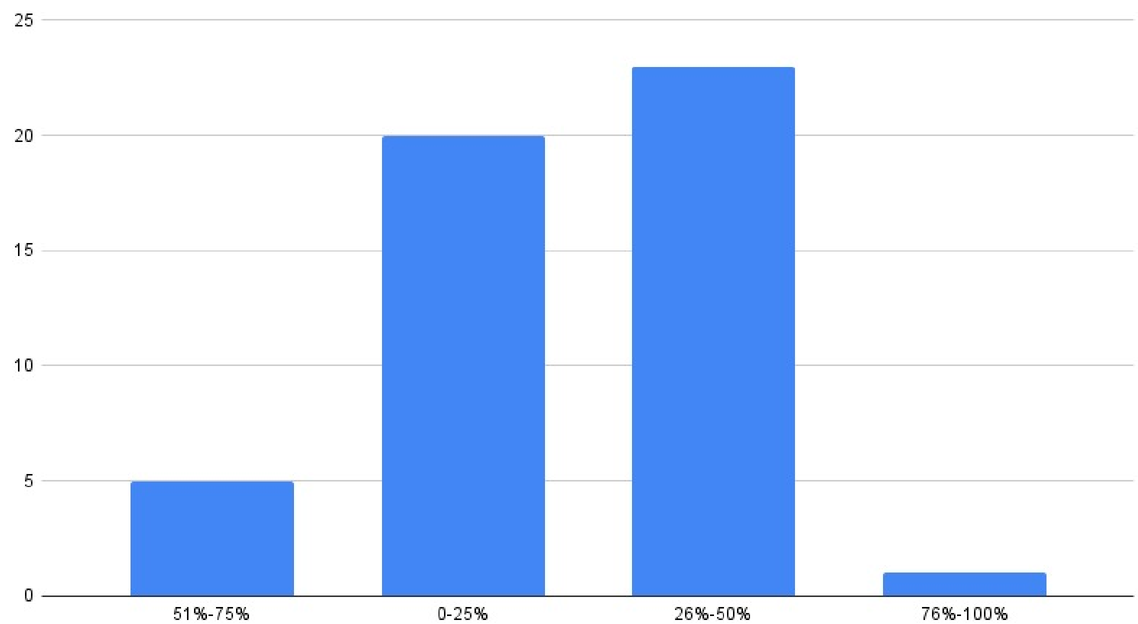
From Graph/figure we can infer that most of the population who were interviewed responded that yes the current early warning systems that are working today are somewhat effective, since the number of people who have given their response indicates the same. The graph shows that people have given mixed responses to the question posed with the options provided as to the % of effectiveness on a scale of 0-25%, 25-50%, 51-75%, 76-100%, where 0-25% means effective to some extent and it goes to 76-100% in a increasing order which means machine learning approaches improve forecasting of various natural disaster to a great extent. Amongst the responses, 11 people said that it is 0-25%, 23 said 26-50%, 11 said 51-75% and the remaining 5 said it is 76-100%.



Q12. What is the level of awareness of disaster risk factors at the community level?

From Graph/figure we can infer that most of the population who were interviewed responded that the level of awareness of disaster risk factors at the community level is good to some extent, since the number of people who have given their response indicates the same. The graph shows that people have given mixed responses to the question posed with the options provided as to the % of knowledge on a scale of 0-25%, 25-50%, 51-75%, 76-100%, where 0-25% means sufficient level of awarness to some extent and it goes to 76-100% in a increasing order which means there is more than sufficient level of awarness. Amongst the responses, 20 people said it is 0-25%, 23 said 26-50%, 5 said 51-75% and the remaining 2 said 76- 100%.

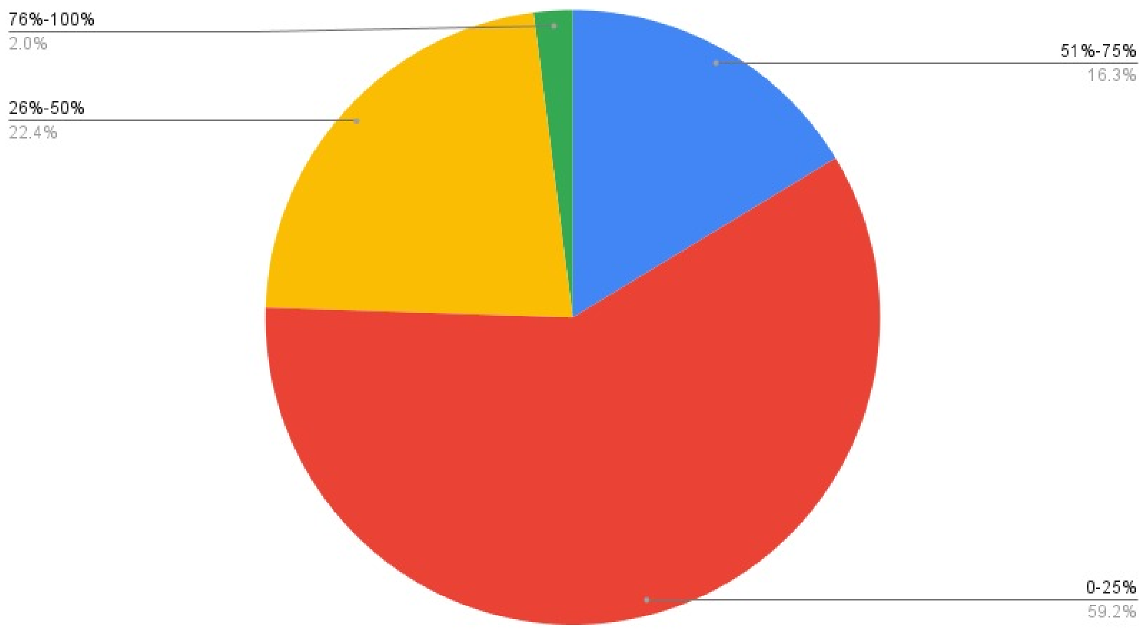
Q12. FIG 12. What is the level of awareness of disaster risk factors at the community level?



Q13. What percentages of vulnerable areas have evacuation plans/maps?

From Graph/figure we can infer that most of the population who were interviewed responded that most of the vulnerable areas dont have evacuation plans/maps, since the number of people who have given their response indicates the same. The graph shows that people have given mixed responses to the question posed with the options provided as to the % of areas on a scale of 0-25%, 25-50%, 51-75%, 76-100%, where 0-25% means the areas having evacuation plan and it goes to 76-100% in a increasing order which means all the areas have the maps. Amongst the responses, 59.2% of the people said it is 0-25%, 22.4% of the people said 26-50%, 16.3% of the people said 51-75% and the remaining 2% of the people said 76- 100%.

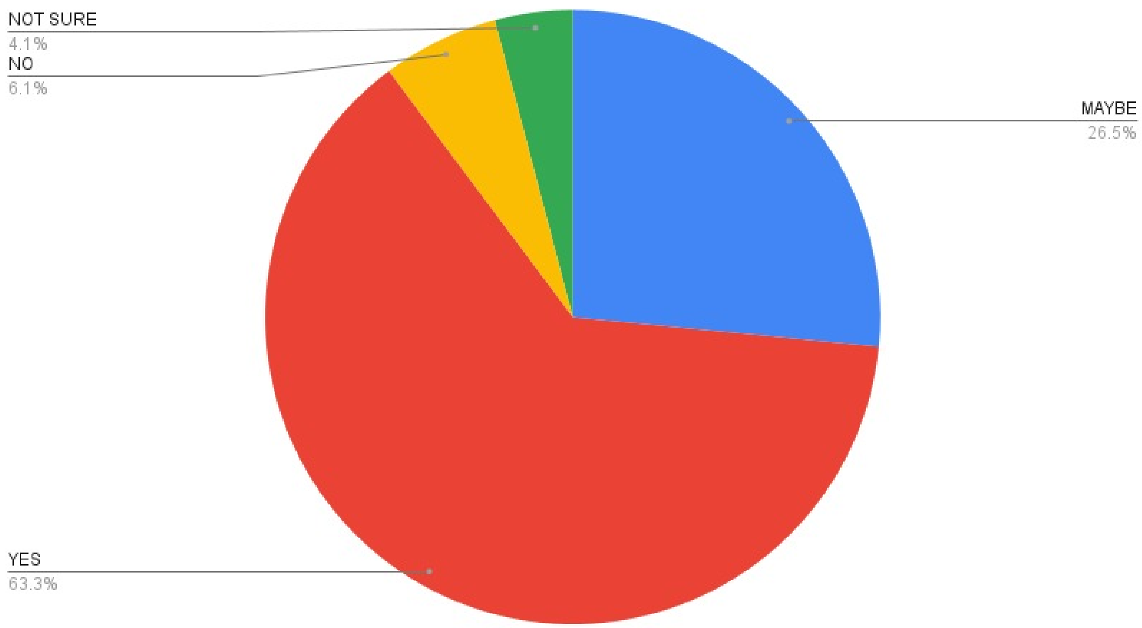
Q13. FIG 13. What percentages of vulnerable areas have evacuation plans/maps?



Q14. Are there national disaster management plans and procedures?

From Graph/figure we can infer that most of the population who were interviewed responded that yes there are national disaster management plans and procedures, since the number of people who have given their response indicates the same. The graph shows that most of the people have agreed and somewhat have disagreed with the question posed with the options provided as to yes, no, maybe, not sure. Amongst the responses 63.3% people voted for yes, 6.1% people for no, 26.5% people for maybe, 4.1% people for not sure.

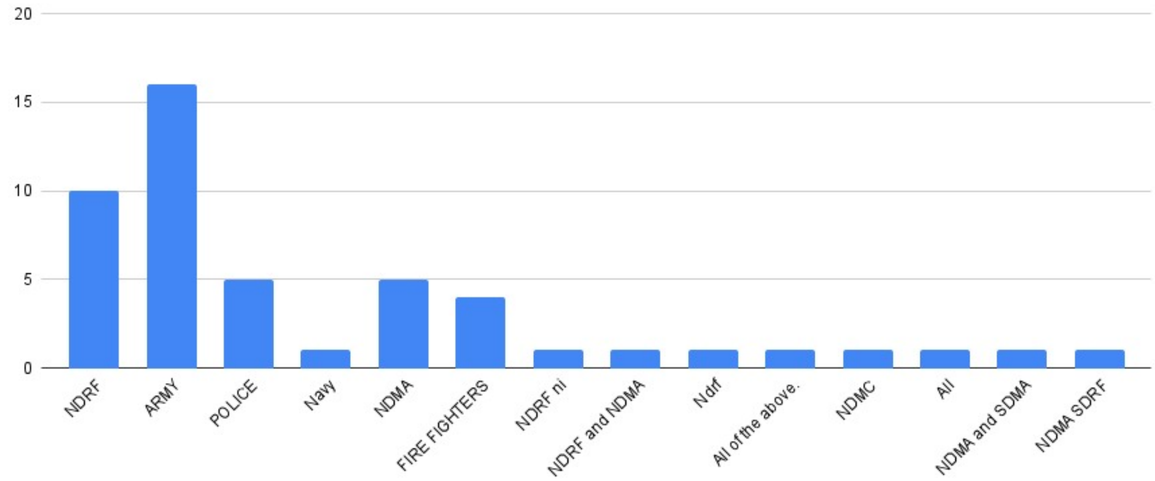
Q14. FIG 14 Are there national disaster management plans and procedures?



Q15. Which governmental entity has the mandate of assisting during a disaster?

From Graph/figure we can infer that most of the population who were interviewed responded that NDRF, Army and Police as the **g**overnmental entity that has the mandate of assisting during a disaster, since the number of people who have given their response indicates the same. The graph shows that people have also responded to others such as Navy, NDMA, Fire fighters.

