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# Artificial intelligence and cloud-based Collaborative Platforms for Managing Disaster, extreme weather and emergency operations

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ABSTRACT

Natural disasters are often unpredictable and therefore there is a need for quick and effective response to save lives and infrastructure. Hence, this study is aimed at achieving timely, anticipated and effective response throughout the cycle of a disaster, extreme weather and emergency operations management with the help of advanced technologies. This study proposes a novel, evidence-based framework (4-AIDE) that highlights the role of artificial intelligence (AI) and cloud-based collaborative platforms in disaster, extreme weather and emergency situations. A qualitative approach underpinned by organizational information processing theory (OIPT) is employed to design, develop and conduct semi-structured interviews with 33 respondents having experience in AI and cloud computing industries during emergency and extreme weather situations. For analysing the collected data, axial, open and selective coding is used that further develop themes, propositions and an evidence-based framework. The study findings indicate that AI and cloud-based collaborative platforms offer a structured and logical approach to enable two-way, algorithm-based communication to collect, analyse and design effective management strategies for disaster and extreme weather situations. Managers of public systems or businesses can collect and analyse data to predict possible outcomes and take necessary actions in an extreme weather situation. Communities and societies can be more resilient by transmitting and receiving data to AI and cloud-based collaborative platforms. These actions can also help policymakers identify critical pockets and guide administration for their necessary preparation for unexpected, extreme weather, and emergency events.

## 1. Introduction

Emergency and extreme weather situations such as earthquakes, floods, pandemics and droughts occur frequently today due to rapid climate changes. These extreme weather events put the lives of millions at risk along with big threat to infrastructure, agriculture and financial system. In the process of disaster management, the loss of lives occurs mostly due to the inadequate and delayed dissemination of information, allocation of appropriate resources and minimisation of risk (Bharosa et al., 2010; Fleming et al., 2020; Gupta et al., 2021). To avoid these losses, it is essential to focus on deploying technologies that can help efficiently manage the different phases and aspects of an emergency, extreme weather and disaster situation (Modgil et al., 2021a). On one hand the cloud platforms allow multiple-tenants (agencies, NGOs, public and private entities) to use the storage capacity, whereas AI further enhances the capability of cloud platforms to extract the meaningful data in pre-disaster to develop the alerts, during disaster to execute the rescue operations and prioritization (Dubey et al., 2021; Schniederjans et al., 2016). During post-disaster AI enabled cloud platforms facilitate the faster recovery of community, and infrastructure to businesses to continue their operations as quick as possible and prepare towards any future events (Ahmad and Ma, 2020; Cao et al., 2021).

In natural disaster and extreme weather situations, most public systems struggle to provide the information to citizens about emergency shelter options, fatalities, government policies, medicines and diagnostic and treatment options available (Vaishya et al., 2020; Miller and Brown, 2018; Blaikie et al., 2014; Burkle, 2006). Additionally, misinformation can create fear and unrest among people, resulting in a

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shortage of commodities due to panic buying, rising prices and discrimination (Gunessee and Subramanian, 2020; Nicola et al., 2020). The discrimination includes the unequal access to assistance, enforced relocation and provision of aid. Therefore, it is critical that vulnerable communities have regular access to accurate and verified information published by agencies and governments in a transparent manner that can help them in extreme weather situations (Klippel et al., 2006). For instance, a location and mobile driven system helped local administration evacuate millions of people in India in recent floods (Sinha et al., 2019).

A number of stakeholders coordinate in emergency, extreme weather and disaster-relief operations, including government entities (fire departments, hospitals, police, local governments, etc.), non-governmental organizations (NGOs, e.g. Red Cross, Oxfam, etc.), and R&D institutes and companies (oil and gas sector, mining, fishing, construction, etc. (John et al., 2019). Seamless information sharing is the key to appropriate coordination (Kunz et al., 2014), and such a system is easy to use and capture real-time information (Ramesh et al., 2014; Middleton et al., 2013). Most of the time, every stakeholder uses their own data and approach to handle and contribute to crisis management, and they often lead to mismanagement or fragmented way of handling the disaster and emergency situations (Akter and Wamba, 2019; Middleton et al., 2013). Through AI and Cloud-based system, when the information shared by each stakeholder can be combined and meaningful data is extracted for further action, can result into more number of lives saved first and speedy execution and recovery.

On one hand cloud facilitate the storage of multiple type and huge data that can be used for alarming the citizens in different ways and AI can facilitate the smooth coordination between the parties (public, private, volunteers and victims etc.) involved right from pre-disaster to post-disaster scenario (Fan et al., 2021; Sun et al., 2020). This way AI and cloud-based collaborative platforms offer the supporting environment to handle the disaster, extreme weather and emergency operations. AI and cloud-based collaborative platforms can improve disaster response by processing information faster and accurately among stakeholders and help to align inter-organizational activities (Garg et al., 2021). This will further help in reducing the time for damage assessment and enabling quicker delivery of aid and supplies in extreme weather (Behl et al., 2021; Farnaghi and Mansourian, 2013).

Whenever an emergency or extreme weather situation arises, everyone first thinks about how quickly they can get out of it, either by reaching a safe place (e.g. in floods or cyclones) or attaining a drug or prevent a disease (Ebrahim et al., 2020; Cox and Perry, 2011; McGuire et al., 2007). Apart from this, many companies are applying approaches from green manufacturing (Choi et al., 2012) to commodity distribution (Cao et al., 2021) and track them with potential technologies such AI. Apart from this AI is also employed to reduce the environmental impact of production and minimise the carbon footprint by advancing the materials and employing robots to reduce waste and energy consumption. Similarly, in extreme weather situations, AI tools and cloud-based collaborative platforms can be applied to understand the spread of weather and prepare plans for mitigation, preparation, response and recovery (Sun et al., 2020; Helbing et al., 2015). For instance, tools like international charters (for satellite images and damage assessment), remote sensing (for physical characteristics of the area) and climate service (detect extreme events). These tools can also be instrumental in enhancing situational awareness, resource distribution, rapid damage assessment and evacuation notification tracking among stakeholders. Critical uses of such a technology could include an automatic alert to a hospital if patients need a specific care (Chou et al., 2022; Lee et al., 2021). The movement of citizens is restricted usually in affected areas, therefore facial recognition technologies can help identify people's movements in extreme weather or situation affected areas (Huang et al., 2020), and autonomous vehicles such as drones can be used for delivering household items (Chowdhury et al., 2017). AI and cloud-based collaborative platforms can also help identify people not following the rules in extreme weather situations and alert them from time to time.

Two aspects are critical in any emergency or extreme weather situation from business perspective: first, the storage, security and availability of data to drive business decisions, and second, the analytical and information-processing capability of the organization (Kunz et al., 2014). In this context, AI requires a robust dataset to provide the best predictions and recommendations (Bui et al., 2020; Campbell et al., 2020), which can be achieved with an AI and cloud-based collaborative platform that is capable of translating speech into text and vice versa. AI employ natural language processing, pattern recognition and forecasting techniques for better prediction, whereas cloud computing provides a service platform for emergency and extreme weather situations (Akter and Wamba, 2019; Behl et al., 2021). Mobile applications facilitate on-the-go access, ease of use and ease-of-update that is suitable for emergency and extreme weather conditions. A mobile application is a highly connected, protected, real-time, adaptable and agile platform that has capability to facilitate an emergency in emergency and extreme weather condition, which is most relevant in today's context of internet and smart phone penetration. Data in different forms (text, video, audio, numbers and images) in emergency and extreme weather conditions can be analysed through intelligent technologies such as AI and require continuous data synchronisation capabilities for quick dissemination (cloud platforms) across stakeholder network. Existing studies have considered technologies resolving the problems in pre-disaster (Sakurai and Murayama, 2019), during disaster (Fan et al., 2021) or post-disaster (Sinha et al., 2019). However, the studies, lack in exploring the integrative approach of employing intelligent technologies to address the complete phases of a disaster cycle (Cao et al., 2021; Fan et al., 2021). Additionally, studies lack employing technology in re-evaluating their status quo for any near future disasters. In building upon these gaps, this work explores the following research question: *How can AI and cloud-based collaborative platforms help to effectively address emergency, extreme weather and disaster relief operations?* To answer this question, a set of semi-structured schedule is developed for interviews with respondents who use AI and cloud-based collaborative platforms during extreme weather and emergency situations. It is critical to have technologies and structure in place to handle uncertainties developed through a disaster; hence, OIPT becomes suitable for this study. Further, after data collection themes, propositions and an evidence-based novel framework (4-AIDE) have been developed through a systematic coding process.

The rest of the paper is composed of six sections. Section 2 presents a review of existing studies and highlights the research gaps, whereas section 3 discusses the research context and theoretical background of the study. Section 4 highlights the research design and methods adopted for this study. Data analysis and findings are presented in section 5, followed by a discussion of implications for theory, practice and policy in section 6. Section 7 concludes the study.

## 2. Literature review: emerging technologies for disaster, extreme weather and emergency operations management

Emergency, extreme weather and disaster situations create obstacles to prevent organizations from supplying essential products and services in affected areas (Akter and Wamba, 2019; Keleş et al., 2018; Choi et al., 2012; Tierney, 2007). The emergency and extreme weather life cycle can be divided into three phases, i.e. (i) pre-disaster (preparedness phase); (ii) during the disaster (response phase); and (iii) post-disaster (recovery phase), including the rehabilitation of affected people and individuals discharged from hospitals and the construction of required infrastructure (Ahmad and Ma, 2020; Sheppard and Landry, 2016; Noran, 2014). Literature also highlight developing the enough resilience to mitigate any upcoming disruption, once the post-disaster phase is over (Aldunce et al., 2014; Modgil et al., 2021b; PwC, 2013).

