Chapter 4

Emerging Trends in Crisis Management: Usability, Earth Observation and Disaster Management

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Additional information is available at the end of the chapter

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Abstract

Availability of Earth observation (EO) data and dissemination has been revolutionized with technological advancement in computation and use of mobile tools such as phones, tablets and laptops. This is further expanded with availability of affordable data/internet connections which no longer require Ethernet cables to get internet connection. The result is explosion of spatial data on various blogs and personal profiles such as Tweeter, Facebook, Instagram and other internet feeds. This has created explosion of information with a lot of integrity issues on data quality, lack of data source and lack of responsibility and authenticity. The problem is further compounded with advancement in search engines and data harvesting applications which collects similar archived information and makes them available to the user on the internet search engines. There should be a clear link detailing the nature of EO and the kind of relevant information that can be derived from them.

Keywords: earth observation, usability, disaster management, mobile technology

1. Introduction: emerging trends in Earth observation and crisis management

Capturing EO data has been improved with increased spatial resolution where spatial features are now more vivid in captured images. The images are now freely accessible over connected computers and phone gadgets through various plug-ins and software's such as Google Earth, Bing maps, Arc Earth, Google Maps and other online web based platforms. The end result is explosion of diversified, semi organized and sometimes disorganized information available for use whenever a disaster or crisis is reported.

Population response to crisis varies with personality and perceptions especially in situation that require quick emergency response capabilities such as natural disasters or human hostilities such as terrorism and wars. Fear, despair and uncertainty normally brings [1]confusion among the population which creates a complex platform for managing surging population towards or away from disaster scene [2]. In any crisis, the populace always seeks reliable and authentic information which sometimes is hard to find; in that case a debate arises and experience are sought from past similar events and the nature responses that were administered. Disaster management trends has evolved from immediate response in the 1970s to risk reduction in the continuous years from the year 2000 to present where emphasis is on preparedness, response and mitigation through simulation. The economic losses have increased significantly to fourfold in most developed economies; a situation would probably be much greater in developing economies [3].

The role of EO is critical is traversing space within a short span of time and proving reliable information which can be interpreted by space experts to extract useful insights for meaningful decisions whenever the crisis is put into context [4].

EO especially use of commercial drones and satellite is useful for targeted monitoring of crisis in hostile and inaccessible areas since information collected provide useful insight for pre and post crisis period including human movements with new advancements like night satellite imagery monitor through Visible Infrared Imaging Radiometer Suite sensor (VIIRS) [5]. The main focus should be on minimizing redundancy of information and proposing models which supports building of resilience for risk and disaster monitoring [6] which will eventually reduce occurrence of crisis.

Accessing EO data for countries without capability to operate their own satellite systems rapidly within a short time largely depends on international cooperation and bilateral agreements among space agencies which can request (disaster) charters to be activated whenever a crisis is reported. The nature of ownership of systems have now shifted from previously military intelligence to privately licensed space and defense companies [7].Creating a balance between crisis disruption and real time demand for reliable information is current emerging trend in development of allied information communication technologies (ICT) which is critical is disseminating information through the web based crisis alert and warning systems [8]. Moreover, reliance on initially mapping and survey organizations as the sole custodian of spatial data and maps has been revolutionized with volunteered citizen participation through geotagging and development of mobile compatible web based applications which can display those maps with little data or through mobile data hotspots which can be set up whenever there is need even in vey adverse disasters through VSAT [9].

Processing of EO data and has been revolutionized with improved number of people with capacity of interpreting digital spatial imagery and wide range of application areas such as climate change, yield estimation, crop failure, land degradation and use of various sensors in early warning [10] where trends in surface solar radiation are estimated with reliable precision [11].

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Post crisis management receives less attention since immediate loss and damage normally receives a lot airing in both print and electronic media. This lowers confidence in recovery phase of crisis management projects which require external funding which largely depends on quality proposals and international cooperation which requires proper justification of the crisis aftermath [12]. Use of EO in post crisis management is sole responsibility of the affected country and her interested development partners who have to purchase such products where necessary. Public participation in post crisis especially through mapping is minimal more so through voluntary basis.

The policy systems in disaster management laws in many countries is a reserve of the senate or upper house [13]. Biased shifts to administrative systems with state control other than administrative policies create a scenario of overlaps and confusion in cases where administrative systems do not guarantee seamless integration of roles and resources at play [1].