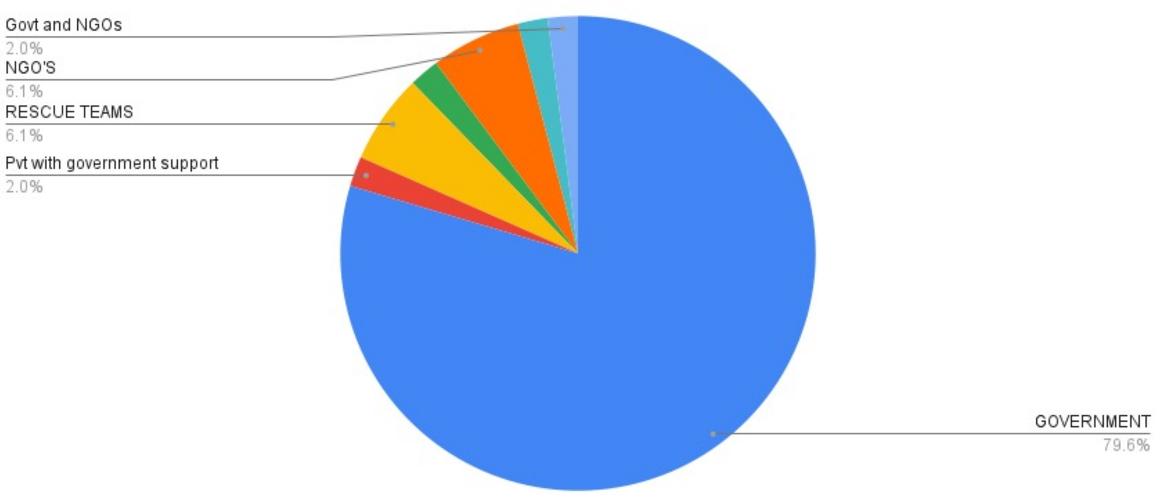
Q15. FIG 15. Which governmental entity has the mandate of assisting during a disaster?



Q16. who plays significant role in infrastructure development after a disaster?

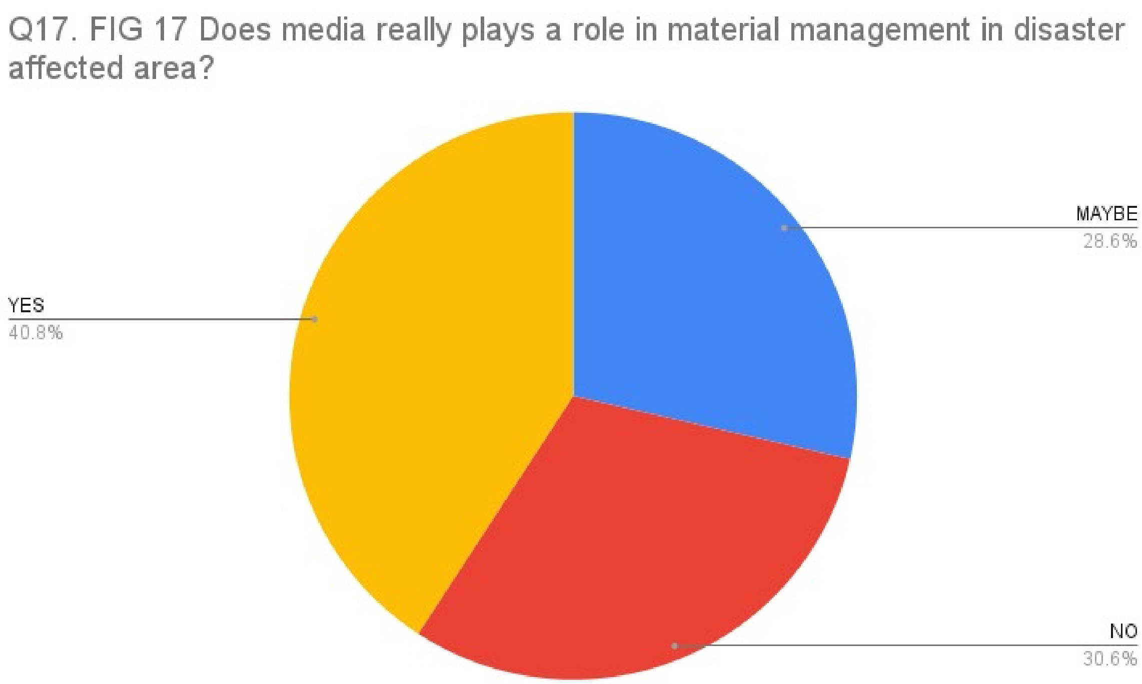
From Graph/figure we can infer that most of the population who were interviewed responded that government plays significant role in infrastructure development after a disaster, since the number of people who have given their response indicates the same. The graph shows that people have also responded to others such as rescue team, NGO's. The fig shows that 79.6% of the people responded for government and the remaining 6.1% of the people for NGO and rescue teams, the other 2.0% of the people responded to Govt and NGO and Private with govt support.

Q16. FIG 16. who plays significant role in infrastructure development after a disaster ?



Q17. Does media really plays a role in material management in disaster affected area?

From Graph/figure we can infer that most of the population who were interviewed responded that yes media does plays a role in material management in disaster affected area, since the number of people who have given their response indicates the same. The graph shows that most of the people have agreed and somewhat have disagreed with the question posed with the options provided as to yes, no, maybe, not sure. Amongst the responses 40.8% people voted for yes, 30.6% people for no, 28.6% people for maybe, remaining people for not sure.



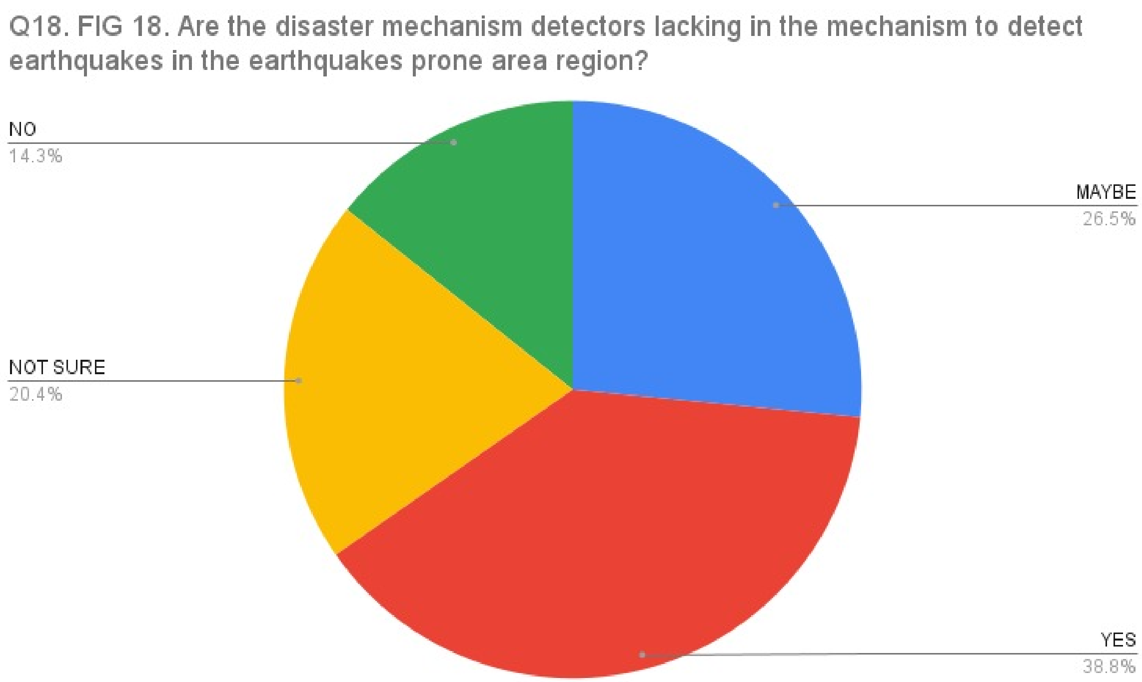
Q18. Are the disaster mechanism detectors lacking in the mechanism to detect earthquakes in the earthquakes prone area region?

From Graph/figure we can infer that most of the population who were interviewed responded that most of the people said yes **the disaster mechanism detectors lack in the mechanism to detect earthquakes in the earthquakes prone area**

region, since the number of people who have given their response indicates the same. The graph shows that most of the people have agreed and somewhat have disagreed with the question posed with the options provided as to yes, no, maybe, not sure. Amongst the responses 38.8% people voted for yes, 14.3% people for no, 26.5% people for maybe, 20.4% people for not sure.

Other questions

The suggestions were Such disaster management plans for each locality need to be worked out by state Corporations and may be insisted to builder to develop such a plan while handing over the house by the builder linking NOC, awareness among people and need to identify the prone areas and should create awareness point, compulsory disaster management training in class 10 and 12 etc.



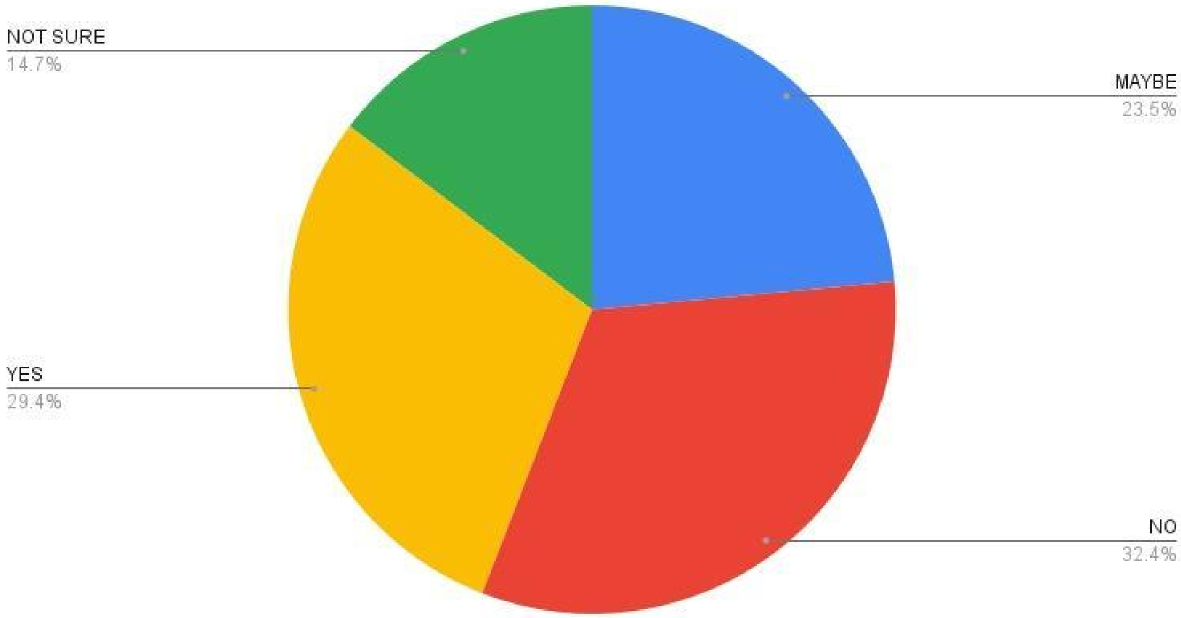
Questionnaire 3

The 2nd questionnaire was prepared to people living near disaster prone areas. The responses were and collected and based on the same graphs and figures were made and the analysis has been done accordingly. A total of 35 responses were collected.

Q1. Do you think that whether the govt multidimensional approach to vulnerability during natural calamities are sufficient?

From Graph/figure we can infer that most of the population who were interviewed responded that to some extent people have agreed and some have disagreed the govt multidimensional approach to vulnerability during natural calamities are sufficient, since the number of people who have given their response indicates the same. The graph shows that most of the people have agreed and somewhat have disagreed with the question posed with the options provided as to yes, no, maybe, not sure. Amongst the responses 29.4% people voted for yes, 32.4% people for no, 23.5% people for maybe, 14.7% people for not sure.