Firms, government and other parties involved can contribute significantly in each of these phases by adopting a resilient and preventive approach to prepare the community (Djalante et al., 2020; Alduncе et al., 2014). Healthcare services and temporary infrastructure play a critical role during disaster, extreme weather and emergency situations, (Watson et al., 2019; Burke et al., 2004); however, there is need of a system that can support structural, functional and non-structural assessment to reduce the damages caused by emergency, extreme weather and disaster situations (Jiansheng et al., 2020). Such frequent evaluations and interventions can also help strengthen community resilience during emergency and extreme weather situations (Masten and Obradovic, 2008).

The list of stakeholders obstructed by an extreme weather and disaster includes everyone from individuals to healthcare services, transportation system, schools, shops, offices, factories, public and private properties etc. (Sakib et al., 2021; Fleming et al., 2020; Mojtahedi and Oo, 2017; Chen et al., 2013). In pre-disaster phase (first phase), AI and cloud-based collaborative platform technologies can be helpful in developing an early warning system for stakeholders to be alerted and better organize in case of an extreme weather or disaster strikes (Collins and Kapucu, 2008). For instance, Odisha (India) has developed an early warning system for public in the state, district and block level, where they integrated the technologies such as location-based alert system, digital mobile radio, a universal gateway and remote siren system (Sinha et al., 2019; Ray et al., 2017). AI and cloud-based collaborative platforms can facilitate monitoring and evaluation of different risks associated with natural or manmade extreme weather and disasters of near future (Kemper and Kemper, 2020; Sun et al., 2020).

In this way, AI and cloud-based collaborative platform technologies can be employed to create user-friendly and meaningful advisories based on the current setting and historical patterns to minimise risk and ensure sufficient preparedness (Gupta et al., 2021). AI and cloud-based collaborative platform technologies help integrate data from forecasts, observations, sensors and spatial or non-spatial data provided by various agencies (Akter and Wamba, 2019). These parameters help authorities to frontline professionals efficiently and effectively execute the preparedness measures.

The second phase (during the occurrence of disaster and extreme weather) is among the most critical, as it directly pose threat to human lives (UNDRR, 2020). The objective of this phase is to reduce casualties and damages as much as possible within the short period of time (Wex et al., 2014). This period is referred to in terms of 'golden' hours, days and weeks, where disaster response activities must be implemented quickly and effectively (Lai et al., 2009). Algorithm-based integrated platforms can use crowdsourcing so that heavily impacted areas can be prioritised based on geo tags (Poblet et al., 2018), which can further help to develop heat and cluster maps to guide army, police and disaster relief teams to exact coordinates in the field (Wex et al., 2014; Burke et al., 2004).

In the third phase (recovery), AI and cloud-based collaborative platform technologies can play a critical role in the assessment of affected population, redeveloping or restoring the supply chain network and the cooperation among stakeholders to develop a shelter and clothing system (Cao et al., 2021; Fleming et al., 2020; Mojtahedi and Oo, 2017). It is very difficult to forecast and predict the exact impact of extreme weather and disaster event (Siegrist and Gutscher, 2008; Baum et al., 1983). Greater resilience can be achieved when there is a transparent and accurate assessment through emerging technologies such as AI and cloud computing (Aitsi-Selmi et al., 2016; Modgil et al., 2021b; Sun et al., 2020), and quickly communicable. In addition to helping identify the impact of an extreme weather, these technologies also prepare critical stakeholders such as rescue teams, insurance agencies and concerned health personnel to increase their capacities to handle such an emergency (Fan et al., 2021).

Earlier studies have highlighted the importance of pre and post phases in the extreme weather and disaster life cycle (Hazarika et al., 2020; Sakurai and Murayama, 2019; Oloruntoba et al., 2018); however, these studies lack in focusing on integrating and disseminating information for alert and warning systems along with the execution of location-based systems in the field. For instance, Poblet et al. (2018) discussed crowdsourcing with a focus on types of data and the people's use of a mobile application post-disaster; however, the study does not highlight the potential of AI and cloud-based collaborative platform technologies in the effective management of extreme weather, emergency and disaster like situations and use of mobile application during and pre-disaster phases. In another study, Hazarika et al. (2020) demonstrated the role of social media posts in recovery coordination during Hurricane Harvey, which hit Texas and Louisiana in August 2017; however, they did not cover the role of social media in other phases of disaster management. Another recent study by Kemper and Kemper (2020) discussed the fusion of GPS, AI and sensor-generated data; however, this work missed a grounded theory perspective to offer integrated insights and the study focus more on during and post-disaster and ignore other phases of disaster management.

To address these gaps, this study emphasizes on the effective management of emergency and disaster relief operations through AI and cloud-based collaborative platform technologies grounded in organizational information processing theory.

Table 1 highlights a select review of studies of AI-based technologies in extreme weather, emergency and disaster relief situations. It is evident that either a theoretical lens is missing or the studies only address a particular phase—i.e. readiness or response or recovery or re-evaluation either in pre or post-disaster scenario. To identify, develop and propose an AI and cloud-based collaborative platform, we considered the research gaps highlighted to pursue a qualitative study in which experts' views were analysed to develop a framework.

## 3. Research context and theoretical background

### 3.1. Artificial intelligence

Artificial intelligence has received a great deal of attention in the last decade due to its rising economic and organizational significance (Wamba-Taguimdje et al., 2020). The information processing capabilities of AI help convert inputs (videos, images, numbers, text and audio stored at clouds) to outputs (informed decision and solution) by employing processing algorithms those are particularly relevant in emergency, extreme weather and disaster relief operation situations (Sun et al., 2020; Fan et al., 2021; Kunz et al., 2014). In traditional and manual systems, it may take longer to evaluate and respond to the needs of victims stuck to emergencies. Additionally, traditional approach of hieratical structure takes longer time to rebuild infrastructure, leaving affected people vulnerable. However, due to its accurate and quick processing capabilities, AI can help reduce and repair damage by more accurately and efficiently allocating resources, as it creates a healthy environment for cooperation and coordination among multiple stakeholders (Bharosa et al., 2010). AI is capable of assisting rescue professionals more quickly and accurately assess needs and deliver aid to different locations (Modgil et al., 2021a). However, to successfully deploy AI technologies, experts and professionals from both the public and private sectors need to collaborate to direct the data towards meaningful applications and alignment of resources.

AI can prevent the death of thousands of citizens by employing predictive modelling that learns from the trends of earlier events. For instance, AI can facilitate the prediction of location and analyses the magnitude of earthquakes and aftershocks (Reyes et al., 2013), and it can utilise geological and seismic data to predict volcanic eruptions (Akter and Wamba, 2019). AI can use rainfall records, density and flood simulations to predict the impact of flooding and help monitoring the extent (Fleming et al., 2020), that can act as a base for further planning. AI technology can also be integrated with drones for the continuous monitoring of extent of extreme weather, disaster degree and necessary relief efforts (Chowdhury et al., 2017), and it can analyse satellite data to examine the intensity and route of hurricanes and tornadoes

**Table 1**
Select review and positioning of the study.

| Author(s) and Year | Objective of the study | Theoretical lens/ approach | Pre-disaster use of technologies | During disaster use of technologies | Post-disaster use of technologies | Gaps and limitations |
|---|---|---|---|---|---|---|
| Marić et al. (2021) | Develop a unified view of digital technologies adoption in humanitarian supply chain operations | Literature Review | Yes | Yes | Yes | Lack of insights from technology developers and supply chain professionals to apply digital technologies in humanitarian supply chain operations. |
| Fan et al. (2021) | Design and develop a disaster city digital twin integrating AI for emergency situations like disasters | Gaming theoretical decision-making approach | No | Yes | No | Applying AI to develop a disaster management approach using dynamic network analysis during disaster for better situation assessment |
| Behl et al. (2021) | Identifying the applications of AI for donation based crowdfunding platform | Uses and gratification theory | No | No | Yes | Focus only on crowdfunding platforms for faster recovery in post-disaster scenarios |
| Dubey et al. (2020) | Usage of Blockchain to enhance swift trust and transparency in operational humanitarian supply chain | Organizational Information Processing Theory and Relations View | No | Yes | Yes | Focus on the pre-disaster phase and non-linear relationships for emergency situations |
| Sun et al. (2020) | Identify the applications of AI in disaster management | Literature Review | Yes | Yes | Yes | Lack of a theoretical lens and no highlighting of the elements of different phases |
| Vaishya et al. (2020) | Identify the applications of AI for emergency situation like Covid-19 | Literature Review | Yes | Yes | Yes | Uses screening, analysis, prediction and tracking to monitor patients but lacks an adequate theoretical lens. |
| Sakurai and Murayama (2019) | Review the impact of El Nino Southern Oscillation on disaster risk | Conceptual | Yes | No | No | Preventive risk measurement can be strengthened with technologies and their usage in during and post disaster to reduce the impact of disasters. |
| Sinha et al. (2019) | Identify the applications of Internet of things in rescue planning operations | Task-Technology Fit | No | Yes | No | Application of Task-Technology Fit view with Internet of Things (IoT) for rescue operations vs the complete cycle of disaster management. |

(Nagendra et al., 2020; Behl and Dutta, 2019; Ansari, 2014).