The center of crisis management is subject to a number of internal and external dynamics. The economic growth, levels of development, social status and the nature of spatial planning plays a major role in the internal dynamics of any crisis and influences approaches laid down towards its management. Since crisis at times gets political in nature, influences from external dynamics are unavoidable which at times are influenced by geolocation of the country in crisis and interest of neighboring countries or interested international organization or unions [14].

Planning for post crisis requires budgets which are either funded by the government affected or through bilateral agreements. The post crisis phase receives a negative perception since the urgency is never seen; hence treated as low priority concern which does not require urgent approval of budgets from governments since some emerging issues might override until another disaster reoccur.

Extensive crisis with overlap of people displacement and inter border migration possess a new trend of threat to national security. Non affected countries/states perceive those migrating as taking advantage of the crisis situation to run away from their economic stagnation. The trend then changes from helping the survivors of such crisis to confining them to a controlled area which might pose a new threat of cascading effects such as disease outbreak, competition of resources and denial or restricted access to necessary rights and opportunities which are normally constrained by the crisis such as access to quality healthcare, education, socialization and at times lack of free movement [15].

Crisis perception by bilateral partners have a huge effect on access to international goods and trade systems especially where alliances of aggression are suspected by an international union. This leads economic sanctions and embargos with key allies and partners which eventually affect local currency stability and degrades local economy growth [16].

Creating a suitable crisis management plan is crucial successful management. This can be realized through establishment of committee for crisis deployment, developing a clear response policy in place for each category of crisis and design a suitable toolbox for crisis response [17]. Fundamental attention should be paid to addressing emerging issues such as

public demonstration and chaos through a vivid risk management mechanism [18, 19]. The process should outline clear procedures before, during and after crisis management which should be shared with local established teams in various established location for quick mobilization. Necessary drills should be carried out to facilitate establishment of any existing gaps to improve lessons learnt. It is paramount to have extensive inoculate for public negativity by creating structures that support strong ethical theme with capability of managing population mistrust [20].

2. Research methodology

Review of existing technologies in EO and their use in crisis management is done with emphasis in the role they play in crisis management. Since crisis management does not have a direct approach; but involves amalgamation of a myriad of approaches; this study focuses on the usability and challenges that arises from such developments. This study also places a lot of emphasis on the timing of the phase of crisis at which EO data is freely made available and dissemination of such information to wider targeted audience.

The initial phase is data organization and authenticity which also affects the data integrity and data quality. Since usability is independent but quality is dependent on accessibility and medium of dissemination, EO data has to be subjected to a usability filtering model on which basic quality parameters can be ranked to facilitate rapid decision making for novice users who might not be GIS specialists as shown in **Figure 1**.

Once the information is organized in an agreed model, dissemination of such information needs to be channeled through acceptable political leadership. Access to EO technologies and dissemination channels are controlled by state agencies, hence their collaboration is paramount for success in gathering local information from the survivors in any crisis management. This is important despite the fact that some data can be collected using UAV through eye in the sky mechanism.

The process of reducing uncertainties among survivors is a vital process and analysis of addressing the bottlenecks associated with bureaucracies in relaying critical information and setting up priorities in evacuation and installation of critical equipment. The role of local administration is taken into consideration for seamless operation and effective people management. Presence or absence of reliable statistical information and people whereabouts is crucial in estimating the possible fatalities and survivors. This creates demand for accurate model for people identification that has the ability to reduce uncertainties.

Since every technology comes with associated challenges, focus is on the best practices that are able to improve the use of EO data and mobile technology in crisis management. Technology alone without proper protocol has proven to be another source of problem which slows down uptake of information and eventually the whole process of crisis management. This study therefore, proposes a technological inventory audit model which maps out the possible areas