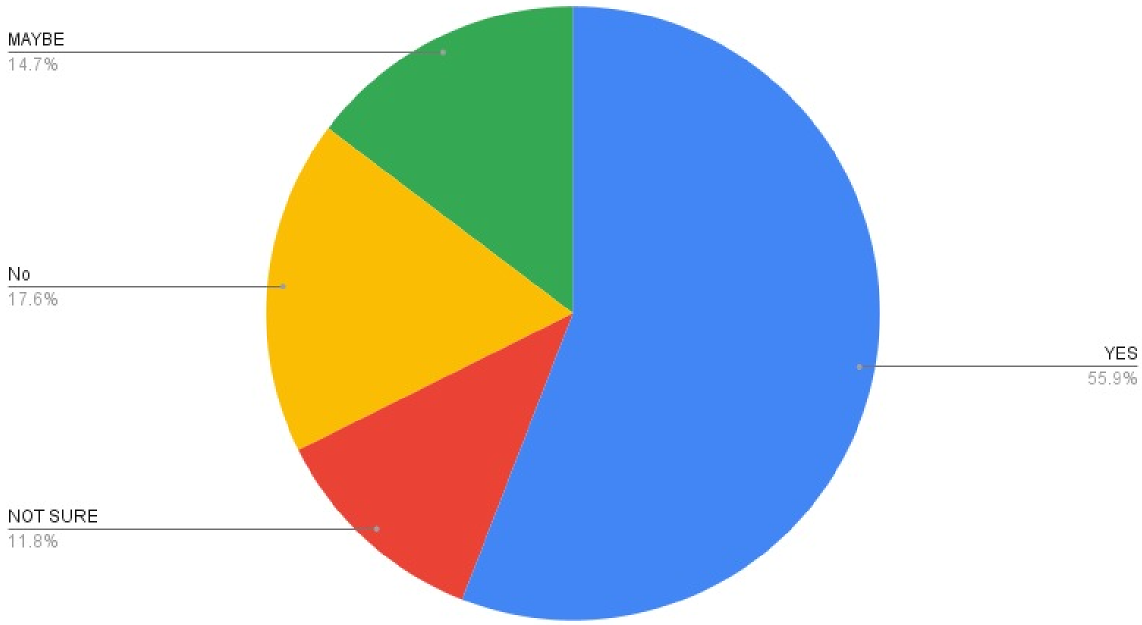
Q1. FIG 1. Do you think that whether the govt multidimensional approach to vulnerability during natural calamities are sufficient?



Q2. Are the impacts heterogeneous across different sets of vulnerable groups?

From Graph/figure we can infer that most of the population who were interviewed responded that yes the impacts are heterogeneous across different sets of vulnerable groups, since the number of people who have given their response indicates the same. The graph shows that most of the people have agreed and somewhat have disagreed with the question posed with the options provided as to yes, no, maybe, not sure. Amongst the responses 55.9% people voted for yes, 17.6% people for no, 14.7% people for maybe, 11.8% people for not sure.

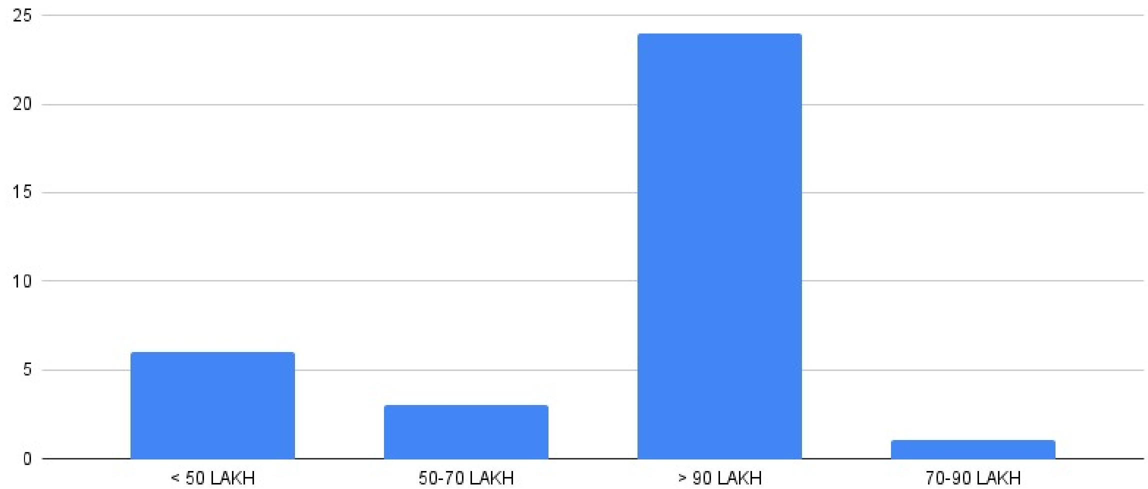
Q2. FIG 2. Are the impacts heterogeneous across different sets of vulnerable groups?



Q3. As per your knowledge, what would be the approximate population of the area you live in?

From Graph/figure we can infer that most of the population who were interviewed responded to the population in thier area on a scale of less than 50 lakh, between 50-70 lakh, between 70-90 lakh, hreater than 90 lakh. It can be inferred that most of the people have responded that the area they live in is having a population of greater than 90 lakh.

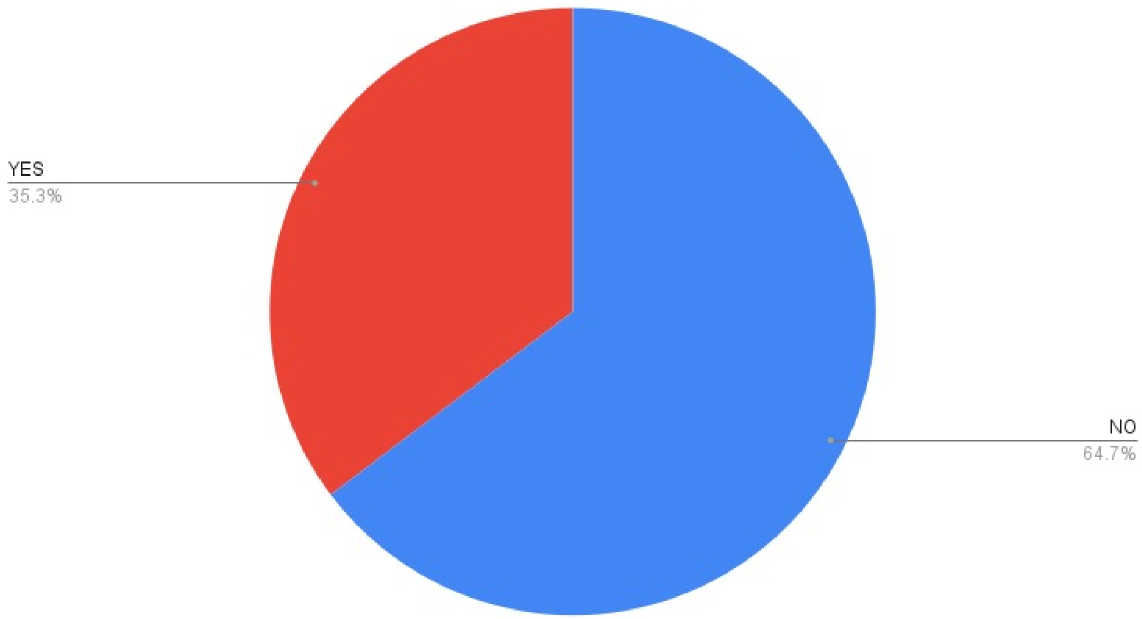
Q3. FIG 3. As per your knowledge, what would be the approximate population of the area you live in?



Q4. Have you experienced any (earthquake) disaster in this region?

From Graph/figure we can infer that yes almost half of the population who were interviewed did experience a (earthquake) disaster in their region, since the number of people who have given their response indicates the same. The graph shows that most of the people have agreed and somewhat have disagreed with the question posed with the options provided as to yes, no, maybe, not sure. Amongst the responses 35.3% people voted for yes, 64.7% people for no.

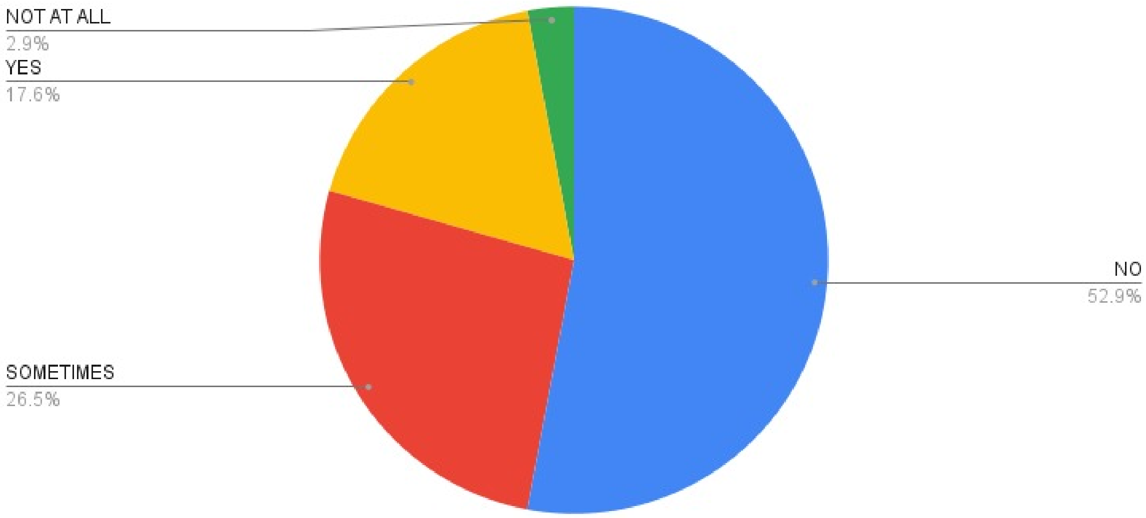
Q4. FIG 4 Have you experienced any (earthquake) disaster in this region?



Q5. Are you able to prepare yourself for sudden occurrence of such disaster (earthquake)?

From Graph/figure we can infer that most of the population who were interviewed were not able to prepare himself for sudden occurrence of such a disaster (earthquake), since the number of people who have given their response indicates the same. The graph shows that most of the people have disagreed and somewhat have agreed with the question posed with the options provided as to yes, no, sometimes, not at all. Amongst the responses 17.6% people said yes, 52.9% people said no, 26.5% people said sometimes and the remaining 2.9% people said not at all..

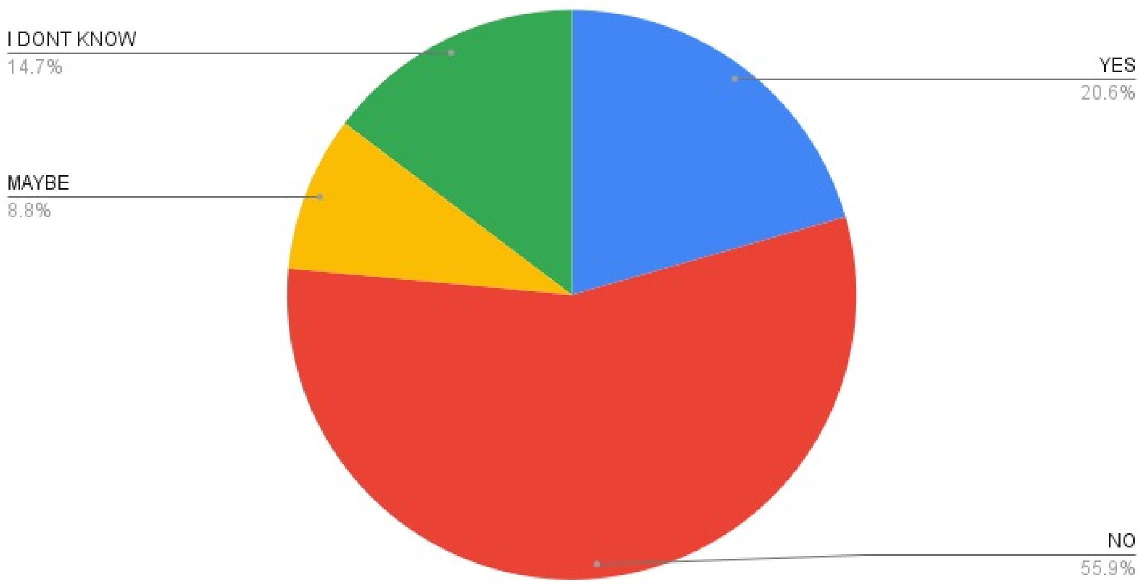
Q5. FIG 5. Are you able to prepare yourself for sudden occurrence of such disaster (earthquake)?



Q6. Is there any emergency assembly point during (earthquake) occurrence of any natural calamity in your area?

From Graph/figure we can infer that most of the population who were interviewed responded that no there are no emergency assembly point during (earthquake) occurrence of any natural calamity in your area, since the number of people who have given their response indicates the same. The graph shows that most of the people have agreed and somewhat have disagreed with the question posed with the options provided as to yes, no, maybe, not sure. Amongst the responses 20.6% people voted for yes, 55.9% people for no, 8.8% people for maybe, 14.7% people for not sure.