### 3.2. Cloud technologies

The cloud is a virtual space on the internet where digital resources including files, folders, software and applications can be maintained, stored and retrieved as and when desired. Cloud computing technology enables the use and sharing of satellite network without being physically present. When cloud technologies are adopted, the upgrading of memory size is not a concern, unlike the case of physical devices and incurring the cost again and again. Emergencies generally require considerable processing capabilities of a system, when there is a high level of uncertainty and complexity, and the cloud facilitates the matching of fluctuating bandwidth requirements (Gunessee and Subramanian, 2020; Chowdhury et al., 2017). In other words, cloud technologies can be relied on for operational agility during emergency, extreme weather and disaster relief operations. Furthermore, cloud technologies eliminate the need for physical hardware and do not create disposal problems further down the road.

It is often necessary to access multiple remote locations during emergencies, and cloud technologies facilitate the access to online resources from any part of the world, thereby enhancing collaboration among different stakeholders (Kerle and Oppenheimer, 2002). The cloud technologies are increasingly employing AI along with satellite and drone data to further prepare the ecosystem to tackle disaster operations. The usage AI in cloud computing can help in accurate forecasting the movement of floods, wildfires, windstorms, earthquakes and hurricanes etc. Further this accurate information can help in reducing the damage, planning and allocation of resources and restoration plan in effective way (Fan et al., 2021). The use of AI in cloud computing can also help in notice any changes in the pattern in the weather that can be an early sign and governments and administration can quickly assess the degree of physical damage, before the ground workforce get into the relief work (Hernández et al., 2021). The combination of cloud and AI also capable to crowdsource the information from different social media platforms to view the changing conditions. Further AI facilitate cloud systems to present the visual analytics to the citizens for awareness point of view (Kuglitsch et al., 2022; Munawar et al., 2022). Different stakeholder and multiple-tenants can store their data on the cloud platform, which is not visible to other tenants, but AI can use this data on the permission to offer an optimal solution to the situations to tackle during disasters (AlJahdali et al., 2014). The multi-tenancy cloud offers greater pool pf resources available to government bodies and ease of access to almost any location and device in emergency situations.

Apart from this, government organizations and private entities can utilise cloud technologies on a pay-per-use basis to disseminate information to concerned stakeholders in emergencies (Ujjwal et al., 2019). In addition to helping communities, AI and cloud-computing technologies can help organizations design and develop strategies in a faster and more efficient way compared to normal weather and traditional disaster plans by generating map overlays that can further increase the situational awareness. Cloud computing technologies help create, test and update useful information to ensure the safety and continuity of business operations, and it offers organizations the use of ‘infrastructure as a service’, ‘platform as a service’ and ‘software as a service’ (Ferrer et al., 2016).

### 3.3. Organizational information processing theory

According to Galbraith (1973, p.2), there is no ideal way to organize and methods of organizing are not equally effective. Organizational information processing theory (OIPT) focuses on ‘information processing capabilities and requirements’ and emphasizes the need for quality information when organizations have to deal with considerable amount of uncertainty (Cho et al., 2018; Kreye, 2017) in emergency, extreme weather and disaster situations (Nagendra et al., 2020; Poblet et al., 2018). In disaster situation, it is critical to have contribution of every stakeholder (Freeman, 2010) ranging from public to private to NGOs and therefore stakeholder theory may seem a fit here, but in the age of digitization and big data flow, the coordination becomes much easier when information is shared quickly and accurately across in disaster management (Akter and Wamba, 2019). In disaster and emergency situations, it is critical to process and disseminate the information to stakeholders for timely efforts in integrative, accurate and quick manner (Bharosa et al., 2010). Further, the disaster management eco-system ability to handle the event depends upon how accurate and quick co-ordination is conducted between government, non-government agencies and resources both in urban and rural areas. Apart from this information processing capabilities of the disaster management eco-system can further facilitate assisting citizens, victims to contribute to real-time information in emergency and extreme weather conditions. Further the information continuously stored and retrieved from the cloud platform can be extracted and processed through AI to train the back-up resources both in terms of community and special forces. Hence, OIPT becomes relevant to this study, where *AI and Cloud-based Collaborative Platforms for Managing Disaster, Extreme Weather and Emergency Operations* are explored.

Certain features of an organization and system make it capable of handling emergencies (John et al., 2019). Features like structured design enable efficient operations in emergencies (Akter and Wamba, 2019). The design, development and implementation of effective operations in emergency, extreme weather and disaster situations needs to be closely integrated into the overall objective of the emergency operation, and it is necessary to split tasks into sub-tasks and drive decisions (Chou et al., 2022; Lee et al., 2021).

Frequently in emergency situations, a considerable amount of information is required that needs to be processed by decision makers and different stakeholder process it as per their understanding and capabilities (Poblet et al., 2018; Sakurai and Murayama, 2019; Shareef et al., 2019). The traditional style of individual processing of large amounts of information results in a bottleneck due to the lack of an integrated approach while handling the larger scale of an extreme weather and disaster (Noran, 2014; Sinha et al., 2019). Hence, to improve response time and effectiveness of information processing, it is necessary to adopt emerging technologies such as AI and cloud computing (Fan et al., 2021; Sun et al., 2020; Ujjwal et al., 2019).

Other technologies have also been used to enhance information processing capabilities; however, AI and cloud computing have been found the most suitable due to their ability (i) to enhance the organizational ability to pre-plan; (ii) to process and integrate data insights; and (iii) to be accessed remotely (Behl et al., 2021; Vaishya et al., 2020). Moreover, information-processing capabilities can be employed according to the level of goal difficulty and complexity or performance requirement during an extreme weather and emergency disaster situation.

## 4. Research design and methods

This study is designed based on epistemological principles and guided by the theoretical lens of organizational information processing theory. A qualitative approach is adopted, as it is best suited to the development of new theories and concepts. Strauss and Corbin (1990) illustrate a process of classifying and categorising the data into concepts (open code), categories (axial code) and then develop their relationship (selective code), therefore a three-layer approach of open, axial and selective coding is considered. A semi-structured interview (questions presented in Appendix A) is conducted to extract meaningful themes and categories. This study uses a thematic analysis as compared to other methods such as content analysis, because thematic analysis is useful in extracting the phenomenon and how the different components of a phenomenon are connected. In this study thematic categorisation helps provide evidence and extract insights into emergency situations and how AI and cloud-based collaborative platform technologies can play a critical role. The research protocol and mapping to different sections of the study is indicated in Fig. 1.

The qualitative study has its limited scope and conceptualization. The scope of this study is limited to disaster, extreme weather and emergency situations and how AI and cloud-based platforms are employed in the different phases of disaster, extreme weather, and emergency situations.

The issue of bias is common in qualitative research. To address the problem of bias in the study we adopted an individualistic approach in pre-interview stage of designing the questions and at the initial stage of interviews until the analysis and reporting of the data. To address this, if respondent somewhere tried to choose a yes or no, they are asked an alternative question to reduce the bias. Additionally, the study adopted an approach where they asked: what a third party would do in this particular situation to minimise the input bias. Further to make respondent connected, engaged and comfortable in responding the interview questions, the study designed general questions first and then leads to specific ones.

Experts, researchers and reports from archived resources are consulted further to minimise the bias. To support the case, a report (Alford, 2020) and three researchers working on a cloud and AI technology application for use in emergency, extreme weather and disaster relief operations are referenced. The structured process for the methodology adopted to conduct this research is presented in Fig. 2.

Further, to validate the findings of the study, a triangulation approach adopted, where industry report(s), data from the respondents and research articles is integrated to extract the emerging themes. Table 2 highlights the approach of triangulation and mapping to emerging themes.

### 4.1. Case selection

A case-based approach is adopted to drive propositions. The works of Eisenhardt (1989), Ketokivi and Choi (2014) and Pagell and Wu (2009) have confirmed the worth of case research in operations management. Case-based research facilitates building, validating and extending theory (Pan and Tan, 2011; Stuart et al., 2002). The proposition(s) developed through the cases can be viewed as a first step towards theory generation (Denyer et al., 2008). In case-based research, it is necessary to understand the figures indicated by events while speaking to experts in the field (Baxter and Jack, 2008; Pagell and Wu, 2009). Therefore, in-depth interviews are conducted with practitioners and professionals in the emergency, extreme weather and disaster field.

The utility of any technology can be best understood from the viewpoint of both users and providers (Munawar et al., 2022). Similarly, how AI technologies and cloud-based technologies are employed and what kind of decision support they provide can be extracted from the experts and organization's experience involved in each phase of usage during pre-disaster to post-disaster cycle (Cao et al., 2021; Fan et al., 2021; Sakurai and Murayama, 2019; Sinha et al., 2019). Therefore, this research began with case selection by cataloguing key disaster, extreme weather and emergency situations occurring in India along with identifying certain firms and how they used or are using AI and cloud-based collaborative platform technologies to address emergency situations in the disaster life cycle. Diverse respondents (Managers/Sr. Managers, Engineers, Vice Presidents, Board Members, Directors/CXOs/Founders and Consultants) using or providing cloud services such as platform as a service (PaaS), internal cloud and software as a service (Saas) were interviewed. All of these professionals have witnessed at least one emergency situation over the last five years, i.e. those with experience during floods (Gujarat, Kerala, Maharashtra, Assam and Telangana) or cyclones (Amphan (May 2020), Bulbul (November 2019), Fani (April 2019) and Nisarg (June 2020)) in India and employed SaaS or PaaS. These professionals spread indicate organizations such as Oracle, Amazon Web Services, IBM Cloud and Google Cloud, among others.