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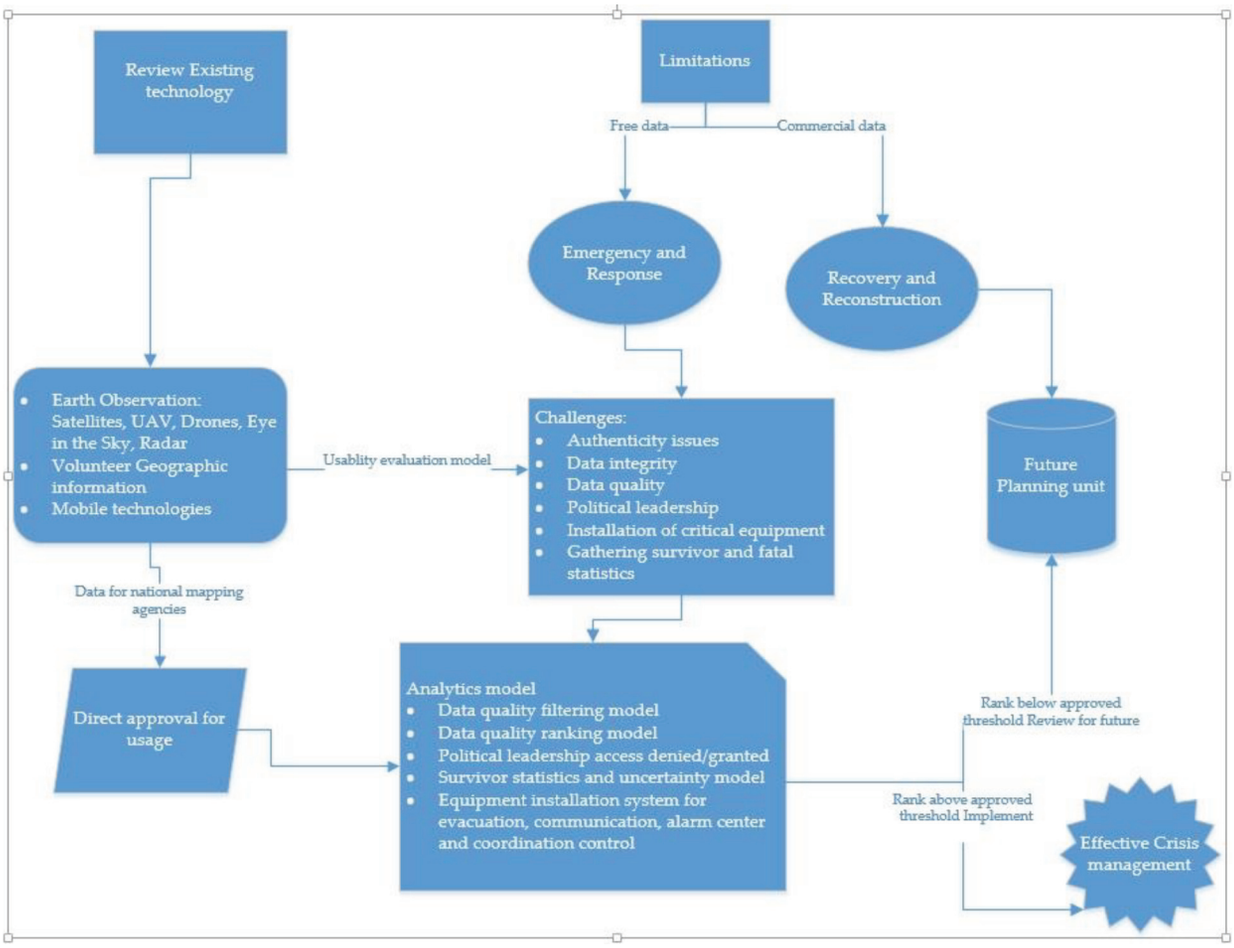

Figure 1. Crisis management data model.

that have the capability to relay mobile information to both survivors and response coordinators. This has to take into account the cascading effects, especially in floods, fire and nuclear disasters which worsen over time whenever a quick rebuttal approach is not taken.

Adoption of analytics with capability of assessing the level applicability of EO data based on certain pairwise comparative parameters with defined scores is vital in ensuring that non expert users have a chance in selecting the right product. It has also vividly emerged that data mining challenge from enormous volunteer sources shall be easily managed through such analytics since the usability shall be determined through a defined score index table which is recommended in this study.

Effective data management requires effective coordination during the initial phases and relevant measures designed for future mitigation. Lessons learnt from usability and analytical models are integrated to be used for review, future planning and establishment of effective mitigation mechanisms. The datasets meeting the criteria are eventually used for effective crisis management.

3. Usability of EO crisis data and role of mobile technology

Explosion of information during the initial phase of crisis creates an explosion of information which in most is highly disorganized and enormous. Most countries have national disaster and crisis management established bodies responsible for managing information related a given crisis in their respective countries [21]. Such bodies face the challenge of controlling proliferation of information in the social medial which could be trending faster than their official communication channels [22]. The situation is exacerbated with current use of mobile technologies which has made log on hotspots for sharing information readily available [23].

