Building Resilient Future: Information Technology and Disaster Management- A Malaysian Perspective

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Abstract. The recent events of flooding, earthquakes, uncontrolled wildfires, hurricanes, and deadly storms in world has considered a serious threat to mankind and preparing for devastating disasters has never been more critical and urgent. Emergency Events Database suggests that by year 2050 the damages to flood related incidents to coastal cities will cost near to US$1 trillion. Risk from acts of nature cannot be fully prevented but needs to minimize and safe the innocent lives and property by utilizing disaster management technique to mitigate the losses. This paper presents Information Technologies applications in disaster management phases such as Mitigation, Preparedness, Response and Recovery. Geographic Information System, Remote Sensing, mobile technology, drone, and satellite imagery and MOBILISE analytic platform considered as effective and efficient ways of strengthening resilience when disaster strikes and tremendously helpful for coordinating responses and accelerating the recovery of individuals and communities in the aftermath of recent natural disasters.

Keywords: Resilient; flood; disaster management; information technology

1. Introduction
Malaysia is strategically located in Southeast Asian country, blessed with 4674km of surrounding coastline the country. It has estimated that more than 60% of the population of Malaysia live near the coastline because of the social and economic activities [1][2][3]. Flood is considered a severe natural disaster for the coastline population of Malaysia. More specifically, the east coast part is more vulnerable to the flood and affected in many ways [4]. The 2014/2015 series of devasting flood events were considered as one of the worst natural disaster. Malaysia economic losses suffered by approximately 2 billion Ringgits Malaysia in 2014-2015 floods. According to [5] 20 casualties were reported, more than 250,000 people were affected and left homes, whereas the government spent 900 million Ringgits to reconstruct and maintain infrastructure, such as schools, hospitals, roads, and bridges [6]. The 2014/2015 series of floods have destroyed more than 2500 permanent residence houses. In past years, the natural disaster and climate changes have been magnificently exposed. Figure 1 showed that the major disaster occurs from 1970 to 2019. These disasters include volcanic activities, wildfire, landslides, earthquakes, droughts, and floods. The flood is the most frequent disaster that happened as reported by the Emergency Events Database and estimated that more than US$2billion of damages has been done in that period.
Weather changes are frequent as compared to previous years with higher intensities. The hazards will be considered a disaster if the community's vulnerable people are affected. For example, the same devastating flood can be passed over the three different countries of different vulnerable communities of the Caribbean, and that has other effects on each region. The magnitude of its impacts depends on the vulnerability. To succeed the disaster risk reduction, it is must to eliminate or at least overcome the disaster vulnerability to the community. Table 1 shows the natural disaster frequency in Malaysia. Natural disasters frequency and intensity have caused the significance of economic and economic losses [8][9]. It is essential to manage the disaster risk reduction policies, so that disaster impacts and the environment, social, physical, and economic losses are reduced.

In recent years, Disaster risk management (DRM) and disaster resilience (DR) have emerged and gained huge attraction due to the paradigm shift, from managing the natural disasters to addressing the disaster risk instead [10][11]. The strong support and ratifies from the institute like the United Nations and pioneer academic advocacy member from the disaster field emphasized on disaster management practices. Disaster professionals from different backgrounds mentioned that one of the effective ways to mitigate the enormity of the disaster risk is to employ information technology. Over the years the role of information technology and advancement has opened the new lines of information management to become a valuable driver in disaster risk reduction, leading to community resilience [12]. The industrial revolution and the application of information technology playing a critical role by expanding community preparedness, response action, and recovery procedures for capacity building of the community.

Geographic Information System (GIS) and Remote sensing (RS) are one the examples of information technology, which are widely used worldwide to monitor the early warning to overcome the events of
the disaster like flooding and earthquake [13]. While considering telecommunication technology such as mobile and wireless technology, social networks, Facebook are technology hubs that are critical for rescue and response purposes during post & past-disaster events [14][15][16]. However, although the advancement of IT application.

Authors have emphasized the application of information technology to reduce the impact of natural disasters from past decades. In Malaysia, usage of these applications is still not enough and believe to be little successful. The RS, GIS and other information systems such as early warning system to alert the local community and vulnerable areas to hazards is still not exploited to overcome the disaster influence. The Malaysian Directive 20(SOP) is designed to mitigate the disaster impact are still ineffective which ultimately causing a low level of collaboration among the multi-agencies which led to ill preventive measure and causes destruction of communities.