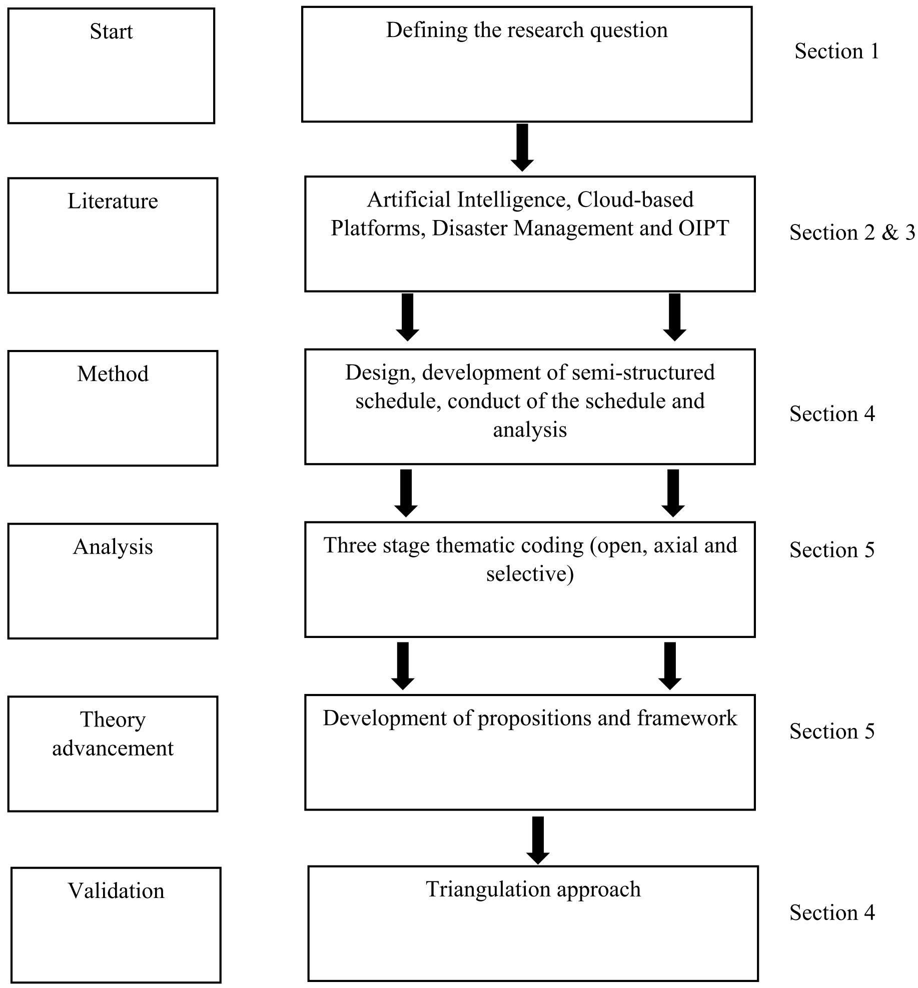


**Fig. 1.** Research protocol adopted in the study.

### *4.2. Data collection*

LinkedIn (a business networking platform) is used to examine the individual profiles (Jarrahi and Sawyer, 2013) related to emergency situations, to connect with professionals and schedule interviews. The profiles of professionals are extracted by using advanced search option (Davis et al., 2020). Boolean operators such as 'OR', and 'AND' are used (Bradbury, 2011). For instance, the syntax indicating the keywords (AI **OR** CLOUD) **AND** (DISASTER **OR** EMERGENCY **OR** EXTREME WEATHER) resulted in appearing 158 professionals involved in harnessing AI and cloud infrastructure in emergency situations are approached. Around 60% of the professionals did not reply to the first message, so a written reminder message is sent requesting them if they can assist in the research. After giving three reminders fortnightly, a total of 37 professionals agreed to participate in the interviews. Once they agreed via LinkedIn, a detailed background regarding the purpose of the study is sent to familiarise respondents with the research topic (Rowley, 2012). These 37 responses are further filtered for appropriateness and specificity in relation to the research objective. Finally, 33 responses are considered for further analysis (response rate 21%). Interviews are conducted across a period of four months (July–October 2020), and responses are collected in three phases. Virtual and telephone interviews are conducted (Novick, 2008), as travel and in-person interaction was not possible due to Covid-19. Table 3 indicates the respondents' details and their organizational roles. Additionally, the type of services (software as a service or platform as a service) used or provided by the respondents is noted. Most respondents had 5–10 years of work experience in the AI and cloud field. The identities of respondents R1 to R33 are masked to preserve anonymity. Almost the same answers started to be received after 31 responses, and the interview process is therefore saturated. Hence, at this point of time the interview process is halted.

### *4.3. Data analysis*

Various arrays and arrangements are developed, analysed and coded to drive meaningful themes from the interviews, and the relationships among different categories are identified. The range of views covered in the interviews indicated the potential of the data to answer the research question. A common technique of axial, open and selective coding is adopted to develop insights from the interview data. This coding approach made it possible to define the sub-themes and themes. In the first stage, the raw information on AI and cloud-based collaborative platforms for emergency, extreme weather and disaster relief situations is coded. In the second stage, axial codes are matched to a theoretical lens. Finally, a selective technique is adopted to present the observed phenomena. Axial codes are then integrated with OIPT theory principles with a back-and-forth examination to develop a framework (4-AIDE) that define the relationships among emergency situation management parameters through AI and cloud-based collaborative platform technologies.

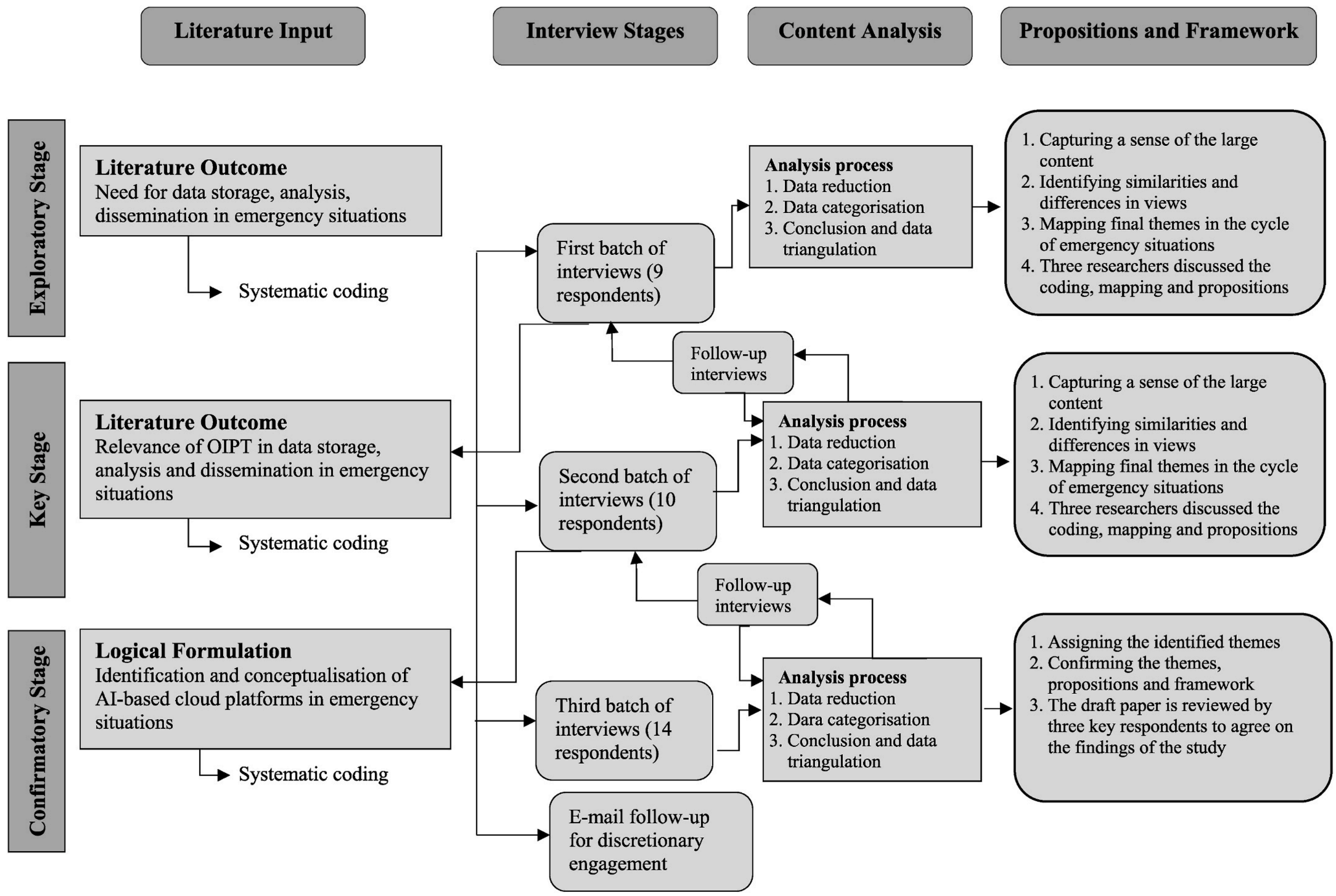


**Fig. 2.** Research design - coding, themes, mapping and framework stages (adapted from Shaheen and Azadegan, 2020).

## 5. Findings

### 5.1. Readiness

Table 4 presents the axial and related codes under the theme of 'Readiness'. Since the frequency of natural disaster, extreme weather and emergency situations is rising in the last two decades, firms and public systems need to prepare a multi-dimensional approach to be ready for such situations (Rodríguez-Espíndola et al., 2021). A well-prepared and flexible plan makes it possible to act quickly for a strong response and recovery (Oloruntoba et al., 2018). AI and cloud-based collaborative platform applications are capable to integrate business and community data from diverse perspectives and design-specific actions (Sun et al., 2020), and they can integrate data from local communities and governments for disaster-associated inclusive planning efforts. These technologies also offer multiple avenues according to different degrees and complexities of emergency situations and this way AI and cloud-based platforms can help the system getting ready.