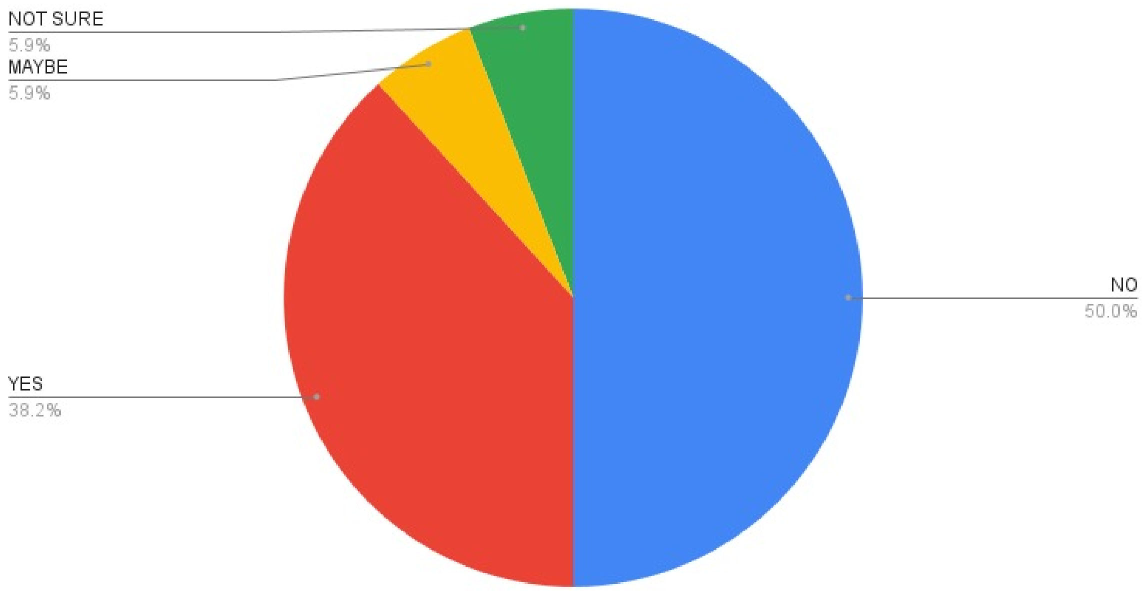
Q6. FIG 6. Is there any emergency assembly point during (earthquake) occurrence of any natural calamity in your area?



Q7. As this is the DISASTER prone area, are you people properly trained for disaster management skill? Do you think it really helps?

From Graph/figure we can infer that most of the population who were interviewed responded that even though being in disaster prone area, people are not properly trained for disaster management skill, since the number of people who have given their response indicates the same. The graph shows that most of the people have agreed and somewhat have disagreed with the question posed with the options provided as to yes, no, maybe, not sure. Amongst the responses 38.2% people voted for yes, 50.0% people for no, 5.9% people for maybe, 5.9% people for not sure

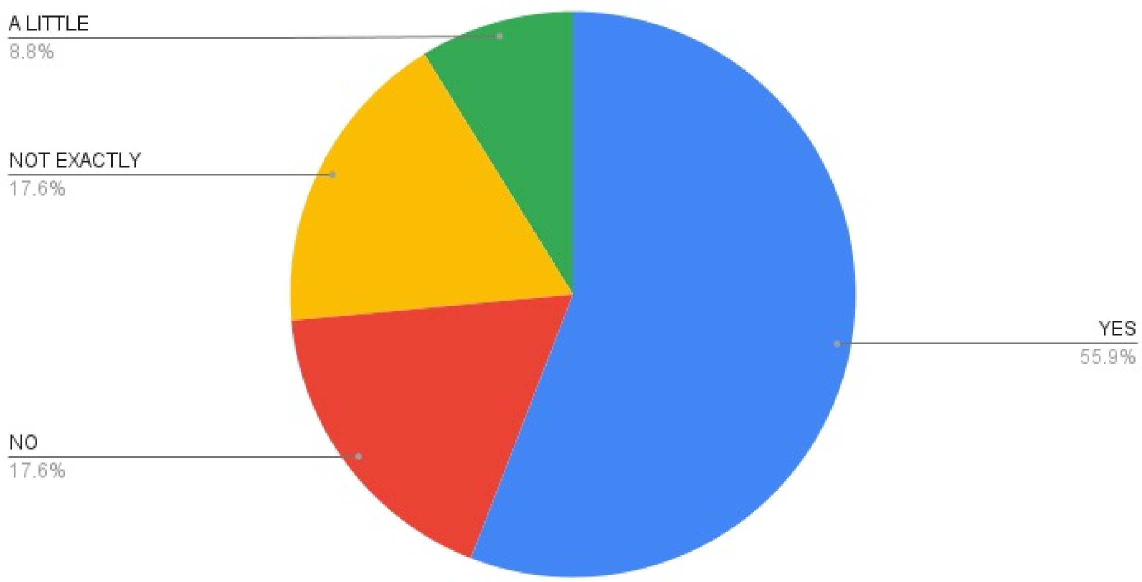
Q7. FIG 7. As this is the DISASTER prone area, are you people properly trained for disaster management skill? Do you think it really helps?



Q8. Are you aware of earthquake safe building technology and practices?

From Graph/figure we can infer that most of the population who were interviewed responded that they are aware of earthquake safe building technology and practices, since the number of people who have given their response indicates the same. The graph shows that most of the people have agreed and somewhat have disagreed with the question posed with the options provided as to yes, no, not exactly, a little. Amongst the responses 17.6% people voted for no, 55.9% people for yes, 17.6% people for not exactly, 8.8% people for a little.

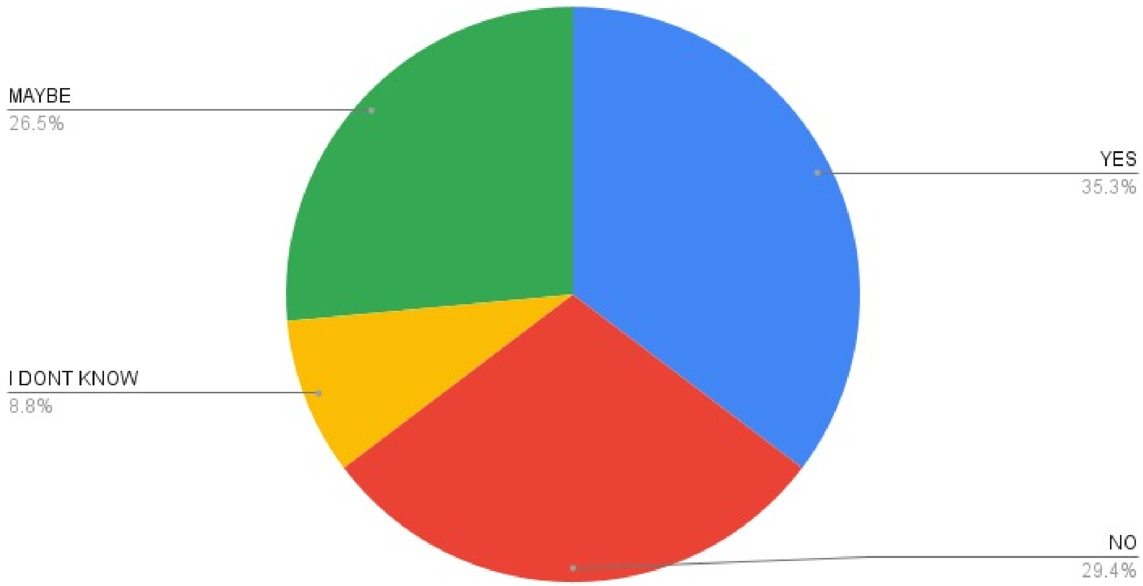
Q8. FIG 8. Are you aware of earthquake safe building technology and practices?



Q9. Do you think that there is non competency of government and other organization in releasing funds to meet the full material requirement in any disaster?

From Graph/figure we can infer that most of the population who were interviewed responded that they are of the opinion that there is non-competency of government and other organization in releasing funds to meet the full material requirement in any disaster, since the number of people who have given their response indicates the same. The graph shows that people have agreed and somewhat disagreed with the question posed where the options are yes, no, maybe, i dont know. Amongst the responses 35.3% people voted for yes, 29.4% people for no, 26.5% people for maybe, 8.8% people for i dont know.

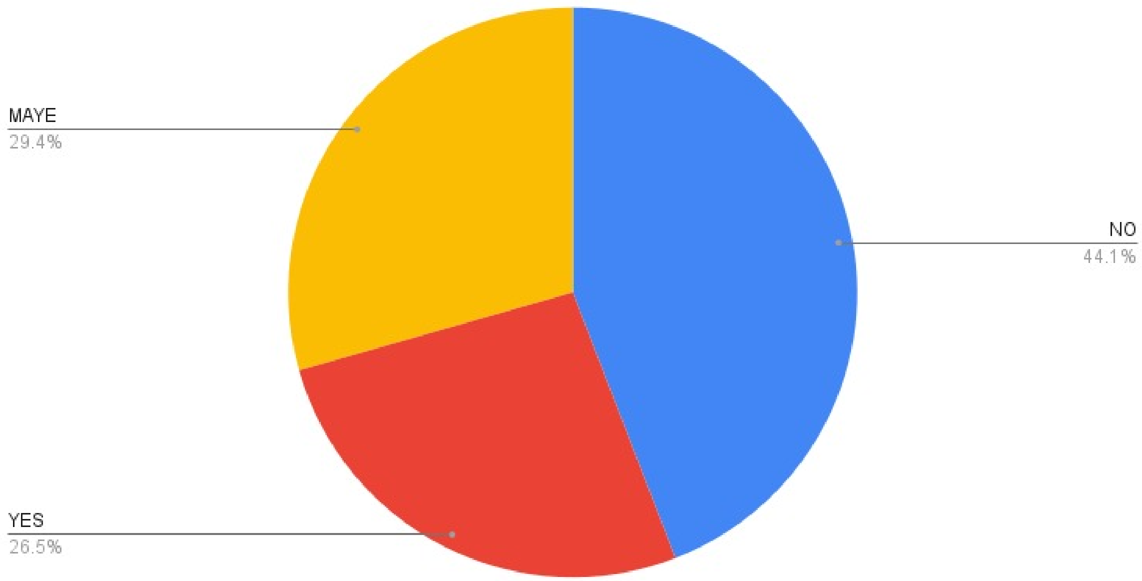
Q9. FIG 9. Do you think that there is non competency of government and other organization in releasing funds to meet the full material requirement in any disaster?



Q10. Whether the existing National resources are sufficient to combat disasters?

From Graph/figure we can infer that most of the population who were interviewed responded that no the existing National resources are not sufficient to combat disasters, since the number of people who have given their response indicates the same. The graph shows that most of the people have agreed and somewhat have disagreed with the question posed with the options provided as to yes, no, maybe, not sure. Amongst the responses 26.5% people voted for yes, 44.1% people for no, 29.4% people for maybe.

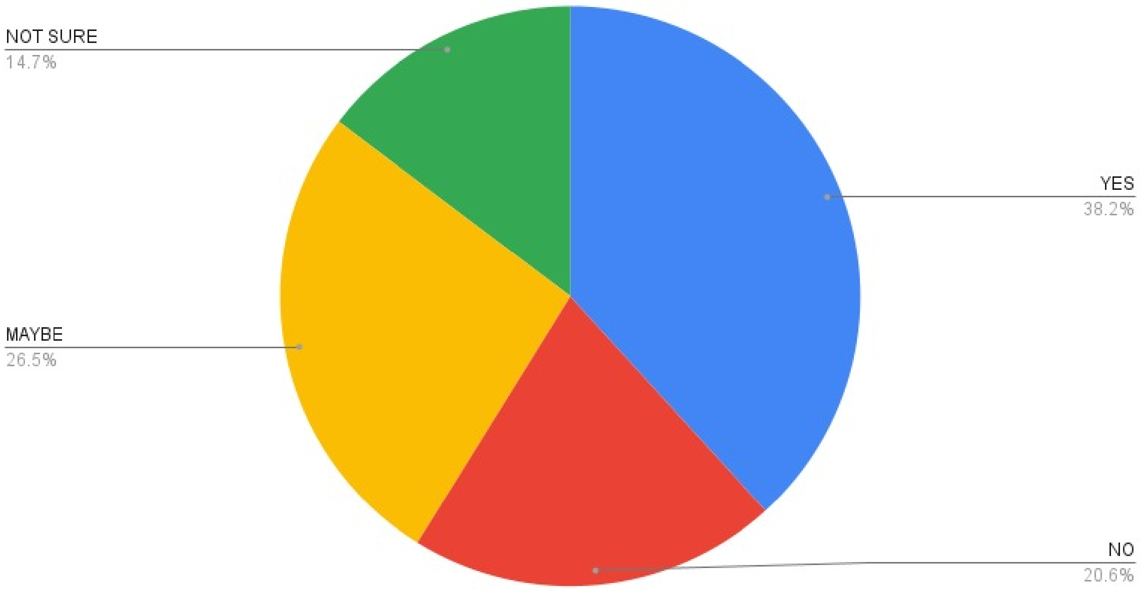
Q10. FIG 10. Whether the existing National resources are sufficient to combat disasters?