Evaluating the reliability and usability of such volunteered information requires a reliable framework with detailed quality check parameters with quantifiable rating [9]. Creating a balance between immediate needs of response and long term needs for coordination with all partners involved presents additional challenge especially managing proliferation of volunteers which might create a disaster within a disaster [24].

Data is generated to be used for decision making when it has been processed to useful information. The mobile technology revolution has made sharing information almost seamless and real time. This situation makes it easy to redistribute non authentic information to unsuspecting users. Crisis provides no time for argument but quick decision geared towards response. The speed of response is useful for saving life and rescue of property within the crisis area. However, new mechanisms have been developed with algorithms with capability of addressing needs of immediate responders using eye of the sky through UAVs.

Automated alerts can be synchronized for predictable disasters such as those with slow onset such as flooding and wildfires. Use of technology makes easier to disseminates such information through temperature monitoring and use of sensors of accomplish success through coordinated data mining algorithms which can easily relay information to contacts within the database and for action to be taken.

With improvement is web 2.0 technology, it is now possible to develop crisis dashboard monitoring system where one stop shop for crisis is established for a given crisis/disaster [25]. The data flow frequency provides insight to need for authenticating the information being passed. With new aspect of geo coding and geotagging, spatial components can easily be incorporated through simple data collection apps which can be installed into the gadgets given to individuals participating in crisis/ disaster management. The information be improved further through of geo-visualization and use analytics skills to improve data mining [26].

Usability model proposed in **Figure 2** examines suitability of such datasets against reference materials for both expert and general users of EO based data and products. The process of evaluating user categories varies from those with requirements well known to those unaware of EO requirements. This creates the need of reference data materials with capability of assisting in interacting with the datasets already ranked and not meeting the criteria for further check before being subjected to analytics model.

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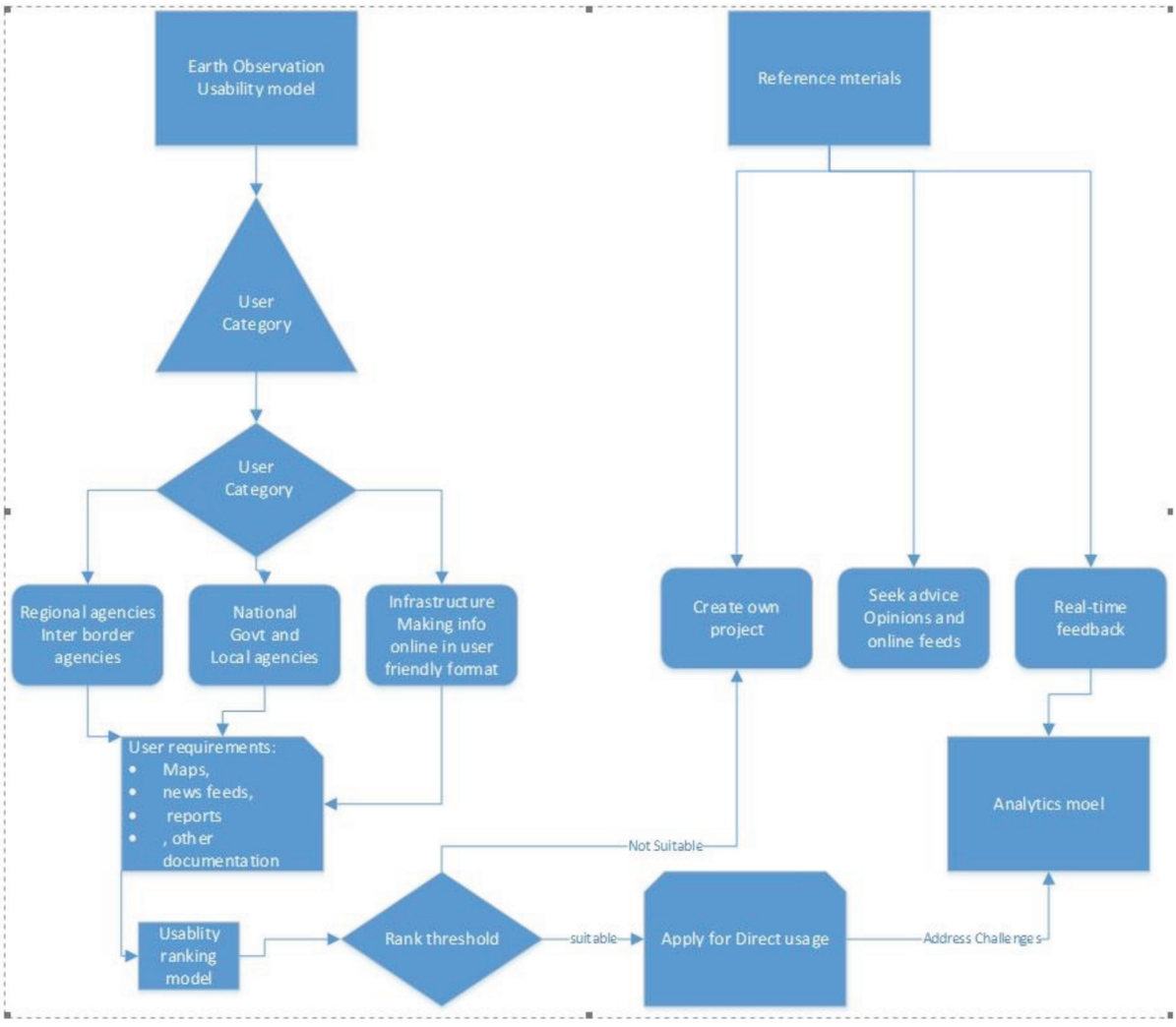