### 5.2. Response

Table 5 presents the axial and related codes under the 'Response' theme. The deployment of AI and cloud-based collaborative platforms helps with preparation as well as sensing, analysing, and mitigating threats in disaster, extreme weather and emergency situations. AI and cloud-based collaborative platforms can help save many more lives by quicker response as compared to traditional approaches. Crowdsourcing through cloud computing algorithms can help meet humanitarian basic needs such as health, safety, food, shelter and clothing (Poblet et al., 2018). Sensor data and images from multiple sources can be integrated through AI and cloud-based collaborative platforms to design and execute an effective response (Kemper and Kemper, 2020). In addition, these technologies help allocate public and private resources to respond immediately in extreme weather, disaster coordination and relief activities. Business recovery centres can be created through mapped locations to assist in communication among critical stakeholders connected virtually at different locations. The feedback of victims' loops in cloud platforms can further enhance the effectiveness of the relief program in extreme weather and disaster situation.

### 5.3. Recover

Table 6 presents the axial and related codes under the theme of 'Recover'. In the third phase of the extreme weather and disaster cycle, businesses and public systems enter the restoration phase, and the repair and reconstruction of damaged assets and inventory begins. AI and cloud-based collaborative platform applications can help establish confidence and clarity when defining short- and long-term recovery phases for services, public systems and businesses (Masten and Obradovic, 2008). A structured mechanism that can facilitate the creation of new resources, economic diversity and new partnerships is necessary for long-term economic and capacity development. AI and cloud-based collaborative platforms can also be deployed to consider the social, economic and psychological effects of extreme weather, disasters and contribute to multi-dimensional well-being (Nicola et al., 2020). Remote areas can receive better services and have transparency if they are integrated into AI and cloud-based collaborative platform. For instance,

**Table 2**
Triangulation and emergence of themes to selective code.

| Industry Report(s) | Research Article(s) | Respondent Comment | Emerging themes | Mapping to selective code |
|---|---|---|---|---|
| Cheatham et al. (2015): In natural disaster (s), it is a challenge for government and other non-government organizations to design and develop a quicker, transparent and faster system. Intelligent technologies have the potential to get the public and private system on track along with ensuring business continuity. | Nicola et al. (2020): After disaster, the responsibility of restoring the infrastructure and progress of construction and other multi-dimensional well-being can be mapped through intelligent system. | R3 (Consultant in IT Services/Software domain): AI and cloud-based technology platforms can help in integrate the services being offered right from rehabilitation to ensuring supply systems. | -Business continuity<br>-Mapping progress of construction activities<br>-Ensuring the rehabilitation of vulnerable population | Recovery |
| KPMG (2018): The natural disaster prevention and readiness goes hand in hand with risk management, therefore a technological sound system can help in preventing and mitigate the risks. | Sun et al. (2020): AI based platforms can help in assessing the degree of risk that helps in aligning the resources and minimise the damage. | R30 (Vice President in Consulting domain): Given the widespread access to social media, it is critical how much organizations are ready to tackle a disaster. | -Identifying the risk<br>-Evaluating the degree of risk<br>-Technical readiness | Readiness |
| Deloitte (2012): Whenever a disaster strikes, the life of victims and physical assets are on top priority of the organizations. The response to any disaster is the resultant of scenario planning, simulations and aggressive preparedness. AI based platforms can support in data analysis and rescue planning that will speed up the response when needed most. | Kemper and Kemper (2020): The action taken at time of occurrence of a disaster indicate the outcome of the effort and intelligent platforms and data about communities can help in designing, planning and executing an accurate and timely response. | R21 (Manager in IT Services/Software domain): AI and Cloud-based technological assistance during the strike of a disaster helps insurance companies to visualize the damage assessment and settle down the claims at faster rate. | -Rescue planning<br>-Quick and accurate response<br>-Transparent damage assessment | Response |
| PwC(2013): The infrastructure does not have any value of business is destroyed by a disaster, therefore apart from infrastructure to develop a long-term resilience in the system AI and cloud-based platforms can be employed in re-evaluating and predicting near future disasters. | Fleming et al. (2020): The trends and forecasting is accurate when considered for shorter periods and identifying the hidden mechanism. AI supported system can help in self-learning of the mechanism and predict better the impact of a disaster. | R5 (Sr. Manager in Manufacturing Domain): An organization may suffer from different kind of disasters, cloud and AI based platforms can be employed to develop a specialized approach that in turn develops a resilient approach of the organization. | -Predicting uncertainty<br>-Long run resilience<br>-Preparing for near future disasters | Re-evaluate |

regional heads or community can observe through AI, if the allocated or collected amount (through crowdfunding) has been utilized in recovering the infrastructure in the stipulated time.

### 5.4. Re-evaluate

Table 7 presents the axial and related codes under the theme of 'Re-evaluate'. After experiencing an emergency situation, stakeholders (victims, rescue professionals and rescue agencies etc.) need to assess their circumstances and re-evaluate the importance of controls and business practices that can strengthen resilience. Firms need to re-evaluate how different types and scales of emergency situations can affect their business and what kinds of measures they need to put in place for that. Additionally, the role of public systems becomes critical during disaster and extreme weather situations. Public and private entities need to integrate their systems through hierarchy and deploy AI and cloud-based collaborative platform applications to simulate emergency situations that help in re-evaluation (Chen et al., 2013). Different variables and parameter-based simulations can help public and private systems understand their coordinated roles if an extreme weather or disaster strikes (Fleming et al., 2020). Such a re-evaluation will help reduce risk and enable preparation for an effective response and resilient recovery in disaster, extreme weather and emergency situations.

### 5.5. AI-based cloud applications in disaster, extreme weather and emergency situations

The scale of emergency situations and the range of response choices have changed with the advent of new technologies over the past decades. In the traditional system, the response and recovery approach are adopted in emergency situations. Later, the system evolved to include preparedness to strengthen the disaster life cycle and address the extreme weather and emergency situations (Oloruntoba et al., 2018). With the emergence of new technologies and the focus on AI and the cloud in the last decade, organizations have started to learn from emergency situations and are revaluating their role in making themselves strong enough to tackle any kind of unexpected and emergency situation that can impact public systems, businesses and ecosystems (Burkle Jr, 2006). As R27 (Sr. Manager from the insurance sector with more than 10 years of experience) stated: *AI-based cloud techniques can be helpful in processing information and generating insights from social media messages. Furthermore, information on impacted populations in terms of insurance status can be explored and healthcare services according to the health coverage can be provided apart from regular services.*

In this way, organizations from the healthcare, banking and financial services sectors can also help in emergency situations when they are integrated through AI and cloud-based platforms. By identifying risk nodes and early involvement of relevant stakeholders, firms can be more resilient, if an extreme weather appears or disaster strikes. These focal points resulted in to the first proposition:

**P1:** *AI and cloud-based collaborative platforms can have a significant impact in identification, analysis and assessment of associated risk and ensure the r-readiness to handle an extreme weather and disastrous situation. Contingency theory can be further integrated to test this hypothesis for practical application.*

The most dangerous phase in any disaster, extreme weather and emergency situation is when the disaster strikes and individuals respond to it along with the public system, agencies and volunteers. Detailed planning facilitates a better response. Once an AI and cloud-based collaborative platform is deployed to identify failure modes and recognise severity, the response will be much more effective (Fan et al., 2021). However, when responding, front-line agencies and volunteers need to understand characteristics such as the geography of the affected area, the number of available routes and the kind of aid required at different locations. AI and cloud-based collaborative platforms can deploy different tools ranging from crowdsourcing to algorithm-based solutions that can help design and execute an effective response in an emergency situation. According to R32, (an IT services engineer with around 10