In Malaysia, the national security council (NSC) is responsible for managing disasters. The NSC coordinating among National Disaster Management Agency (NADMA), state-level agencies, local government bodies, non-government organization, and other stakeholder agencies generally follow the four phases of disaster management also called four phases of disaster management cycle (DMC) [7]. As per figure, 2. The DMC is generally implemented and practiced all over the globe [17][18]. Managing disaster is a rigorous technique that is based on communication and information [19]. In the whole process of disaster management from start to end, whenever the disaster strikes, information technology performs a leading role in achieving successful disaster risk reduction. IT practices is effective in the mitigation preparedness, response, and recovery phase.

![Disaster Management Cycle](image_url)

**Figure 2.** Disaster management cycle in Malaysia, adapted from FEMA [20].

We are in the fourth industrial revolution, the revolution of technology. Over the years, information technology has emerged and provided promising and efficient disaster management techniques [21], particularly in offering and delivering powerful solutions in the disaster management segments such as the mitigation, preparedness, response, and recovery phases [22].

The 2014/2015 flood-hit east coast part of Malaysia, including the states Kelantan, Pahang, and Terengganu, Johor were severely affected. As per the reports, more than one hundred thousand flood victims were evacuated from their homes [23]. After the flood, the community faced several problems which includes, the shortage of foods and livestock, breakdown of communication and infrastructure such as powerplants, electricity and clean water problems [24]. Additionally, the flood community were complaining that the relief operation and assistance program from government were slow that created more chaos and anxiety to flood victims [24].

The community's major problem in the deadliest disaster is the communication between the government agencies and the problem still faced after the flood events. People complained about relief activities, especially in food supplies and clean water. At that time, local citizens and non-government organizations used social media to facilitate the rescue effort and share data information about the flood from different prone areas. The deficient flood victims requested help in social media platforms such as Facebook, Twitter, and Instagram [23]. One of the studies that emphasized the 2014/2015 floods and
social media role suggested that social media emerged as a new communication technology in disaster situations by sharing information quickly. The study results indicated that the flood victims were attracted to mobile message applications, such as Facebook and WhatsApp messaging applications. The messages services vigorously used during the flood event and sharing the information. More than one thousand people were displaced and out of homes. They do not have access to television, print media, and other communication modes. Still, mobile technology gave hope to talk and share their feeling to love once, and it was also beneficial for the relief agency who is continuously working in crises. The success and effectiveness of flood disaster execution and management should be given more awareness and attention so that these situations caused by the disaster can be assuaged [24]. In Malaysia, MOBILISE Platform for building resilience communities supported by Global Challenges Research Fund (GCRF) & Engineering and Physical Sciences Research Council(ESPRC) in UK, under Kanzu Research, Universiti Tun Hussein Onn Malaysia (UTHM) developing a digital platform, that provides intelligence to multi agencies to collaborate together, MOBILISE is the most advanced system using informed technology, which contains big data analytics for disaster management agencies to work together to mitigate the impact of natural disasters and build resilient communities[34]. Hence, this paper intends to get the information about how the disaster issues have been handled in Malaysia as stated in the available literature. Examining the resilient community concept and the role of information technology in the Malaysian disaster management process entails a systematic procedure [25]. To review or derive useful information from the existing documents, both published and electronic materials. For this paper, a document analysis method was used.

2. Literature Review

2.1. Information Technology and Disaster Management

It is now needed to understand that the information is the strength of disaster management. The information plays a backbone role in disaster management phases [26]. For successful disaster management, the appropriate data must be obtained in a logical and organized form to take a timely step to prevent disaster. We take the four phases of disaster management as it is followed tradition worldwide. The four stages include Mitigation, Preparedness, Response, and Recovery, validate how information technology can be employed in each phase [27][28]. Information Technology is transforming every aspect of individual life. It improves the quality and efficiency of commerce, production, service industries, other parts of human life such as education, exploration, civilization, recreation, communication, national security, etc. Disaster management needs drastic expansions in its sources to decrease damage and save people's lives. To achieve this primary object, disaster management must face data compilation challenges, data management, interpretation integration, and communication. IT plays a crucial role in this regard. The advanced techniques of information technology, such as remote sensing, satellite communication and Geographic information system can help to prepare and execute disaster management practices [28]. The Information and Communication Technology tools are discussed below.