Q11. Whether the organizational characteristics enable an organization to effectively and efficiently alleviate human suffering in the event of a natural disaster?

From Graph/figure we can infer that most of the population who were interviewed responded that yes the organizational characteristics enable an organization to effectively and efficiently alleviate human suffering in the event of a natural disaster, since the number of people who have given their response indicates the same. The graph shows that most of the people have agreed and somewhat have disagreed with the question posed with the options provided as to yes, no, maybe, not sure. Amongst the responses 38.2% people voted for yes, 20.6% people for no, 26.5% people for maybe, 14.7% people for not sure

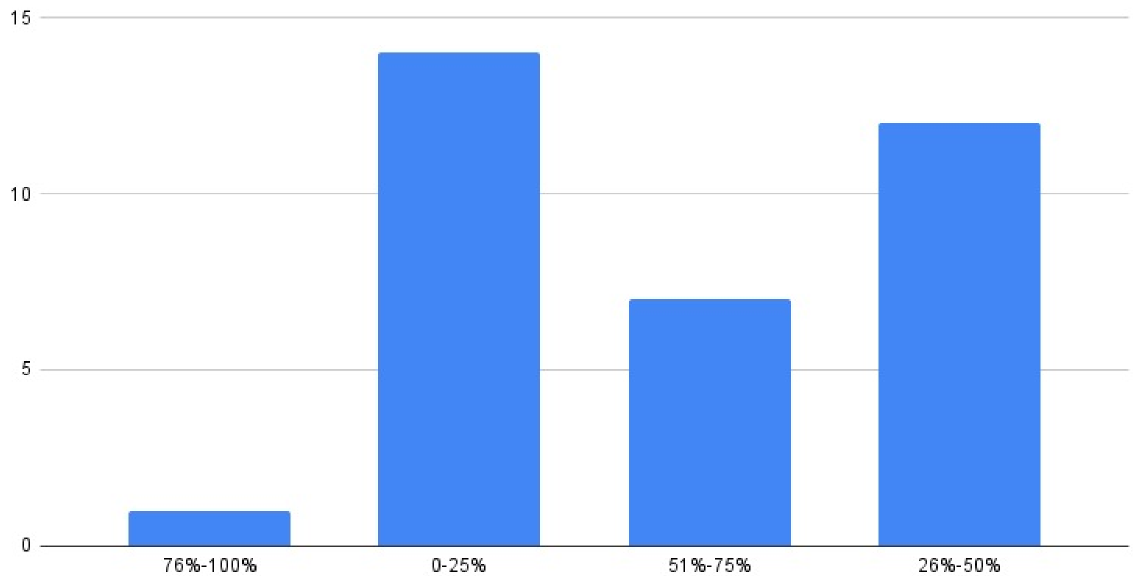
Q11. FIG 11. Whether the organizational characteristics enable an organization to effectively and efficiently alleviate human suffering in the event of a natural disaster?



Q12. How much effective are the current early warning systems that are working today?

From Graph/figure we can infer that most of the population who were interviewed responded that yes the current early warning systems that are working today are somewhat effective, since the number of people who have given their response indicates the same. The graph shows that people have given mixed responses to the question posed with the options provided as to the % of effectiveness on a scale of 0-25%, 25-50%, 51-75%, 76-100%, where 0-25% means effective to some extent and it goes to 76-100% in a increasing order which means machine learning approaches improve forecasting of various natural disaster to a great extent. Amongst the responses, 14 people said that it is 0-25%, 12 said 26-50%, 7 said 51-75% and the remaining 1 said it is 76-100%.

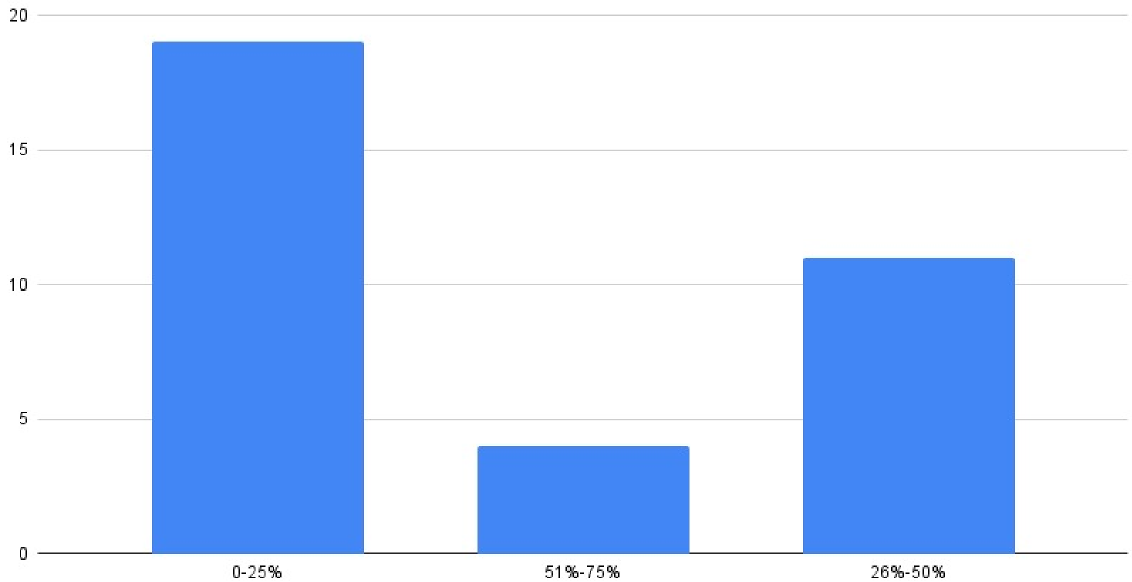
Q12. FIG 12. How much effective are the current early warning systems that are working today?



Q13. What is the level of awareness of disaster risk factors at the community level?

From Graph/figure we can infer that most of the population who were interviewed responded that the level of awareness of disaster risk factors at the community level is good to some extent, since the number of people who have given their response indicates the same. The graph shows that people have given mixed responses to the question posed with the options provided as to the % of knowledge on a scale of 0-25%, 25-50%, 51-75%, 76-100%, where 0-25% means sufficient level of awarness to some extent and it goes to 76-100% in a increasing order which means there is more than sufficient level of awarness. Amongst the responses, 19 people said it is 0-25%, 11 said 26-50%, 4 said 51-75% and the remaining few said 76- 100%.

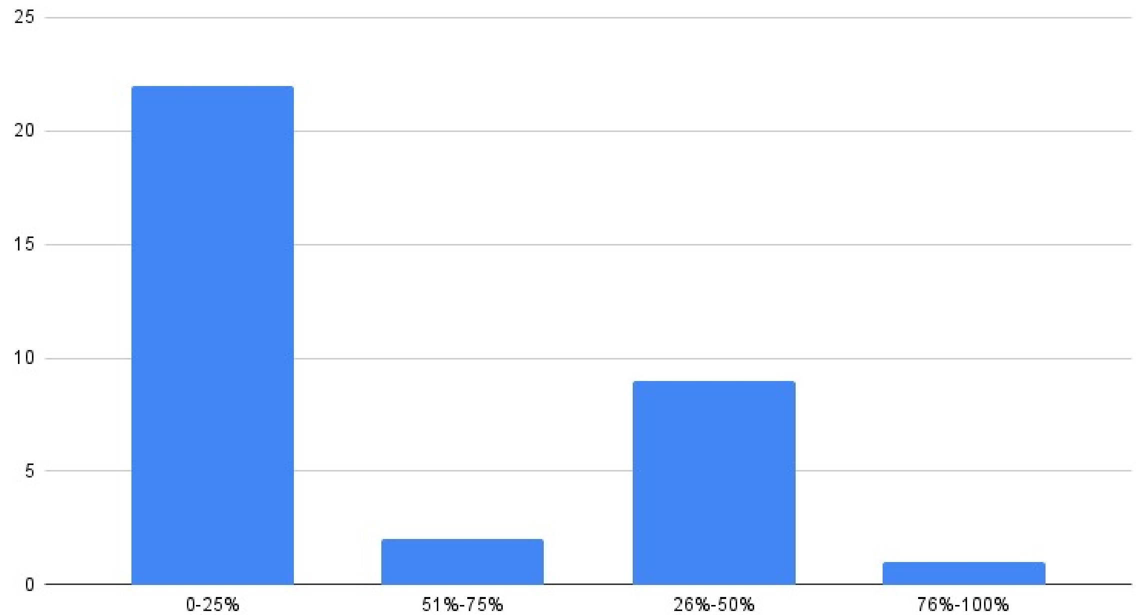
Q13. FIG 13. What is the level of awareness of disaster risk factors at the community level?



Q14. What percentages of vulnerable areas have evacuation plans/maps?

From Graph/figure we can infer that most of the population who were interviewed responded that most of the vulnerable areas dont have evacuation plans/maps, since the number of people who have given their response indicates the same. The graph shows that people have given mixed responses to the question posed with the options provided as to the % of areas on a scale of 0-25%, 25-50%, 51-75%, 76-100%, where 0-25% means the areas having evacuation plan and it goes to 76-100% in a increasing order which means all the areas have the maps. Amongst the responses, 22 people said it is 0-25%, 9 people said 26-50%, 1 said 51-75% and the remaining 2 people said 76- 100%.

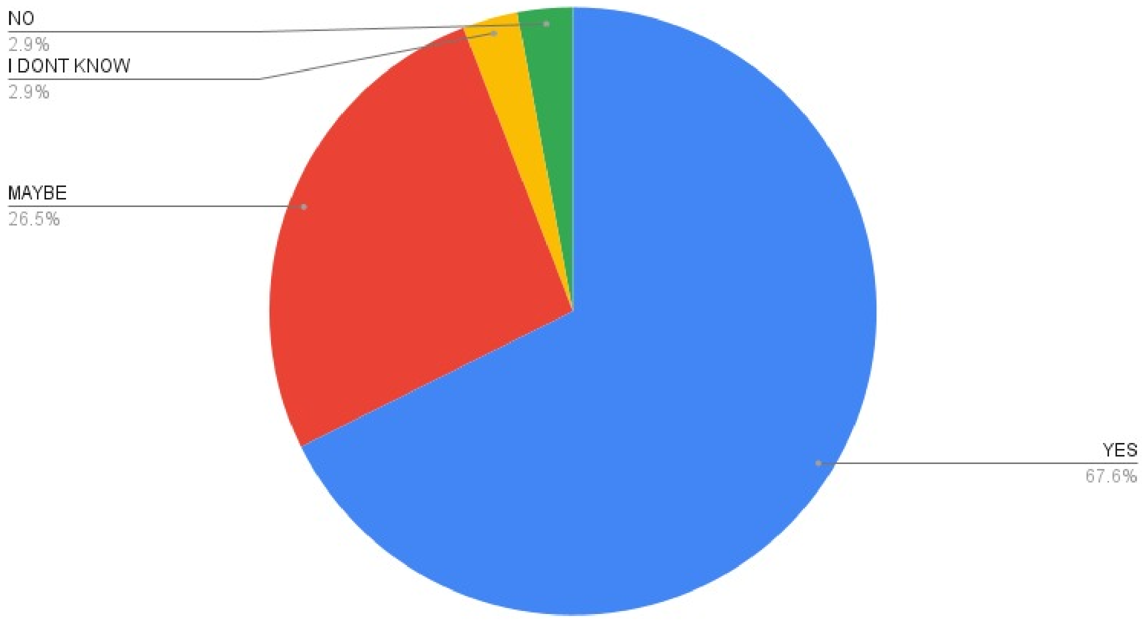
Q14. FIG 14. What percentages of vulnerable areas have evacuation plans/maps?



Q15. Are there national disaster management plans and procedures?