**Table 3**
Details of respondents.

| Respondent Code | Age Group | Education | Type of Cloud Services Experience | Role in Company/ Institution | Number of Employees in Company/Institution | Domain of Work | Total Work Experience |
|---|---|---|---|---|---|---|---|
| R1 | 41–50 | PhD | Software as a Service (SaaS) | Consultant | 300–500 | IT Services/Software | More than 10 years |
| R2 | 41–50 | Post-Graduate | Software as a Service (SaaS) | Manager/Sr. Manager | 50–300 | Education/Research | 5–10 years |
| R3 | 51–60 | PhD | Platform as a Service (PaaS) | Consultant | 300–500 | IT Services/Software | 5–10 years |
| R4 | 31–40 | Post-Graduate | Software as a Service (SaaS) | Manager/Sr. Manager | 300–500 | Banking/Insurance/ Financial Services | 3–5 years |
| R5 | 41–50 | Post-Graduate | Software as a Service (SaaS) | Manager/Sr. Manager | 300–500 | Manufacturing | 3–5 years |
| R6 | 51–60 | PhD | Platform as a Service (PaaS) | Consultant | 500–1000 | Education/Research | 5–10 years |
| R7 | 31–40 | Post-Graduate | Internal Cloud | Consultant | 300–500 | Consulting | 5–10 years |
| R8 | 31–40 | Post-Graduate | Internal Cloud | Engineer | 500–1000 | Education/Research | 5–10 years |
| R9 | 20–30 | Post-Graduate | Software as a Service (SaaS) | Engineer | 300–500 | Banking/Insurance/ Financial Services | 5–10 years |
| R10 | 31–40 | Post-Graduate | Software as a Service (SaaS) | Engineer | 300–500 | Consulting | 3–5 years |
| R11 | 31–40 | Post-Graduate | Internal Cloud | Engineer | 500–1000 | Consulting | 5–10 years |
| R12 | 31–40 | Post-Graduate | Software as a Service (SaaS) | Engineer | 50–300 | Banking/Insurance/ Financial Services | 1–3 years |
| R13 | 20–30 | Graduate | Software as a Service (SaaS) | Engineer | 500–1000 | IT Services/Software | 1–3 years |
| R14 | 20–30 | Graduate | Software as a Service (SaaS) | Engineer | More than 1000 | IT Services/Software | 1–3 years |
| R15 | 20–30 | Graduate | Platform as a Service (PaaS) | Sales/Marketing Executive | 50–300 | Logistics and Supply Chain | 1–3 years |
| R16 | 20–30 | Post-Graduate | Software as a Service (SaaS) | Consultant | 300–500 | Consulting | 1–3 years |
| R17 | 41–50 | PhD | Platform as a Service (PaaS) | Director/CXO/Founder | More than 1000 | IT Services/Software | More than 10 years |
| R18 | 20–30 | Graduate | Software as a Service (SaaS) | Engineer | 500–1000 | IT Services/Software | 1–3 years |
| R19 | 31–40 | Post-Graduate | Software as a Service (SaaS) | Corporate Finance Executive/Analyst | More than 1000 | IT Services/Software | 3–5 years |
| R20 | 31–40 | Post-Graduate | Software as a Service (SaaS) | Consultant | More than 1000 | Consulting | 5–10 years |
| R21 | 20–30 | Post-Graduate | Software as a Service (SaaS) | Manager/Sr. Manager | 300–500 | IT Services/Software | 3–5 years |
| R22 | 20–30 | Post-Graduate | Platform as a Service (PaaS) | Engineer | More than 1000 | IT Services/Software | 3–5 years |
| R23 | 20–30 | Graduate | Software as a Service (SaaS) | Sales/Marketing Executive | More than 1000 | IT Services/Software | 1–3 years |
| R24 | 41–50 | Graduate | Platform as a Service (PaaS) | Government Employee | More than 1000 | Government | More than 10 years |
| R25 | 31–40 | Post-Graduate | Software as a Service (SaaS) | Engineer | 300–500 | Education/Research | 5–10 years |
| R26 | 31–40 | Graduate | Software as a Service (SaaS) | Engineer | More than 1000 | IT Services/Software | 5–10 years |
| R27 | 31–40 | Post-Graduate | Software as a Service (SaaS) | Manager/Sr. Manager | More than 1000 | Banking/Insurance/ Financial Services | More than 10 years |
| R28 | 31–40 | PhD | Software as a Service (SaaS) | Manager/Sr. Manager | More than 1000 | IT Services/Software | 5–10 years |
| R29 | 31–40 | Post-Graduate | Software as a Service (SaaS) | Manager/Sr. Manager | More than 1000 | Logistics and Supply Chain | 5–10 years |
| R30 | 41–50 | Post-Graduate | Software as a Service (SaaS) | AVP/VP/EVP | 50–300 | Consulting | 5–10 years |
| R31 | 20–30 | Graduate | Platform as a Service (PaaS) | Engineer | 300–500 | Education/Research | 3–5 years |
| R32 | 31–40 | Graduate | Platform as a Service (PaaS) | Engineer | 500–1000 | IT Services/Software | 5–10 years |
| R33 | 20–30 | Graduate | Software as a Service (SaaS) | Engineer | More than 1000 | IT Services/Software | 1–3 years |

years of experience), *AI-based cloud platforms can be helpful in fast tracking catastrophe relief efforts. AI and cloud-integrated drones and satellites can facilitate locating survivors and processing the relevant information to emergency teams for further action.* Coordination and swift trust becomes a concern in most emergency situations due to the involvement of a large number of stakeholders, and a large amount of information processing is required (Shayganmehr et al., 2021). Technological platforms supported by AI and cloud-based collaborative platform technologies can therefore address these issues. These observations resulted in the second proposition:

**Table 4**
Themes and excerpts identified under 'Readiness'.

| Axial code | Respondent characteristics | Supporting excerpts from interviews and open codes |
|---|---|---|
| Risk identification | Sr. Manager from health insurance sector with 5 years of experience | R4: *AI-based and cloud-inspired applications can help the local public systems to recognise the risk elements to facilitate better preventive measures of action.* (Open code: leveraging regional information and systems for accurate risk identification) |
| Risk analysis | Sales executive from IT services with 3 years of experience | R23: *Cloud-based platforms can be helpful in analysing disaster, extreme weather prone areas from a safety view and keep a basic tool kit ready. Past and current seismic data further can help in analysing the level of risk in an emergency situation.* (Open code: Seismic data can be utilized for assessing the level of safety in emergency situation) |
| Risk assessment | Engineer from consulting domain with 10 years of experience | R11: *Organizations can utilise AI based solutions as strategic planning tool through multi-dimensional risk assessment and severity of risk associated can guide investment decisions to the businesses.* (Open Code: Design business strategy through risk assessment in extreme weather and disaster situation) |
| Technical readiness | Manager from IT service with 5 years of experience | R21: *Firms and public systems can develop its e-readiness by developing a connected and robust IT infrastructure that further helps in creating a resilient culture in the organization.* (Open code: Developing information processing capabilities that can be helpful in future disasters and extreme weather situations) |

**Table 5**
Themes and quotes identified under 'Response'.

| Axial code | Respondent characteristics | Supporting quotes from interviews and open codes |
|---|---|---|
| Optimal search | Manager from insurance sector having more than 10 years of experience | R27: *Cloud based and AI technologies can be helpful not only in identifying and searching for victims in need during emergency situations like flood and storm, but also in developing a potential vaccine for Covid-19 and advancing the stages of human trials.* (Open code: Advancing search and research activities) |
| Damage assessment | Engineer from research domain having around 5 years of experience | R31: *Data from geo-spatial, current and past weather and disaster types can be analysed through AI-based algorithms to generate insights regarding the approximate number of people who will be impacted and the amount of aid (food, healthcare, water, along with other essentials) that will be needed at different locations.* (Open Code: Assessing the multiple dimensions of potential damages to chart the action plan) |
| Optimum rescue plan | Vice president from a consulting firm having around 10 years of experience | R30: *The lives of individuals are of utmost priority in any emergency, extreme weather and disastrous situation. Therefore, emerging technologies such as AI can be integrated with sensors, drones and robots to quickly understand and design the action towards saving the people. Hence, the use of AI and cloud-based platforms can help make rescue efforts safer and less time consuming.* (Open Code: Assignment of resources matching needs and priorities) |
| Fast response | Engineer from IT services sector having 3 years of experience | R33: *It is often difficult to respond and design fastest routes to affected area in emergency situations. Hence, cloud-based technologies can utilise satellite data to design a faster and reliable response in extreme weather and disaster situations.* (Open Code: Capturing satellite images and data to design quick response) |

**P2:** *AI and cloud*-supported *platforms can positively affect the rescue operations in terms of fast, accurate and effective response. This further develops the trust and transparency among stakeholders. Stakeholder theory can be used further to test the practical applications of this hypothesis.*

An effective response in a disastrous situation is short-term and leads to the next phase of recovery. Businesses, public systems and private stakeholders (NGOs) need to prioritise, collaborate and coordinate multiple aspects with the objective of bringing the life activities on track as soon as possible after the disaster and extreme weather is over (Shaheen and Azadegan, 2020). The first order of humanitarian operations is to restore basic and essential services such as sanitation, food, clothing, drinking water, electricity, LPG gas supplies and housing as well as public systems such as Municipal Corporation (Cho et al., 2018; Tierney, 2007). This restoration work needs to be conducted in parallel with the procurement of initial relief and rescue operations (Moshtari et al., 2021).

**Table 6**
Themes and quotes identified under 'Recover'.

| Axial code | Respondent characteristics | Supporting quotes from interviews and open codes |
|---|---|---|
| Rehabilitation priorities | Manager from IT service with 5 years of experience | R21: *The public system comes under pressure during recovery phase to restore essential services. Smart technologies can set up a structured plan to set up rehabilitation priorities.* (Open Code: Smart technologies to restore and set up rehabilitation priorities) |
| Business continuity | Sr. Manager from Banking and financial service with more than 10 years of experience | R27: *Today's business operations are driven through data, and that can be protected through cloud applications and used for resilient recovery in case an extreme weather appears or disaster strikes. Cloud services also help with server backup and off-site data storage that is critical for business operations.* (Open Code: Cloud applications act as backup for business continuity) |
| Construction priorities | Engineer from research domain having around 5 years of experience | R31: *Intensity maps and satellite images can be helpful to prioritise construction in terms of public and private properties. Hence, cloud-based evidence can help in identifying and coordinating with government, NGOs and private players to boost physical infrastructure.* (Open Code: Enhancing coordination among stakeholders for construction priorities) |

In addition, businesses need to ensure the continuity of their operations, and AI and cloud-based collaborative platforms help organizations design a structured mechanism and utilise data to explore to