2.2. Disaster Risk Reduction

Every country has some sort of disaster risk reduction policies, procedures, and manual in term of science and technology. These policy documents are guidelines in crises and reduce the impact of disaster. With the technology expands the disaster risk reduction has been benefitted a lot. One of the important benefits is the early warning system (EWS) [29][30]. The early warning system provides spatial and temporal techniques that reduce disaster and strengthen the infrastructure from different kinds of hazards. The Remote sensing techniques and Geographic information system have been significant in organizing the role of higher education in disaster risk reduction to recognize how science and technology have contributed and advance [31]. A survey was conducted in 11 Asian countries. The Asia Science Technology Academia Advisory Group (ASTAAG) has collected the data from researchers, scientists, policymakers, and stakeholders. It is also important to mention the methodology
adopted for the survey. The literature review analysis was conducted to determine the importance of science and technology in disaster risk reduction. The members of ASTAAG indicated that there are no proper stats found of science and technology at local or federal level.

The Sendai Framework stated seven clear targets and four priorities to challenge the disaster. By focusing on the importance of disaster, it must understand the significance of risk pertaining to natural or human-made disasters. The second priority is to focus on the capacity building and strengthen the governance who fight with disaster management and mitigate the disaster risk. The third one regarding the investment focuses on investing in disaster managing to reduce the impact and build resilience among the communities. The last and fourth aims are to plan and enhance the Build Back Better strategy.

[32] has highlighted the disaster risk reduction and information science. Monitoring the infrastructure [33], application of remote sensing, unmanned aerial vehicles (UAV), sensor network systems, GIS patterns help local authorities and agencies to reduce disaster risk [29]. Utilization of remote sensing techniques, which includes the sensor system installed in busy and major highways and rivers bridges to monitor the vulnerability infrastructure in case of any hazards. The sensors techniques provide continuous monitoring and detecting the water level and ensure that the water level is under control. By enabling these systems, the local authority and disaster professionals who are giving a relief operation provide predication of water river and give warning of river flooding and estimating the real-time situation analysis [28]. Satellite image is another important and powerful tool to monitor land use and provide timely information regarding climate change [24]. The sensor data involves complex operations and continuous observation. Once the data is ready and available for analysis, it would be useful for hazard assessment, which further helps in disaster recovery planning [34]. Hence, we must say that the role of information systems in disaster is like a backbone and impeccable, which reduces the impact of disaster risk. Spatial analysis developments give more reliable information, such as the AI technologies. It provides a platform to analyze the spatial data more reliably. It enables managers to record and analyze the information and alert in any crisis. Moreover, the AI technology can give more detailed analysis by using social media post to detect the rise of water level and inform the local authorities to plan accordingly [28].

2.3. Mitigation

Information technology such as GIS & RS provides an appropriate and reliable flood mitigation solutions. When the flood area has found in the numerical map, the GIS provides the access routes of different locations. The GIS stipulates the hazard area’s exact location, resilient and emergency partners, hospitals and health-care centers, police stations, and defense offices. The GIS has more analytic capability and provides a proper place for emergency landing of helicopters and planes in hazards events by identifying the vulnerable communities, drainage and sewage system, urban infrastructure, and power plant operations. Web Crawlers engine techniques are used for geographic analysis [29][35]. These engines are used as google API and have been used search for spatial points. This GIS service allowed constant updates to web services that can easily access and display the data for web-based geospatial users.

The MapReduce mechanism is the technology of remote sensing [27]. This mechanism provides storage and search methods further combines with the Pyramid model. It recodes the title of remote sensing image, searches, and stores and redefine the searches in parallel [36]. This technology achieves useful input and output performance. The GIS distance analysis tools help ensure the questions like who will be affected. After the flood crisis and cases like community and address of residence, we further determine some limitations of systems for finding the required information. GIS can combine the data and all the information into layers and make an integrated map. The GIS users can analyze the different layers of several factors by mixing knowledge of different operating system layers. The factors such as river data, land use data, road, infrastructure data, and geology data. For example, after marking the flood area by flood location layer, we have also generated different layers like network route and demographic data and other routes, roads, and rails under the water surface due to flood. Now the GIS techniques provide the best route to the flooded area in minimal time. This GIS
capability further provides the accident victims, vulnerable people of hazard area by combined data and information through layers [10]. When the flood occurs, the land is most affected by losses. The remote sensing techniques provide an appropriate land use mapping strategy. The remote sensing imagery (RSI) is the efficient land use mapping method and generates the combined map in flood crisis situations. This technique provides the accuracy, activity in density zones during the daytime and nighttime and analyzes the variation of people working and living in the hazard zone. The MOBILISE platform for resilient communities provides web-based resilience for urban communities. MOBILISE also offers a spatial based technology for multi agencies to collaborate and analyze the disaster patterns to mitigate the impact of natural disaster [34].