Figure 2. Usability evaluation model.

The widening of user category is useful in catering for accommodating various important organizations such as Global Earth Observation System of Systems (GEOSS), Disaster charter, DLR, among others who promote good community practice with emphasis on system and information quality which enhances user and use satisfaction to realize individual and organization impact on crisis management.

4. Challenges of using technology in crisis and disaster management

Response to crisis is dynamic and complex process which makes it difficult to determine the actual source of signal received over the internet [27, 28]. Responders have difficult task of

examining the ever growing traffic of information to filter useful information which would realistic for immediate and long term response especially scheduling of units efficiently [29]. In some instances, ICT is deployed with heavy investment but underutilized due lack of effective coordination [30].

Filtering data from various sources can realized by setting priority identification of datasets through a semantics filter. The filter can be optimized to ensure that datasets with user feedback feeds shows up as the higher rank in that order and subsequently to those of low ranks. The information can be improved with enabling of geocodes customized for any feedback received and anti-robotics codes captcha to ensure only human results are collected.

The recent development in use of eye in the sky (UAV) is also affected by spectrum scarcity since new devices have been developed which operate within these bands with development focus on cognitive radio technology to address the problem using intrinsic characteristics [31]. Use of EO based data and associated products still faces challenges of data access, availability of high spatial resolution and technological limitations which are further compounded with proliferation of crowdsourced data [32].

Extraction of useful information from EO based products might require heavy investment in terms of technology software and personnel. Hence, collaboration of already existing agencies within the crisis country who are familiar with use of such technologies should be identified prior to crisis occurrence. Understanding of communication and technology spectrum and the distribution of useful investment should be mapped well in advance to improve coordination whenever a crisis occurs. This allows the foreign interested partners to easily engage since the language of operation can easily be harmonized.

Technological developments are perceived to be the mode of communication in most urban regions, however, the reality is that rural areas are normally ill equipped with latest wireless technology like 3G or sometimes such regions lack strong GPRS signal network for GSM communication [33]. Therefore, reliance on technology alone for disaster management can itself be another crisis whenever there are power failures; or inconsistency in network upgrades.

The bureaucracy and legal bottlenecks associated with licensing and authorization at the time of crisis may slow down the process of getting reliable information or access of critical infrastructure such excavators, firefighting equipment, setting up emergency rescue centers and establishment of reliable communication channels which can be used by families of those affected. The problem is exacerbated when the equipment necessary for scanning possible survivors is either lacking or have to be borrowed from other countries abroad with strict protocol from government of the day.

Crisis and certain types of disasters normally occur and creates a myriad of uncertainties especially communicating to the public and adoption of open up approach where certain failures have to be admitted as precursor to increase in casualties and damage to property [34]. The situation further becomes complex when issues of adherence to stipulated regulations have been ignored or corruption has prevailed over the stipulated policy.

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5. Results and discussion

From this study, it has emerged that there are already certain approaches which have been developed to assist in usability evaluation such ranking of individual products through online portal as discussed by Sweta and Bijker [9] and Ferguson et al. [35]. However, in these approaches, none of them proposed the use of analytics model. In this study, the analytics model improves the extent to which the information can be filtered and used with less difficulty by both novice and expert users.

This study also proposes a solution of a more robust ranking system which takes into account more variables which previous studies examined individually. The collective approach allows more detailed comparison to be carried out by first allowing comparison of usability model results with limitation and challenges arising from emergency and response phase of crisis management.