**Table 7**
Themes and quotes identified under 'Re-evaluate'.

| Axial code | Respondent characteristics | Supporting quotes from interviews and open codes |
|---|---|---|
| Evaluate amount of uncertainty | Engineer from consulting domain with 10 years of experience | R11: *Policy related decisions could be taken based on the amount of uncertainty present in correlation with disaster, extreme weather and emergency situations. Intelligent technologies can help in evaluating the extent of uncertainty and right course of action.* (Open code: Volume of uncertainty and re-evaluating the course of action). |
| Prepare for future crisis | Engineer from banking and financial service domain with 3 years of experience | R12: *In the future, AI and cloud-based environments can facilitate extensive interactions among practitioners and multi-faceted data. This will help organizations prepare with the desired degree of intelligence and tasks to be ready for resilience if an extreme weather or disaster strikes.* (Open code: Data-based preparations to address the upcoming crisis). |
| Build long term resilience | Consultant with 10 years of experience | R20: *Sometimes, it is difficult to fight a crisis alone; therefore, through cloud and AI technologies, organizations with similar networks can collaborate to build long-term bonds that can be exercised to restore the disrupted business quickly.* (Open code: Partnership among stakeholders for long term resilience) |

establish existing and expand into new markets (Wamba-Taguimdje et al., 2020). AI and cloud-based collaborative platforms can help organizations build resilient partnerships and diligently serve consumers during the recovery phase to rehabilitate people without much disturbance. In the words of R22 (an engineer with five years of experience in the IT services/software industry): *The integrated approach of AI and cloud platforms can help in tracking and managing tasks and appropriating the allocation of resources to ensure express recovery. Further, the role of community and local players can be effectively deployed in recovery through cloud and AI-based technologies.*

These technologies help the federal and regional public systems to view a dashboard of progress. The above-discussed points resulted in the third proposition:

**P3:** *Rehabilitation, construction priorities and business continuity are positively influenced by using AI and cloud-based platforms in the recovery phase in an extreme weather, disaster and emergency situation.*

Due to climate change, nature is posing more severe challenges to human beings as well as other natural species (Rodríguez-Espíndola et al., 2018). Hence, it is the collective responsibility of diverse players and individuals to ecosystems to advance their planning towards tackling and surviving the next extreme weather, emergency situation or disaster. Emergencies may not only be natural disasters; they could also be manmade, such as a virus being introduced into a certain region or country or fire triggered by someone in a large forest. Cluster and metric analyses can help categorise the associated parameters to re-evaluate the damages incurred by businesses, communities and public systems. Hence, municipal corporations as well as small and large corporations can deploy AI and cloud-based collaborative platforms to analyse the current and past events so that they can re-evaluate and prepare for the future (Al Qundus et al., 2020). According to R23 (sales executive with three years of experience in the IT services domain), *AI-facilitated cloud platforms are capable of integrating the information from private, public and business agencies to reimagine and re-evaluate the information processing role in preparing organizations to survive in future disasters.* Therefore, data, trend and patterns observed in healthcare, the data from Red Cross and social media can be integrated to develop critical insights for helping public systems and organizations devise solutions for emergency situations and thereby ensure adequate long-term resilience (Kavota et al., 2020). These points resulted in the fourth proposition:

**P4:** *Deploying AI and cloud-based platforms significantly affect public systems and organizations to re-evaluate the amount of uncertainty, resilience and required preparation in case of future emergency situations.*

Based on the above four propositions and elements discussed in findings section, a framework is developed that represents how AI and cloud-based collaborative platform technologies can be deployed in different phases of disaster management and handling extreme weather (Fig. 3). AI and cloud-based collaborative platforms not only help the federal government and other government and private agencies in scenario planning and execution for faster recovery from disasters and extreme weather like situations, they also help public and private businesses to be resilient through accessibility and continuous dissemination of information in different emergency and extreme weather situations. On one hand, AI sense and learns from historical and current data generated during each cycle of disaster management; on the other hand, cloud technologies help secure and disseminate useful information to diverse stakeholders quickly. The proposed 4-AIDE framework can help in each emergency situation cycle. Framework (Fig. 3) indicates the cycle for a disaster, extreme weather and emergency situation starts with readying the resources, technology and stakeholders towards it in near future. The risk assessment and the alignment of associated risk to designate resources can be the first step and this preparation will reflect in the effectiveness of the response during the disaster operations, that how accurate, how quick the response has been. The recovery phase is long-term as compared to the response, but plays a critical role in restoring the previous modus operandi of public system or develops a new one. Re-evaluation of the efforts made and preparing for next disaster and aligning AI and cloud-based platforms can help in building the long-term resilience.

## 6. Discussion

The results of the semi-structured interviews offer some interesting implications for the application of OIPT theory in emergency, extreme weather and emergency situations. This study made an effort to join in the literature from operations management, information management and strategic management. Past research has advocated the role of information processing on firm performance as well as disaster relief operations and its link to strategic planning of businesses and public systems (Bharosa et al., 2010; Kuglitsch et al., 2022; Wamba-Taguimdje et al., 2020). Therefore, OIPT is conceptualised as a theoretical lens to view the implications for theory, practice and policy.

In this study, thematic analysis served as a basis for the development of a 4-AIDE framework that serves as a foundation to design and develop AI and cloud-based collaborative platforms that can effectively address emergency and disaster relief operations. The main-points highlighted by respondents in managing and addressing challenging situations during disaster, extreme weather and emergency like situations are (i) lack of preparation due to 'no awareness' about the event; (ii) degree of impact or threat of an emergency situation on human lives and communities; (iii) route selection and damage assessment during rescue operations; (iv) ensuring a rapid recovery from an emergency situation that can ensure business continuity and community revival; and (v) using the lessons learnt from earlier extreme weather, emergency and disastrous situations. The findings of the study indicate that AI and cloud-based collaborative platforms have the capability to address these concerns.

Few existing studies have considered technologies such as

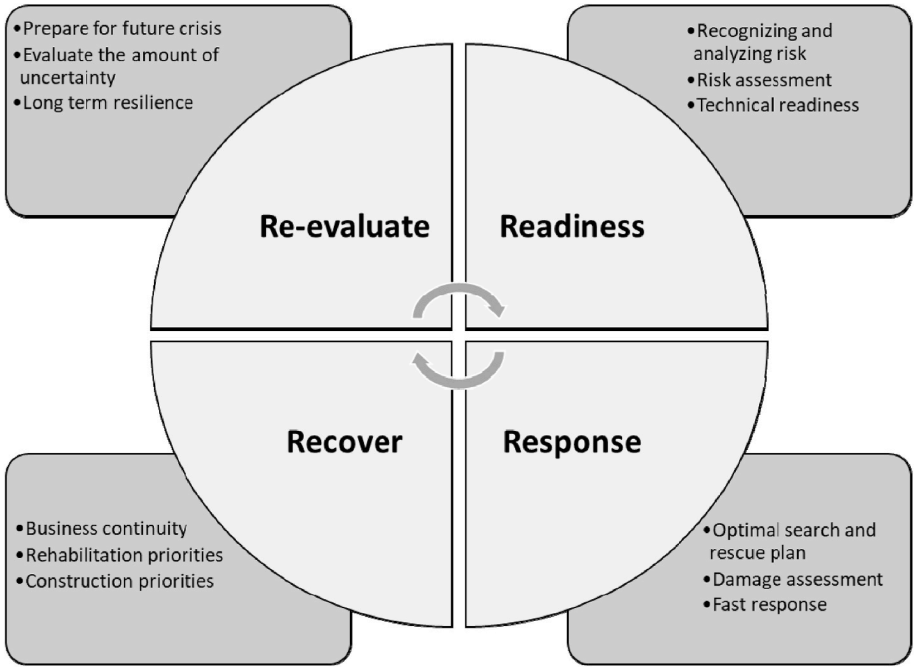


**Fig. 3.** AI and cloud-based collaborative platform for disaster, extreme weather and emergency operations management framework (4-AIDE).

blockchain and artificial intelligence either to resolve pre-disaster or during disaster or post-disaster scenarios (Cao et al., 2021; Kunz et al., 2014). For instance, Sakurai and Murayama (2019) only emphasised the use of technologies for preventive risk measurement in the El Nino Southern Oscillation; thus, their work is limited to the pre-disaster stage (phase 1). Another study by Fan et al. (2021), developed a disaster city digital twin integrating AI that focuses on the time of disaster strikes (phase 2). Additionally, Sinha et al. (2019) used IoT with a view of task-technology fit for rescue operations (phase 3). Another study by Cao et al. (2021) present the distribution system in post-disaster situation using fuzzy-bi level optimization (phase 4). Hence, the existing studies are focusing on different phases of disaster, extreme weather and emergency situations. However, the proposed 4-AIDE framework in this study addresses the complete cycle of disaster/extreme weather management and can act as a guiding instrument to disaster, extreme weather and emergency situation professionals. The proposed framework can also be helpful for accessing information from multiple sources and devising optimal solutions with greater accuracy and speed.

### 6.1. *Theoretical implications*

This study contributes to the literature in three ways. First, it presents key themes and sub-themes through the lens of OIPT to analyse the utility of AI and cloud-based collaborative platforms in disaster, extreme weather and emergency relief operations. Thirty-three respondents from diverse backgrounds and roles from varying organizations supported the use of AI and cloud-based collaborative platforms in emergency and disaster situations. Second, four propositions are derived that can be further tested with grounded theories such as contingency and stakeholder theory. Third, the 4-AIDE framework composed of the readiness, response, recover and re-evaluate phases is developed as a guide to effectively using AI and cloud-based collaborative platforms for timely activities.

This study also highlights the role of OIPT in viewing information as a subjective and objective constituent that further helps multiple agencies and front-line rescue team members to take real time decisions (Rodríguez-Espíndola et al., 2018). Moreover, the study presents system-oriented platforms that can auto-capture multi-dimensional information by sensing, analysing and predicting the probability of occurrence of an unexpected event (Farnaghi and Mansourian, 2013; Bharosa et al., 2010). In addition, the study addresses how AI and cloud-based collaborative platforms can help design strategic orientations for public systems and businesses to deal with emergency situations. The study therefore addresses the research question: *How can AI and cloud-based collaborative platforms help to effectively address disaster, extreme weather and emergency relief operations*, which is a pressing concern for public systems and businesses.