2.4. Preparedness
The data collected from sensor networks can improve the community-based disaster preparedness [6]. Through these sensors, the government officials identify the vulnerable area, and in emergencies, early preparedness can affect and safe their lives. Information technology offers an opportunity to establish a living lab-style and support the disaster field worker [19]. One example of living lab-style is the virtual reality. The VR is new technology gives hope and teaches how to survive from disaster [6]. The VR technology guides the user and share information about the situation. What exactly is going on? The VR tells visually and provides a safe passage to the user to evacuate from the building, school, or indoor office. Risk identification from natural disasters like floods, earthquakes, fire hazards, and cyclones is a crucial requirement for preparedness and mitigation. The GIS & RS provides the automation that could use in micro zonation. As earlier defined, the GIS comprises different interrelated parts that follow the information system. It includes data processing, data dissemination through a geographic database (GDB). These operations provide different layers in micro zonation. Other techniques are used to prepare hazards and risk map depending on the type of disaster. In the case of flood map preparation, first, the flood estimations were prepared, either from historical data or numerical simulation of selected extreme measures. The flood hazards map is one of the unique and imperative outputs of hazards zoning maps provided by GIS & RS by mixing different layers of GIS.

The aim of preparing flood hazard maps is to be identifying the vulnerability and susceptibility of the region against the flood determined to evaluate and taking preventive actions during and after the disaster. Identifying exposure in that region, the water level from each region's surface, the damage settlement area, routes to the damaged area, and the rescue centers included in the hazards map with understandable layers. The maps are prepared in a readable and straightforward way to analyze and predict the damages and easy usage for the GIS users. These produce maps used for residents of the flooded area. The local individuals, the emergency response personnel can receive different information about the flood hazards, and they are well prepared before the crisis. The maps provide the danger zone location and mark the hazards area in vulnerable regions for the resident to not travel to high-risk regions.

2.5. Response
The information technology offers to resolves the structure of information exchange in the initial response. When the disaster occurs the most important thing is to communicate accurate and quick. The aim of the response is to reduce the impact of hazards conduct different operations to save the life. In Japan when the disaster occurs, the local government had taken following steps to safe the community [14]. In Japan, checking the locations and safety of residents, creating and operating migration centers, transferring and managing relief goods, encouraging evacuees, and creating evacuee lists, and making disaster sufferer records. These procedures are extremely distinct from daily-basis duties. It requires situational information that can be enhanced through social media to deliver these operations.

Information systems enhance situational awareness and decision making. As argued earlier, social media has changed the way citizens react to a disaster. Victims can report situations around them through social media. In last phase when the disaster already occurred and the best strategy is minimizing the damages, the disaster professionals and the multi-agency organizations aim is to give quick and fast
response to the effected population combat the situation. The last phase is considered as the difficult phase to manage in terms of other phases. When everyone is panicked and people shouting for help and aid, this time the best strategy is to create awareness among the risk population about the event and guide the people how to cope with this mess. It has to be done in various ways, but the most significant ways are to communicate with the people by available information technology application. The most traditional ways to communicate are audio video calls, radio, television and most importantly the social media applications, such as Facebook, WhatsApp, Telegram, Instagram, and twitter [14]. The MOBILISE platform, social media and real time intelligence through satellite handling offers disaster agencies and professionals to find the vulnerable areas in nominal time. Flood economic cost estimation and crowd movement simulations are one of the intelligences that offers to support disaster response [34].

A recent study of [15] conducted in Japan revealed that the television and radio language is very easy to understand and create awareness among the affected and they reduce the death toll of catastrophe by announcing the precautionary measure. Now we are in the era of industry revolution, where social media playing an effective role to combat and cope with disasters. Sharing tweets and comments from Twitter and Facebook in disaster situation is very effective to minimize the impact of disaster and save many lives. For the disaster professional and workers, the digital elevation model (DEM) in remote sensing is the most efficient and cost saving method that estimate the flood depths from hydrological and remotely sensed data. The flood depth is the most important factor to find out the intensity of flood hazard. Estimating the depths of inundation of the flood zones are prepared from various hydrological and remotely sense data to mitigate the flood risk.

2.6. Recovery

After an initial and early response, a local authority administers assisting communities to get back to their normal life. The recovery phases include the policy and procedures which enables the recovery tools such as the implementation of essentials technology to provide aid to residents. The 2014-2015 flood in Malaysian history is one of the biggest challenges for country in terms of recovery phase and this disaster shows the prominence and how valuable recovery plan is to be. By setting an example, building evacuation centers and other relief activity for the flood community.