From Graph/figure we can infer that most of the population who were interviewed responded that yes there are national disaster management plans and procedures, since the number of people who have given their response indicates the same. The graph shows that most of the people have agreed and somewhat have disagreed with the question posed with the options provided as to yes, no, maybe, not sure. Amongst the responses 67.6% people voted for yes, 2.9% people for no, 26.5% people for maybe, 2.9% people were not aware.

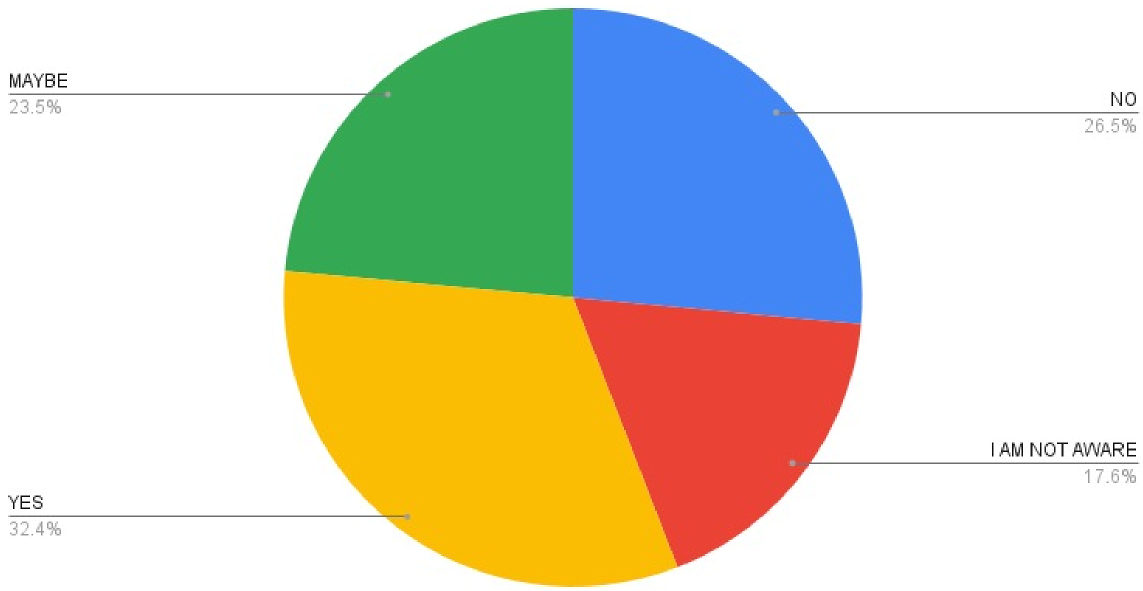
Q15. FIG 15. Are there national disaster management plans and procedures?



Q16. Are there any disaster awareness and public information projects or programs being undertaken in the country regarding your area?

From Graph/figure we can infer that most of the population who were interviewed responded that yes there are disaster awareness and public information projects or programs being undertaken in the country regarding the disaster prone area, since the number of people who have given their response indicates the same. The graph shows that most of the people have agreed and somewhat have disagreed with the question posed with the options provided as to yes, no, maybe, not sure. Amongst the responses 32.4% people voted for yes, 26.5% people for no, 23.5% people for maybe, 17.6% people weren’t aware.

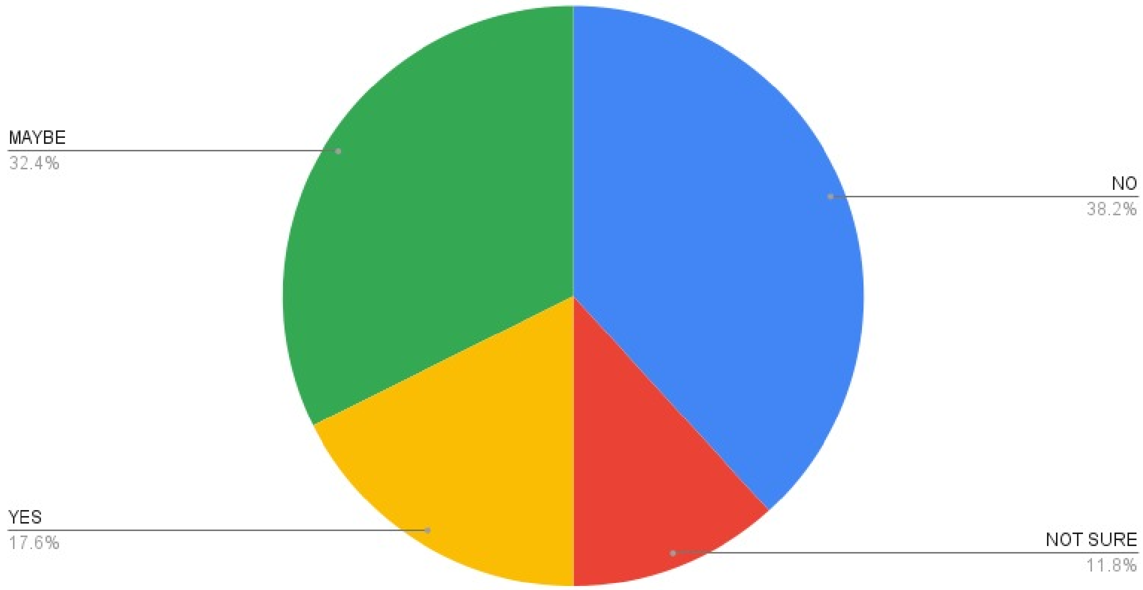
Q16. FIG 16. Are there any disaster awareness and public information projects or programs being undertaken in the country regarding your area?



Q17. Whether the current Disaster Emergency Response framework is up to the mark with respect to material management in comparison to other developed nations?

From Graph/figure we can infer that most of the population who were interviewed responded that most of the people said no the current Disaster Emergency Response framework is not up to the mark with respect to material management in comparison to other developed nations, since the number of people who have given their response indicates the same. The graph shows that most of the people have agreed and somewhat have disagreed with the question posed with the options provided as to yes, no, maybe, not sure. Amongst the responses 17.6% people voted for yes, 38.2% people for no, 32.4% people for maybe, 11.8% people for not sure

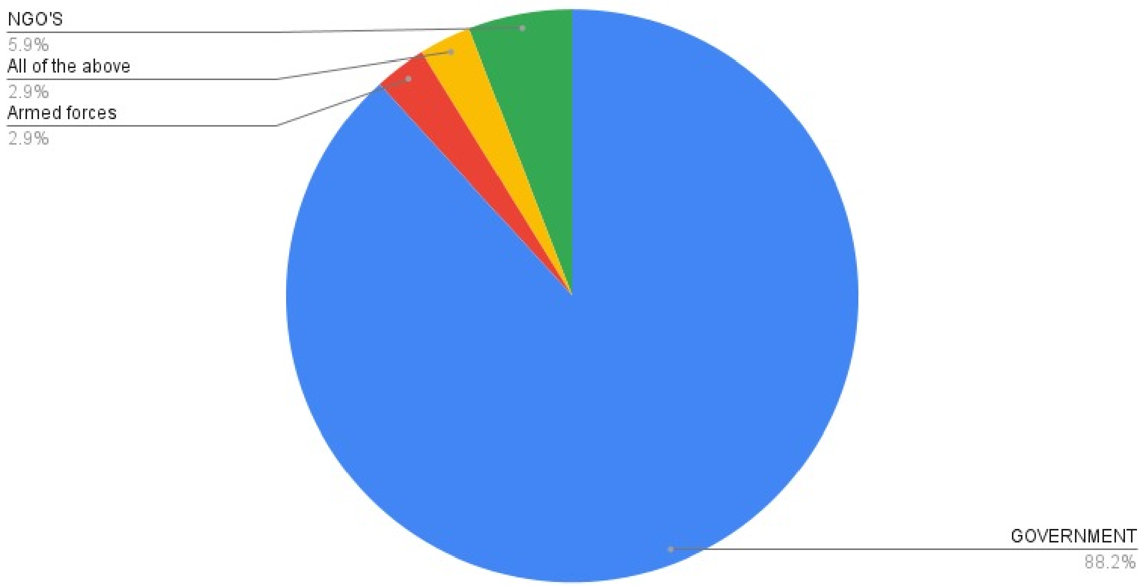
Q17. FIG 17. Whether the current Disaster Emergency Response framework is up to the mark with respect to material management in comparison to other developed nations?



Q18. Who plays significant role in infrastructure development after a disaster?

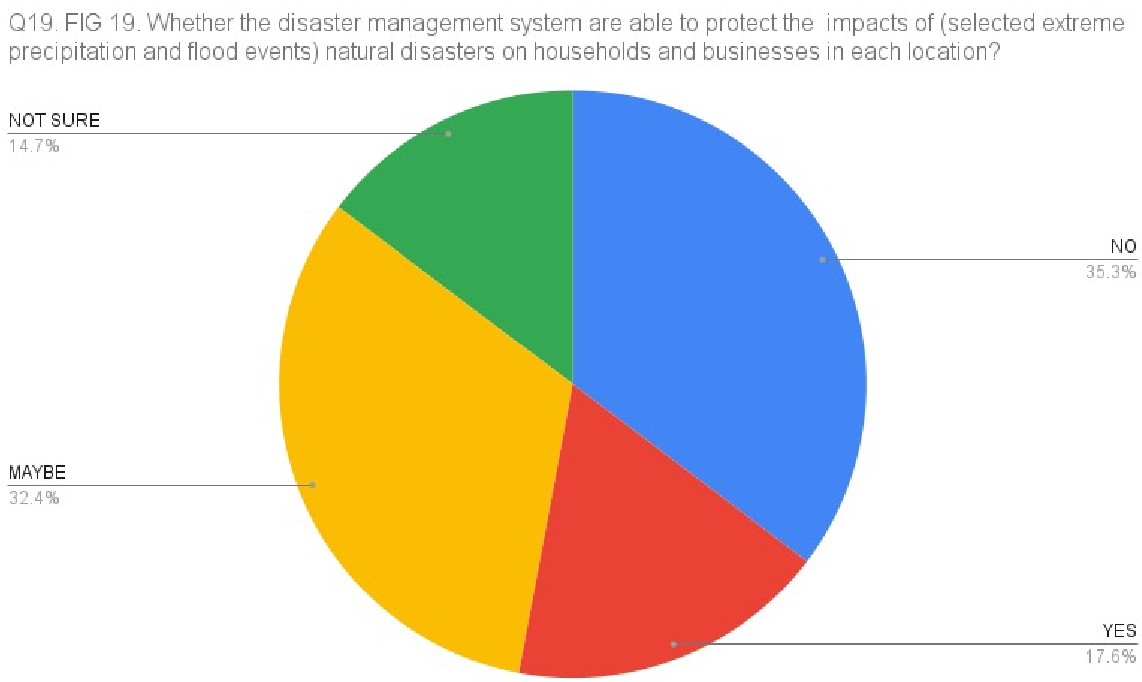
From Graph/figure we can infer that most of the population who were interviewed responded that government plays significant role in infrastructure development after a disaster, since the number of people who have given their response indicates the same. The graph shows that people have also responded to others such as rescue team, NGO's. The fig shows that 88.2% of the people responded for government and the remaining 5.9% of the people for NGO and rescue teams, the other 2.9% of the people responded to Govt and NGO and Private with govt support.

Q18. FIG 18. Who plays significant role in infrastructure development after a disaster?



Q19. Whether the disaster management system are able to protect the impacts of (selected extreme precipitation and flood events) natural disasters on households and businesses in each location?

From Graph/figure we can infer that most of the population who were interviewed responded that no the disaster management system is not able to protect the impacts of (selected extreme precipitation and flood events) natural disasters on households and businesses in each location, since the number of people who have given their response indicates the same. The graph shows that most of the people have agreed and somewhat have disagreed with the question posed with the options provided as to yes, no, maybe, not sure. Amongst the responses 17.6% people voted for yes, 35.3% people for no, 32.4% people for maybe, 14.7% people for not sure



Conclusion

Data pertaining to flood control can be managed and analysed using Geographic Information Systems (GIS), which are effective tools. Real data that can be incorporated into GIS for managing floods includes:

Hydrologic data can be used to model the behaviour of water in a specific region and forecast the likelihood of flooding. This includes data on precipitation, stream flow, and groundwater levels.

Data on elevation, slope, and land cover are included in topographic information, which can be used to pinpoint flood-prone regions as well as those that might be able to naturally protect against flooding.