The earlier studies support the findings of this study; however, the earlier studies focus on a specific phase of disaster life cycle. For instance, a study by Cao et al. (2021) indicates the distribution strategies in post-disaster scenario to rehabilitate population. Additionally, another study by Pernett et al. (2022) focus on the wellbeing of individual in post-disaster phase. Other studies focus on response phase alone highlighting different approaches to rescue people (Kosmas et al., 2022). Another set of studies focus on technologies such as AI, cloud and Industry 4.0 (Choi et al., 2021; Kar and Kushwaha, 2021; Kar et al., 2022; Malik et al., 2021), but they lack in exploring the application of AI and cloud-based platforms in disaster and emergency situations. This study contributes in presenting an integrative approach of exploring the application of AI and cloud-based technologies in complete cycle of disaster and emergency situations. Moreover, scholar(s) interested in replicating the current research design of three-layer coding can further validate the findings from different sources such as industry report(s), respondent(s) and research articles.

### 6.2. *Managerial implications*

The interview findings and the 4-AIDE framework indicate useful implications for stakeholder such as agencies, essential public organizations, NGOs and businesses that are based on OIPT principles. Before deploying an AI and cloud-based collaborative platform, local, public and business organizations need to understand (i) the required type of data integration; (ii) the required speed of information processing; (iii) the degree of uncertainty and risk in the environment; and (iv) the area and density to be covered if extreme weather or disaster strikes (Gunessee and Subramanian, 2020). Working professionals can address these requirements while designing and developing an appropriate AI and cloud-based collaborative platform for emergency situations. The findings of the study can be referred while working with developers to design a system of capturing the data, analysing and mode of dissemination to the users. Managers can help ready their organizations and public systems to better analyse failure modes to improve preparedness for a disastrous situation or extreme weather. The managers on the execution side can employ crowdsourcing with real-time AI and cloud-based platform that help in eliminating the traditional effort of on-site and struggle for alignment among resources. Computational complexity can be addressed by AI and cloud-based platforms because it can handle the size of data, variety (photos, videos, text etc.) and rate of updating in disaster and emergency situations. Further, AI and cloud-based collaborative platforms help front-line rescue teams and managers detect optimal routes to save survivors and provide required aid. Further, AI enabled cloud platforms can share quickly the information among different stakeholders to disseminate from broad to micro-level, that further help in coordination in different phases with different level of resources available. Additionally, in many disasters, extreme weather and emergency situations, insurance managers need to evaluate the damage caused, and AI and cloud-based collaborative platforms can help them accurately and rapidly assess these damages and settle claims faster. Managers can use simulations to process information in manifold directions and build public and private supply chain networks that can be activated immediately after the disaster (Fleming et al., 2020; Keleş et al., 2018; Rahimi-Ghahroodi et al., 2020). In this way collaborators, stakeholders and execution managers in all the phases of disaster cycle can benefit from AI and cloud-based platforms that develops a swift trust and transparency in disaster and emergency situations.

### *6.3. Policy implications*

The government and public systems play a critical role in addressing disaster, extreme weather and emergency situations. Applying the OIPT approach to emergency situations offers meaningful and exciting applications for policymakers as well as policy executioners. The deployment of AI and cloud-based collaborative platforms can help regional and central administration lay down the necessary guidelines in different cycles of extreme weather and disaster management. Moreover, policymakers can guide to align and deploy these technologies for an effective response to provide necessary aid and save more lives. The policymakers can glean meaningful insights from the recovery phase to restore infrastructure features such as transportation services, cleaning and sewage systems, electricity, public distribution systems and drinking water. The interview findings and 4-AIDE framework can be used as a starting point to forecast upcoming extreme weather and disasters and guide public systems, agencies and businesses in using AI and cloud-based collaborative platforms to be perpetually prepared to have minimal losses at the end. The risk identification and assessment can be a part of the organizational system as well as communities for any near future disaster, extreme weather and emergency situations. AI and cloud-based platforms can be a part of national and regional agencies since they are the dedicated organizations for the events of disaster, extreme weather and emergency situations. Due to the self-learning capability of AI, the organizations, government supported agencies other non-profit organizations can better coordinate and re-evaluate the impact, and associated risks before a disaster, extreme weather and emergency situation occur.

## 7. Conclusion, Limitations and prospects for future research

This study investigates the role of AI-based cloud technologies during emergency and disaster relief operations through qualitative exploratory research. Based on OIPT, study examines the deployment of AI and cloud-based collaborative platforms in different phases of the extreme weather and disaster life cycle, and several key themes were identified through an axial, open and selective coding process. Moreover, study put forth four propositions representing different phases of an emergency situation. Based on these propositions, a novel, evidence-based 4-AIDE framework composed of four phases, i.e. readiness, response, recover and re-evaluate is developed with implications for theory, practice and policy.

They key contribution of this study lies in the proposed framework, which highlights the significant role of AI and cloud-based collaborative platforms to inform the design of strategic orientations for public systems and businesses to deal with emergency situations. This study has responded to arguments concerning the lack of an established framework for effective and efficient extreme weather and disaster management. In summary, the findings of this study can help practitioners, policymakers and scholars understand, analyse and deploy effective strategies in each cycle of disaster management. It also shows how public and private systems and business organizations can contribute and effectively utilise information when managing a disaster, extreme weather and emergency situation.

Although OIPT helps apply variable dimensions to enhance the performance of a system, the drawbacks of this framework include the level of required motivation and the conflicting approaches of different involved parties to address an emergency situation like disaster or an extreme weather (Hauβmann et al., 2012). Additionally, OIPT lacks in offering a sustainable approach in different phases of the extreme weather and disaster life cycle.

Based on the findings, AI and cloud-based collaborative platforms have been shown to effectively handle the different phases of a disaster, extreme weather and emergency situation. However, future studies could investigate the role of these technologies in information recording and information exchange among diverse set of stakeholders and still make swift response to a disaster (Ahn et al., 2021). In addition, the deployment of contingency and stakeholder theory can be further tested to establish the suggested propositions as they find a key space in four phases of disaster management. Views and insights from semi-structured interview data have been presented here. Future studies could undertake an exploratory study exploring the effectiveness and appropriateness of AI and cloud-based collaborative platforms during disaster, extreme weather and emergency situations. In particular, a simulation-based study could be conducted to establish a foundation for handling an actual disaster and extreme weather like situation through an AI and cloud-based collaborative platform and observe the difference in both. Finally, future research could be conducted to examine the research question in the context of different types of disasters (floods, earthquake, wildfires, cyclone etc.), as role of AI and cloud-based collaborative platforms may vary in different emergency situations.

## Data availability

Data will be made available on request.


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## Appendix A. : Semi-structured interview schedule to collect data from professionals dealing in emergency situations

1. Disasters are not new to human life. With our progress to digital revolution, people and media can now post the images, videos, text to make them aware. However, it becomes difficult to plan a course of action for a disaster relief team, NGOs and volunteers by having a simple look on the content posted. How can an AI driven platform address this issue of planning a right course of action?
2. Most of the modern supply chains functioning are driven by data and loss of it can damage any business more than a disaster, which

includes revenue, productivity, reputation and even consumers. It is hard to predict a disaster and its severity; however, we can control the response to a disaster and bringing the supply chain on track at faster speed. In your opinion, how do you think cloud computing can help your supply chain in this regard in a disaster situation?

3. In a situation of emergency or disaster before any support, specialized force or machinery reaches out to tackle the situation, it is locality and surrounding people those have to respond first. Therefore, as a first responder it is critical to have an understanding, awareness and preparedness towards an effective first-hand response to the situation. Since, today we are connected with smart phones, how can cloud computing based platform as a service (PaaS- a platform allowing customers to develop, run, and manage applications without the complexity of building and maintaining the infrastructure typically associated with developing and launching an app) be harnessed to involve local people for robust first hand response to the emergency situation?
4. Apart from the local people involvement, recovery agencies with data from infrastructure, weather services including use of earth observation satellites, sensors, and real-time tracking of people and equipment along with specific protocols is critical in a successful emergency situation project. What is your take on importance of aligning and optimising multidimensional sources of data through AI driven mobile platform?
5. Any disaster or emergency management need to have four phased plan that includes mitigation (pre-disaster mitigation efforts), preparation (education, outreach, training, business continuity & emergency management planning) response (immediate response to stakeholders, establishing business recovery centre) and recovery (post-disaster economic recovery plan). How can an AI enabled mobile-based application address these four phases in your supply chain?
6. Different stakeholders are involved in enabling the normalcy in emergency situation (Government organizations like fire, hospitals, police, local governments; NGOs involved in disaster relief operations like Red Cross; Oxfam and R&D institutes) and numerous are affected by the acts of a disaster (oil and gas sector, mining, fishing, construction and so on). How can an AI and cloud-based collaborative platform help enable normalcy and affected members in disaster situation?
7. Past has witnessed the implications of technology for human life. One side it offers the enough space for innovation and other side it reduces manpower. In the past technologies like AI has helped in big way to predict the diseases like Zika (2016) and Ebola (2014). In the recent and present crisis of Covid-19, it becomes difficult to reduce the spread of the disease due to limited resources and use of technology in healthcare sector across the world. In your opinion how can AI and cloud-based collaborative platform mobile system help in this emergency situation?
8. Apart from healthcare services, the pharmaceutical companies are critical at this moment, as the world is racing towards potential Covid-19 drug and vaccine. In a drug or vaccine development it involves multiple stages (pre-clinical development, clinical development and clinical trials) before it is licensed for use. How do you think AI and cloud-based collaborative platform mobile based application can help the scientist and other agencies to zero down and fasten the process of drug or vaccine development?

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