Kemaman Local Heroes Model is another example in Malaysian 2014-2015 floods. The study shows how the local community were involved in making significant contributions in providing prompt responses during a flood, this study is based on Kemaman, Malaysia. [18] used unique Flood management (FM) system specifically implemented in their state along with their Standard Operating Procedure (SOP) throughout the disaster management procedure. These two factors are the main reason of success in Kemaman as compared to other states during 2014/2015 floods. The unique FM system relies on technology and effective & efficient process to be implemented on all disaster agencies.

3. Conclusion

In this research, the usage of information technology, application of remote sensing and geographic information system has demonstrated the spatial tools and techniques in building resilient communities. The information system and other satellite communication can provide an indispensable support to reduce natural hazards. In this research we have reviewed the role of information technology by considering four phases of disaster management for local government perspective. The information included recording, exchanging of data, and passing critical data information for effective disaster management. In earlier the holistic approach is missing. In this paper we have explained the integrated discussion on technology in each cycle of disaster. It has observed that the more enabled information system network is required for quick response in hazard situation. There is need of collaboration between the local authorities, external agencies and information technology professionals are very crucial to conquer the impact of disaster. The disaster normally happened in well-known areas and it is easily to find out the vulnerable zones, but the problem is that the community does not know the coping mechanism. There is need of capacity building in disaster prone areas. In near future, MOBILISE
platform is one of the infrastructures that addresses the issues of disaster risk reduction and also strengthen the disaster risk governance by offering disaster mitigation, preparedness, response and recovery program to build the resilient future through multi agency collaboration. We need to engage innovative technology and it must be initiated at local government and state level in Malaysia to mitigate the impact of disaster. Effective disaster management requires information technology, tools, and practices to enable the disaster response and systematically manage the disaster information by collaborating to mitigate the damages and help communities rebuild.

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References
[1] Erdelj M, Natalizio E, Chowdhury K R, and Akyildiz I F 2017 Help from the Sky: Leveraging UAVs for Disaster Management. IEEE Pervasive Computing 16 24–32
[2] Kiesel J, Schuerch M, Christie E K, Möller I, Spencer T, and Vafeidis A T 2020 Effective design of managed realignment schemes can reduce coastal flood risks. Estuarine, Coastal and Shelf Science 242
[3] Stute M, Maass M, Schons T, Kaufhold M A, Reuter C and Hollick M 2020 Empirical insights for designing Information and Communication Technology for International Disaster Response. International Journal of Disaster Risk Reduction 47
[4] Muqtada M, Khan A, Ashikin N, Shaari B, Muchtar A, Bahar A, Adriansyah D and Nazaruuddin B 2014 Flood Impact Assessment in Kota Bharu, Malaysia : A Statistical Analysis 32(100) 626–634
[5] Center for Public Policy Studies 2015
[6] Chen H Y, Das A and Ivanov D 2019 Building resilience and managing post-disruption supply chain recovery: Lessons from the information and communication technology industry. International Journal of Information Management 49
[7] EM-DAT 2020 Number of Major Disasters from 1970 to 2019 (Centre for Research on the Epidemiology of Disaster)
[8] CFE-DM 2018 Center for Excellence in Disaster Management & Humanitarian Assistance
[9] Sulaiman N, Abid S K, Nazir U, Mahmud N P N, Latib S K K, Hafidz H F, Roslan A F and Rahim N A 2020 Need for Resilience Healthcare Facilities Management ( RHFM ) in Malaysia’s Public Hospitals A Critical Literature Review. Proceedings of the 2nd African International Conference on Industrial Engineering and Operations Management Harare, Zimbabwe
[10] Shekhar S, Xiong H and Zhou X 2017 Encyclopedia of GIS Springer 2nd ed. p 1170-6
[11] NIDM 2014 Malaysia National Profile Disaster Risk Profile Institutional Setup Initiatives
[12] FEMA 2011 The Federal Emergency Management Agency Foundations of Homeland Security (John Wiley & Sons, Inc)
[13] Menon S 2002 Climate Effects of Black Carbon Aerosols in China and India Science 297 (5590)
[14] Sakurai M and Murayama Y 2019 Information technologies and disaster management – Benefits and issues Progress in Disaster Science 2
[15] Fajardo J T B and Oppus C M 2009 A Mobile Disaster Management System Using the Android Technology International Journal of Communications 3(3)
[16] Alias N E, Salim N A, Taib S M, Yusof M B, Saari R, Ramli M W, Othman I K, Annammala K V, Yusof H M, Ismail N et al 2020 Community responses on effective flood dissemination warnings: A case study of the December 2014 Kelantan Flood, Malaysia. Journal of Flood Risk Management 13(S1)
[17] Bennett D 2019 Information and Communication Technology in Crisis and Disaster Management
Oxford Research Encyclopedia of Politics (Oxford University Press)