Meteorological information: This includes information on temperature, wind, and pressure that can be used to simulate how the atmosphere behaves and forecast the probability of severe weather events that could cause flooding.

Demographic information can be used to identify vulnerable populations and areas at danger of flooding. This information contains information on population density, land use, and infrastructure.

Historical information: This includes information on previous floods and their effects, which can be used to spot patterns and trends that can be used to forecast future occurrences and make plans for reaction and mitigation.

Data from satellite and aerial imagery are included in the category of remote sensing and can be used to track changes in land use, spot signs of soil erosion and subsidence, and calculate water bodies.

Data from social media platforms is included here, which can be used to monitor public opinion, pinpoint areas that will need to be evacuated, and comprehend how flooding will affect the local economy and infrastructure.

Using GIS software, these data can be combined and analysed to produce interactive maps and visualisations that assist decision-makers in identifying risky regions and formulating mitigation and response strategies.

CHAPTER 7

CONCLUSION AND SUGGESTIONS

Disasters are extremely dynamic in nature, are defined by severe financial and environmental damage, and as a result, human lives are at risk. The availability of a vast amount of data through artificial intelligence and machine learning as a result of technological advancements has had a significant influence on how disasters have been handled thus far. This has in turn created a number of fresh difficulties for the efficient administration of disasters and the mitigation of disaster risk. To support this process and enable better disaster management, data mining, artificial intelligence, machine learning, and deep learning methods need to be better applied. The relief groups and governmental organisations need to distil this vast amount of data into actionable insights. Although there are several AI methods for processing crisis data, technology still frequently falls short.

We are aware that prompt and wise choices are necessary to avoid, reduce, and manage all types of risks. Artificial intelligence (AI) has enormous potential for the decision-making process in this regard. Despite these assurances, the main difficulties are:

- To actively involve stakeholders in all project stages and foster trustworthy cooperation;
- To effectively convey risk and its uncertainty, it is important to disseminate useful information to key players.
- To do this, hybrid models that combine traditional statistics with human behaviour should be developed.

A promising programme to address the state's increasing disaster risks is the AI-Based Expert System for Disaster Risk Reduction. A comprehensive strategy to disaster management is made possible by this system, which gives stakeholders access to real-time data and insights to aid in decision-making. The system is made to assist local governments and communities in lowering the risks brought on by natural catastrophes, from reducing the effects of events to recovery and rehabilitation. This system has the potential to effectively reduce the damage brought on by disasters and help the communities plan and respond more effectively thanks to its combination of cutting-edge AI technologies, professional knowledge, and local community input. Despite its potential in many areas, AI is not currently a component of the standard operating procedure for managing natural disasters and hazards. There are countless lessons to be learned from every disaster. In order for each state to learn from one another and set up systems that are prepared to handle future disasters, India needs to record the best practises that were noticed during each disaster and make sure that they are captured in the form of a knowledge management platform along with cutting-edge e-learning tools.

This research concentrated on the use of AI in the four stages of disaster management "mitigation, readiness, response, and recovery" to help reduce disaster risk effectively. In particular, this study has examined the use of 26 AI techniques across 17 Application Areas in all four stages of disaster management. Analysis outputs from AI models are extremely helpful for supporting disaster management, according to study and practical experience. The majority of applications currently tend to prioritise crisis response, followed by disaster mitigation. In conclusion, AI apps have enormous potential to enhance emergency preparedness and response. AI-driven technologies can be used to anticipate and spot disasters, locate affected areas, identify affected people, and improve resource management. AI can also be used to deliver real-time analytics and feedback, as well as timely and accurate information, to crisis management teams. Even though AI applications are still in their infancy, they have enormous potential to enhance crisis management and relief efforts. AI can be used to build quicker, more effective, and more precise disaster management and relief systems with continued research and development.

When it comes to data processing speed and thus the amount of data that can be analysed, AI is superior to humans. When the scope is within the bounds of the training data, it can produce forecasts that are reasonable. Predictions that go beyond the realm of possibility, however, may be unacceptable. This is particularly true because the hazard and society are both continuously changing, which may significantly alter the usefulness of the attributes that were used to train the initial model. A further question is whether we should entirely depend on the predictions and suggestions from AI algorithms to deploy resources and create disaster plans, even if they can make passably accurate predictions with the data at hand. There is no easy solution to this query.

There are a number of difficult problems relating to data and computation, as well as the inseparability and repeatability of analysis findings, that need to be resolved for practical AI applications in disaster management. This study also finds a number of untapped applications for various AI techniques. The research community is facing an urgent challenge: how to create more potent and economical AI-based tools to support decision-making in real-world crisis management with improved analysis accuracy and speed. Despite these obstacles and untapped potential, AI techniques offer a wide range of possibilities and simple fixes for a number of effective applications in disaster management. This study seeks to stimulate future research to address the identified difficult problems and advance disaster management with AI for enhancing community disaster resilience by examining the current state of application of AI methods in disaster management. In conclusion, the administration and relief of disasters could be greatly enhanced by the use of AI applications. AI-driven technologies can be used to anticipate and spot disasters, locate affected areas, identify affected people, and improve resource management. AI can also be used to deliver real-time analytics and feedback, as well as timely and accurate information, to crisis management teams. Even though AI applications are still in their infancy, they have enormous potential to enhance crisis management and relief efforts. AI can be used to build quicker, more effective, and more precise disaster management and relief systems with continued research and development.

7.1.1. Building, rehabilitation, and recovery

The goals of reconstruction, rehabilitation, and recovery efforts are to minimise the long-term effects of the catastrophe and quickly return things to normal. The APSDMA and DDMAS will concentrate on the economic and social repercussions of disaster-related disruptions and focus their efforts on restoring public utilities, services, and economic activity as soon as feasible. The State's risk reduction plan will include post-disaster reconstruction and recovery heavily. Where required, APSDMA will create and carry out reconstruction and recovery programmes with the aim of halting the affected community's further descent into squalor and poverty. Other government housing projects will be integrated with programmes to meet needs during the reconstruction period.

7.2. DIRECTIVE PRINCIPLES FOR REHAB

The Building Back Better idea shall serve as the State Government's guiding principal for post-disaster recovery. While doing so, the following standards for healing in the State shall be followed:

Recovery through convergence with development programmes and schemes shall be implemented; Community-centered approach shall be preferred; Gender equity and empowerment of women, inclusion of weaker sections of society. Multi-sectoral joint effort of government, NGOs, private sector, and communities shall be adopted. Promotion of the use of information and communications technology (ICT) in the recovery; Displaced populations and persons with disabilities; Transparency and accountability, including oversight, tracking, and redress of grievances;

For recovery, the State Executive shall take into account the following:

Physical recovery entails repairing and rebuilding the community's damaged roadways, bridges, dams, canals, and private homes; economic recovery entails restoring livelihoods and productive activities.

(c) Social and psychological healing, or the health of the family and the society.

7.3. PHASE OF RECOVERY AFTER A DISASTER

Comprehensive damage evaluation Immediately following disasters, a preliminary damage and relief needs assessment will be done, but before beginning reconstruction and rehabilitation efforts, a thorough assessment must be done. The pertinent Government departments and municipal authorities shall start thorough assessments of disaster-related damages at the appropriate level. In the damage estimate, the following crucial industries will be covered:

1. Housing

2. A productive business encompassing horticulture, industry, services, etc.

3. The infrastructure industry, which includes electricity, roads, and other things.

4. The social sphere, which includes health, education, etc.

LIFEWAY HEALTH

Disasters may result in the loss of employment prospects due to damage to property (equipment, inventory, and workplaces) or supply chain failure. The concerned DDMA will conduct a recovery requirements evaluation with the assistance of line departments and give priority to the quick restoration of affected populations' means of subsistence.

7.3.1 SOCIAL SECTOR RECOVERY

1. HEALTH: When planning recovery activities, the goal should be to enhance and restore health services for the community as a whole. It is important to make efforts to protect the health infrastructure from future catastrophes and to offer everyone fair and affordable services.

2. WATER AND HYGIENE: Infrastructure related to water and sanitation that is already in place, both in urban and rural areas, can be destroyed or seriously damaged by a disaster event. Such circumstances may force impacted communities to use contaminated water sources and maintain poor hygienic standards, increasing their susceptibility to infectious diseases and water-borne ailments. In order to provide safe drinking water, sufficient sanitation services, and good hygiene practises, the recovery programme will do so.

3. PSYCHO-SOCIAL SUPPORT: Communities impacted by disasters need Psycho-social Support (PSS) in addition to logistical and material assistance to recover from the trauma. These interventions may aid in lowering actual and perceived stress levels as well as in avoiding negative psychological and social repercussions for the community that has been affected by a catastrophe. The State Government will therefore take into account including a PSS in the recovery programmes to aid people, families, and groups.

7.3.2. EFFORTS TO OVERCOME DIFFICULTIES IN USING AI FOR DRR

There are numerous obstacles to using AI for DRR, and there are attempts being made to remove them. These initiatives support increased data accessibility, offer packages and tools to aid in AI development, improve model explainability, present novel uses for AI-based techniques (such as digital twins), and contribute to the creation of standards. AI has the power to completely change catastrophe risk reduction strategies. However, there are a number of obstacles to using AI, such as the cost, privacy problems, moral dilemmas, and poor data quality. Governments, researchers, and private businesses must collaborate to create strategies for efficient regulation, data collection, and data sharing in order to handle these issues. Additionally, study is required to create novel methods for utilising AI to lower risk, such as creating new ways to use AI to support decision-making or utilising AI to find early warning signs of disasters. AI has the potential to be an effective instrument for saving lives and lowering disaster risk. DRR currently employs AI in a variety of methods. Using satellite imagery and other data sources, AI algorithms are being used to identify floods, landslides, and other catastrophes in almost real-time. The potential extent of flooding and the population at risk are just two examples of the potential effects of catastrophes that AI is being used to predict. AI is also being used to optimise how resources are allocated in DRR initiatives, including the best locations for shelters and escape routes. Despite the promise of AI in DRR, there are a number of obstacles that must be overcome before its full potential can be realised. These include the need for better data integration, better access to data, and the necessity of stakeholder cooperation that is more successful. The use of AI raises ethical concerns that must be handled as well.

As has already been mentioned, gathering data with accurate sampling and adequate representation of each pattern for a particular issue is one of the biggest challenges when developing an AI algorithm for DRR. Open datasets, also known as ("benchmarking" datasets)[95] can be a useful tool in this situation. Teams aim to enable other researchers to use the data gathered to enhance and supplement current solutions by opening sourcing their data. The given data must be well-documented, accessible, and include metadata in order to meet this objective. To prevent the unintentional release of language that could be used to identify a person, steps should be made to block, remove, or edit the data. Additionally, it is recommended to offer detailed instructions on how to download and start using the data. Many teams open source their work with excellent documentation, but the absence of discoverability prevents them from seeing an increase in use cases. Links can be used to fix this.

A variety of tools that help with the four main components of AI implementation—data collection, model development, model deployment, and

[95] ClimateNet: an expert-labeled open dataset and deep learning architecture for enabling high precision analyses of extreme weather, European GeoScience Union, 2021; WeatherBench: A Benchmark Data Set for Data-Driven Weather Forecasting, Advancing Earth and Space Science, 2020; A set of benchmark tests for JULES, ECMWF, 2009

model retraining/monitoring—can be used by AI developers in addition to open-source data. There are a number of commercial and open-sourced tools for AI developers within each of these categories. For instance, a lot of scientists depend on manually labelled open-source imagery. Shared file systems, on the other hand, can boost productivity by automating annotation and helping with data gathering. The machine learning/data science practitioner should use the most well-known tools once the data have been labelled (e.g., Python Tensorflow, Keras, and Pytorch). The training and model design of many well-liked models can be streamlined. For instance, Pytorch Lightning is a framework for managing data within specific models that is developed on top of Pytorch. Last but not least, there are internal options for model deployment and monitoring (i.e., without the cloud). This necessitates a dedicated model server that provides latency and availability assurances. However, it would be wise to take into account the use case, the cost of resources, the number of trained staff to guarantee the model's availability, and finally, how frequently you anticipate you will need to retrain your model before implementing such a solution. However, to guarantee model accuracy, retraining, and availability, systems like Amazon Lambda and Gateway, Sagemaker, Google AI platform, and Watson model deployment still need on-call machine learning/data science resources[96] or layer-wise relevance propagation[97],One can examine the model and its learned feature significance in the input data to determine what is most relevant for a prediction using XAI tools like integrated gradients or layer-wise relevance propagation. Data imbalances can also be found when switching from local to global XAI techniques, and artefacts can even be unlearned[98].