This study has also found out that there is a weak link between EO data based product information to targeted users since less emphasis is placed on value of citizen observatory with direct information which is usable immediately. It has also emerged that parameters lumped together provides more robust information that individual modeling since several variables are weighed in the pre-processed products. Creating a platform for registering user requirements supported by proper search enabled semantic system is useful in implementing one stop shop for usability evaluation and access of such information to various category of users on several search engines.

Situation analysis coupled assessment and awareness are vital components crisis management and response planning. This study has found out that planning for movements especially provision of detailed routes, critical examination of documents for information validation, deployment of critical equipment for optical resource allocation and creating a well mirrored and secure network system are necessary items to be analyzed for effective crisis management.

The interagency bureaucracies, similarities and differences have been observed as part of challenges contributing to difficulties in effective crisis management. The working culture, public differences, availability of information is different formats are some of the challenges that needs to be harmonized. For example, data sharing in the usability format, tries to address the question of product rating by examining who needs what type of data and preferably in what format. The incorporation of organization psychology analysis is vital.

With multibillion dollar invest in satellite EO and related mechanism, emphasis should be placed in strengthening public–private collaborations to promote free open data access through establishment of relevant policies with little bottlenecks in the use of products from such collaboration. Although initiatives such as European Union (EU), European Space Agency (ESA) and USGS have established mechanisms to ensure free access to certain types of data through open data systems and open software's for processing such datasets, lack of in-situ measurements in some cases limits the full utilization of such products for intended purpose of crisis management.

6. Recommendation

This study recommends adoption of bottom up approach in communicating with public on disasters with high level of uncertainties. Strict adherence to stipulated regulations should be emphasized and made public so that any identified failures in the product or process can be corrected for effective crisis management. Minimizing anxiety is the best approach of containing crowds especially in the immediate aftermath with approaches like streaming electronic lists, use of public address and grouping of people by region. Each of the regions can be assigned an opinion leader and an assigned protocol officer to keep track of inventory. This helps to calm the crowd since they shall feel part of the process being undertaken and with proper approach of population segregation by age and disability, the process of handling dependents becomes efficient and seamless. The communication hub can then synthesize and disseminate feedback through bidirectional model.

This study also recommends availing of relevant documents and resources such as telephone numbers and gadgets with specific numbers for incoming and outgoing calls. Secure electronic system for managing information from social media, access to local area network, mechanisms for documentation of events and subjects, plans and maps to assist in security, fleet, rescue, deployment and location of potential safety location for temporary settlement of displaced persons.

For improvement of usability of EO datasets, that require calibration, this study recommends possibility of utilizing the power of citizen observatory to provide needed additional information to enrich EO products and assist in gathering feedback from use of disseminated products. The feedback data shall provide relevant information to be used in the ranking model gathering user feedbacks.

Mechanisms should be put in place to tackle conflicting and competing interests during crisis management. Focus should be placed in minimizing time taken to make decision to facilitate speedy actions for saving lives. The information being used for decision making could be improved with paradigm shift of incorporating 3D products for realistic contexts targeting geophysical environment using maps with good symbols and complete information for simulation.

The planning for future mitigation through effective approach with vivid incidents cycle of management for crisis detailing description on how future potential crisis can be mapped, disseminated and utilized. Incorporating crisis knowledge from previous lessons learnt through reachback approach. Mapping representations is useful reachback which should be adopted in any crisis management to link the customer service help desk, personnel in the field and crisis victims. The focus should be on delineating the reachback field of various crisis to facilitate information tailoring during communications among the partners involved.

7. Conclusion

This chapter has provided a review of technology development; with meticulous attention to those relevant for use in crisis and disaster management. Further insights are provided on the

role mobile and wireless technology with highlights on usability of such technology. Challenges to crisis management is addressed in terms of limitation of technology application, rigidness of policies and narrowness of bandwidth in use during crisis communication and adoption of technology. The study recommendations are drawn from lessons learnt from previous studies and documented observations from various seminars and conference proceedings.

The role of usability model is highlighted with solution based approach which links the needs of various groups of users to reference data to enable subjection of the result to analytical model. This study proposes a dual method of analyzing crisis data for effective management by addressing the complex scenarios and proposes possible solution to the identified challenges. The methodology further discusses the extensive dynamics associated crisis management and provides a detailed solution based model schema suitable for potential utilization.

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