[18] Saad M F, Latif A A and Othman M 2017 The 2014 flood disaster in Kemaman, Terengganu: Lessons from the Kemaman experience ed Zulikha J & N H Zakaria Proceedings of the 6th International Conference on Computing & Informatics pp 628-635 (Sintok: School of Computing)

[19] Azimi M A, Zakaria S A and Majid T A 2019 Disaster risks from economic perspective: Malaysian scenario IOP Conf. Ser.: Earth Environ. Sci. 244 012009

[20] Shehara P L A I, Siriwardana C S A, Amaratunga D and Haigh R 2020 Examining the Community Perception Towards Communication Modes of Issuing Multi-Hazard Early Warning (MHEW) in Sri Lanka. Moratuwa Engineering Research Conference (MERCon) 60-65

[21] Aisha T S, Wok S, Manaf A M A and Ismail R 2015 Exploring the Use of Social Media During the 2014 Flood in Malaysia Procedia Social and Behavioral Sciences 211

[22] Tobin G A and Montz B E 2004 Natural Hazards and Technology: Vulnerability, Risk, and Community Response in Hazardous Environments eds Brunn S D, Cutter S L and Harrington J W (Geography and Technology Springer Dordrecht)

[23] Faghirinejadfard A, Mahdiyar A, Marsono A K, Mohandes S R, Omrany H, Tabatabae S and Tap M M 2015 Economic comparison of industrialized building system and conventional construction system using building information modeling. Jurnal Teknologi 78(1)

[24] Sulaiman N, Teo W S and Fernando T 2019 Community resilience frameworks for building disaster resilient community in Malaysia. Journal of the Malaysian Institute of Planners 17

[25] McLoughlin D 1985 A Framework for Integrated Emergency Management. Public Administration Review 45

[26] Diya S G, BarzaniGasim M, EkhwanToriman M and Abdullahi M G 2014 Floods in Malaysia Historical Reviews, Causes, Effects and Mitigations Approach. International Journal of Interdisciplinary Research and Innovations 2 59–65

[27] Sahana M and Sajjad H 2019 Vulnerability to storm surge flood using remote sensing and GIS techniques: A study on Sundarban Biosphere Reserve. Remote Sensing Applications: Society and Environment 13

[28] Abid S K, Sulaiman N, Mahmud N P N, Nazir U and Adnan N A 2020 A review on the application of remote sensing and geographic information system in flood crisis management. Journal of Critical Reviews 7(16) 491–496

[29] Usmani R S, Hashem I A, Pillai T R, Saeed A and Abdullahi A M 2020 Geographic Information System and Big Spatial Data: A Review and Challenges. International Journal of Enterprise Information Systems 16(4) 101–145

[30] Levius S, Safa M and Weeks K 2017 Research note for use of information and communication technology to support comprehensive disaster management in the Caribbean countries. Journal of Information Technology Case and Application Research 19(2)

[31] United Nation 2016 ICT in Disaster Risk Management Initiatives in Asia and the Pacific

[32] Xia Y and Yang X (2012) Remote Sensing Image Data Storage and Search Method Based on Pyramid Model in Cloud ed Li T et al RSKT 2012 Lecture Notes in Computer Science 7414 (Springer, Berlin, Heidelberg)

[33] Hanan N A M, Abas M A, Nor A N M, Amin M F M, Hassin N M, Yosoff A H, Awang N R, Mohamed S and Wee S T 2020 A GIS-Based Flood Vulnerability Assessment in Pasir Mas, Kelantan. IOP Conf. Ser.: Earth Environ. Sci. 549 012004

[34] MOBILISE 2019 A Collaborative Multi-Agency Platform for Building Resilient Communities

[35] Subedi J 2010 Disaster Informatics Advanced ICTs for Disaster Management and Threat Detection (IGI Global)

[36] Villodre J and Criado J I 2020 User roles for emergency management in social media: Understanding actors’ behavior during the 2018 Majorca Island flash floods. Government Information Quarterly 37(4) 10152