The sharing of open-source data, the development of tools, and the advancement of AI-related study are all being driven by revolutionary

[96]Sundararajan, M., A. Taly, and Q. Yan, 2017: Axiomatic attribution for deep networks. Proceedings of the 34th International Conference on Machine Learning, 3319–3328

[97]Bach, S., A. Binder, G. Montavon, F. Klauschen, K.-R. Muller, and W. Samek, 2015: On pixel-wise explanations for non-linear classifier decisions by layer-wise relevance propagation. PLoS ONE, 10(7):e0130140.

[98]Anders, C. J., L. Weber, D. Neumann, W. Samek, K.-R. Müller, S. Lapuschkin, 2022: Finding and removing Clever Hans: Using explanation methods to debug and improve deep models. Information Fusion, 77, 261-295

opportunities to use AI to improve DRR approaches and services (e.g., in XAI). For instance, the development of innovative digital ecosystems[99]with user/service-oriented federations of GPU-CPU HPCs as well as specialised software infrastructure is anticipated to be significantly accelerated by the creation of digital twins of the Earth (i.e., digital replicas of the Earth system and its components).[100]. The European Commission has started the Destination Earth project in this context, and some of the initial identified twins and use cases are DRR focused. Digital twins will be implemented and used effectively in large part thanks to artificial intelligence (AI), which will make it possible, for example, to fully couple and depict the human component as a part of the Earth system.

Standardization, or the development of globally accepted guidelines, is another crucial action that can support the adoption of AI in DRR. International standards developing organisations (SDOs), such as the International Organization for Standardization (ISO), the International Electro-technical Commission (IEC), and the International Telecommunication Union (ITU), are currently carrying out fundamental standardisation activities in the disaster management sector. Technical rules are also being produced with assistance from other UN organisations, such as WMO, UNEP, the UN Office for Disaster Risk Reduction (UNDRR), and the World Food Programme (WFP) frameworks, advised methods, and unofficial norms in this area. Artificial intelligence is already being used effectively in many nations, and it has the potential to completely transform catastrophe risk reduction and management. It can be used to increase forecast and prediction precision as well as to give decision-makers more precise and timely information. AI can be used to improve early warning systems, as well as to comprehend catastrophe causes and the results of mitigation efforts. AI can be used to improve disaster risk assessment models and to pinpoint the people and places that are most susceptible. By lessening the effects of catastrophes, this technology can help protect people and property.

[99]Nativi, S., P. Mazzetti, and M. Craglia, 2021: Digital ecosystems for developing digital twins of the Earth: the Destination Earth case. Remote Sensing 13, 2119

[100]Bauer, P., P.D. Dueben, T. Hoefler, T. Quintino, T.C. Schulthess, and N.P. Wedi, 2021: The digital evolution of Earth-system science. Nature Computational Science 1, 104-113.

AI has the ability to be an effective DRR tool. Multiple data sources can be integrated by AI algorithms, leading to more precise forecasts and early notification systems. AI can be used to optimise resource allocation in DRR efforts and to identify disasters in almost real-time. Despite the promise of AI in DRR, there are a number of obstacles that must be overcome before its full potential can be realised. These include the need for better data integration, better access to data, and the necessity of stakeholder cooperation that is more successful. The standardisation of AI for DRR has largely been unexplored, even though these technology-centric standards typically seek to employ existing ICT solutions for improving operational efficiency of early warning systems and maintaining the required services for disaster recovery. ITU, WMO, and UNEP created the Focus Group on Artificial Intelligence for Natural Catastrophe Management in December 2020 in response to this.

7.4. THE FOCUS GROUP IS AT THIS MOMENT

Examining the potential applications of AI for the various kinds of natural catastrophes that can develop into hazards and drafting best practises for the application of AI to support modelling at multiple spatiotemporal scales and the provision of efficient communication during such events.

The Focus Group is actively evaluating proposals on additional topics and currently has ten topic groups investigating the use of AI for multi-hazards, insect plagues, landslides, snow avalanches, wildfires, vector transmitted diseases, volcanic eruptions, and hail and windstorms. The Focus Group is also creating a roadmap with existing standards and technical guidelines on this subject from various international, national, and regional SDOs in order to highlight and grasp the standardisation gaps in this application. This roadmap will enable us to pinpoint upcoming standardization-related areas that need focus.

Additionally, the Focus Group is creating a glossary that maps the words and definitions currently used in connection with the subject to guarantee consistency and clear communication within the DRR standardisation stream.

This study concentrated on the applications of artificial intelligence to crisis management and how they can improve it. This research specifically looked at the various applications of AI to pinpoint the strategies and tactics used during the various stages of disaster management. This study demonstrates the value of AI models in enhancing crisis management. We also came to the conclusion that current patterns emphasise how to react to and lessen a disaster. Geospatial technology is constantly developing, offering an immediate fix and a rich goal for GI Science. As a result, it is crucial to consider and improve the geographical implications. GIS and RS are effective instruments today that give us a new understanding of emergencies.

In the future, we anticipate that AI technology will soon be accessible with a more intricate and multispectral dataset, which will undoubtedly help to lessen the effects of disasters. However, a new, venerable branch of informatics has emerged as a result of geographical analyses using geographic information systems and remotely sensed data. Therefore, using artificial intelligence to deal with both natural and man-made catastrophes has enormous potential. Naturally, the proprietary data management and analytical powers built into the underlying algorithms are directly related to the success of any AI platform. However, other crucial technological elements are also crucial to the success of an effective management team.

7.5. RECOMMENDATIONS

There is a lot of interest in the area of DRR in investigating the advantages of utilising AI to support current approaches and tactics. This article presented a number of use cases illustrating how AI-based models are improving DRR, but it also demonstrated that AI has drawbacks. Fortunately, the potential of AI in DRR has spurred research to address these issues and inspired new collaborations, bringing together specialists from various United Nations agencies, from different scientific fields (such as computer science and geosciences), from various industries (such as academia and NGOs), and from all over the world. Such collaborations are essential for advancing AI in DRR. We think that more work needs to be done, specifically, in the area of developing educational materials that will support capacity development, ensure the availability of computational resources and other hardware, and close the digital gap. We can only ensure that everyone benefits as AI for DRR develops by doing this.

The main objective should be to gain support by presenting a convincing picture of a resilient Andhra Pradesh. The best method to honour the lives lost in such an accident is to prevent it from occurring again. Here, the researcher offers his top recommendations for helping the Andhra Pradesh government and populace prepare for, react to, and recover from disasters. Building community resilience and preparing for one catastrophe, such as floods, can help build resilience for other disasters, such as conflicts, violence, and disease outbreaks.

Communities must be put first in order to rebuild Andhra Pradesh and increase resilience to endure future shocks. The only way forward is through community-owned, -led, and -managed eco-friendly growth pathways for planning, design, development, implementation, and monitoring.

The success of Andhra Pradesh's development paradigm, which is characterised by solid development indicators and abundant social capital, must be built upon by the "Rebuilding Andhra" Initiative. The rebuilding strategy should be based on eco-friendly, sustainable practises, organic farming methods, and the protection and preservation of biological variety.

River banks and coastal regions should be subject to strict enforcement of construction byelaws and Development Control Regulations. People are killed by poorly built buildings, not by earthquakes. The Sustainable Development Goals (SDGs), Disaster Risk Reduction (DRR), and Climate Change Adaptation (CCA) must direct municipal development planning.

Boost scientific rigour, give more attention to tracking weather patterns, and reach out to those living in disaster-prone areas with alert and early warning messages.

Create platforms, tools, and methods for communicating with individuals who have special needs. To guarantee greater coordination before, during, and after disasters, strengthen inter-institutional coordination mechanisms.

For every dam in the province, management plans must be created. All organisations tasked with the duties of power generation, dam safety, water management, and crisis management must effectively coordinate inter-institutional monitoring of management plans and rule curves for releasing water from the dams.

The "Rebuilding Andhra" Initiative must acknowledge the collective strength and compassion of everyday people, the social capital of Andhra Pradesh, and the collective capability of community-based organisations, tech-savvy youth, the private sector, educated and experienced seniors, elected local representatives, democratic institutions, frontline workers and cadres of political parties, the fish worker community, ex-servicemen, media, multidisciplinary professionals, faith-based organisations, and others.

The use of tools and techniques for monitoring reservoir levels, inflow into reservoirs from rivers, river water levels, rainfall forecasts and "nowcasts" to enable micro level weather forecasting should direct the application of technology to water management in dams.

It is necessary to develop mechanisms for better coordination between the Central Water Commission (CWC), the Indian Meteorological Department (IMD), the Andhra State Electricity Board (ASEB), the Andhra State Disaster Management Authority (ASDMA), the Andhra Dam Safety Authority, the Andhra Coastal Zone Management Authority, and other pertinent Central and State government agencies.

The use of drones for risk assessment and vulnerability analysis in riverbanks and coastal areas vulnerable to coastal erosion, soil piping, subsidence, etc., as well as the application of scenario analysis, expert systems, artificial intelligence, virtual reality, and other emerging technologies, should be adopted.

Arrange peer-to-peer exchange trips to places and communities (both inside and outside the nation) that have established effective local disaster preparedness and response initiatives (e.g. Orissa, Bangladesh, Cuba). The "immersive and practical learning" will benefit from this.

Before the upcoming rainy season, Andhra Pradesh should start the following practical measures:

1) Instruct all kids in swimming. It is necessary for pool owners, both private and public, to assist and collaborate with the fish workers.

2) Teach students, educators, cabbies, and fishermen life-saving first aid techniques as well as flood-related protective public health.

3. Leadership in crisis situations differs from leadership in other situations. Conduct an all-day experiential learning simulation session for various groups using activities that immerse them in a real-world environment.

The improvement of leadership and decision-makers' preparedness is dependent on this, including important Ministers and Politicians from all parties, District Collectors and other important officials, as well as media, journalists, and social media influencers.

Palliative care and pain management for those who are terminally ill or need end-of-life care are lacking on a worldwide scale. Andhra Pradesh offers a fantastic platform for the development of a worldwide model for the provision of palliative care, pain relief, and end-of-life care in humanitarian contexts thanks to its excellent and distinctive cadre of palliative care workers and community networks. This invention may serve as the lasting memory of Andhra Pradesh's contributions to global humanitarianism.

The true measure of crisis readiness is not just how well-prepared the government is, but also how well-prepared the populace is. Simple solutions and practical actions can make a big difference in preventing catastrophes from turning into humanitarian crises.

Governments must act quickly to help rebuild homes and lives after a catastrophe; there is an urgent need for a quick evaluation of damage estimates and repair costs. Disaster damage and repair expenses can be estimated using AI techniques. Particularly, supervised models, like regression and neural networks, have been used to quickly process imagery for spotting structural damage, figuring out what repairs are necessary, and estimating the cost of those repairs. They have also been used to analyse historical dispersion data of disaster recovery funds for budget allocations and to process insurance claims more quickly. The fact that there are so few papers in this area suggests that AI applications are still in their infancy. The cost of damage caused by disasters is currently approximated based on actual data from various sources, including insurance claims, post-disaster assessments, and grants and loans to victims. Big data availability and the quick advancement of data analytics present a once-in-a-lifetime opportunity to advance AI applications in the near future for the quick estimation of catastrophe loss and repair costs. However, there may be wide variations in estimates of the economic effects due to the absence of standardised procedures for data collection and documentation. As a result, there is a pressing need to create policies and standards for data collection.

Following a catastrophe, rumours and fraud pertaining to disasters may surface, necessitating the knowledge and alertness of both disaster victims and governments. Data mining can be used to spot potential fraud, monitor information flow trends, and spot rumours.

There are numerous groups, conferences, and reports available to WMO community members who are interested in learning more about the application of AI for DRR. For instance, the Committee on Artificial Intelligence for Environmental Science and Climate Change AI of the American Meteorological Society provides the chance to communicate with other experts in this area. Two examples of conferences showcasing ground-breaking research and use cases are the "AI for Earth Sciences" session at the recent Neural Information Processing Systems (NeurIPS) meeting or the "Artificial Intelligence for Natural Hazard and Disaster Management" session at the upcoming European Geosciences Union General Assembly. Finally, additional advice can be found in documents like "Responsible AI for Disaster Risk Management: Working Group Summary."

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