Influence of Geographic Information System on Natural Disaster Management in the United Arab Emirate

Saif Ali Alblooshi
saifalblooshi59@gmail.com

Mohd Yamani Bin Yahya
yamani@uthm.edu.my

Faculty of Technology Management and Business, Universiti Tun Hussein Onn Malaysia
86400 Parit Raja, Batu Pahat, Johor, Malaysia.

Abstract

The aim of this study is the examine the influence of geographic information system, on disaster management in the United Arab Emirates (UAE). In light of the new nuclear development at Braqa and other expansions in UAE energy sectors, it is important to understand the vulnerabilities of the sector as a means of preparedness for a future natural disaster. Therefore, a structured questionnaire with a 5-point Likert scale was used as the instrument for data collection from the total of 329 respondents from The National Emergency Crisis and Disasters Management Authority (NCEMA). The findings show that there is a significant positive influence between geographic information system and disaster management. This implies that geographic information system plays a crucial role in the disaster management effectiveness. This study will contribute the existing literature related to the factors effacing the effectiveness of the disaster management. Also, future researcher might investigate further on the relationship between the other geospatial technologies and disaster management.

Keywords: Geographic Information System, Disaster Management, United Arab Emirates

1. Introduction

The United Arab Emirates is a wealthy country with a per capita GDP of $73,878.50 USD as of 2017 (World Bank, 2018). However, Ruwaithi (2019) pointed that due to various geographical, political, and social issues in the UAE contribute to either increased risk of disaster or ineffective disaster management. Hence, before four decades the total population of the UAE was 1 million and therefore, it sharply increased to 8.4 million only 30 years later. Besides, very large majority of the population lives in urban areas in coastal zones, which is also prone to a number of natural and manmade hazards (Dhanhani et al., 2010). Thus, the rapid population growth led to the UAE to several natural hazards/risk including those atmospheric, geological and anthropogenic in origin. As development continues in the nation the country and its people become even more vulnerable to the effects of those hazards (Pathirage & Al-Khaili, 2016).

Additionally, Pathirage & Al-Khaili (2016) based on their study on Disaster Vulnerability of Emirati Energy Sector and Barriers to Enhance Resilience, highlighted that there are three most risks that vulnerability within Emirati energy sector namely; terrorism, atmospheric and tectonic hazards. Likewise, absence, limited or lack of national government legislation, awareness and education are shown as the main barriers. Thus, Pathirage & Al-Khaili (2016) suggested that improving human resource management through better awareness, training and practices is considered as a priority on the effectiveness of the disaster management in the UAE.

Given that disasters are spatial phenomenon, the application of geospatial information technology (GIT) is essential to the natural disaster management process (Herold & Sawada, 2012). However, in developing countries there are numerous barriers to the effective use of geospatial information technology, especially at the local level, including limited financial and human resources and a lack of critical spatial data required to support geospatial information technology use to advance disaster management related decision making processes (Herold & Sawada, 2012). Furthermore, although there some previous studies examined the challenges and potential solutions of data handling, but there is limited studies focusing on socio-technological issues or advanced applications (Carlos Granel, 2016). Similarly, Almarzouqi (2017) stated that There is an evidence that little has been done in terms of pre-disaster planning, not only in the UAE but also throughout most of the Islamic countries.

The National Emergency Crisis and Disasters Management Authority was used as a case study of this research. As NCEMA is the only agency that promotes the supportive and authoritative roles of the UAE federal government in disaster management. Its roles include but are not limited to building a strategic emergency plan, coordinating operations among emergency agencies, defining bodies' responsibilities and overseeing and controlling emergency committees (Dhanhani et al., 2010). In addition, Abdalla (2017) among issues that may face accurate utilization of spatial analysis, is the accuracy of data and time of processing, as well as shared coordination among stakeholders. Furthermore, Abdalla (2017) stated that a challenge to effective risk reduction is providing disaster managers with access to data and approaches that may help them in analyzing, assessing, and mapping risk models Abdalla (2017) and Pirasteh & Li (2017).

Abdalla & Li (2010) argued that there is a need for adopting a more effective geospatial solutions for saving life and property influenced by the increasing number of disasters. Due to the level of accessibility, reliability and effectiveness in providing accurate models and simulations of the real world phenomena. Thus, the application of geospatial technologies in disaster and emergency management is becoming an extra important nowadays. Therefore, geospatial technologies are capable of addressing both the spatial and the temporal aspects of disasters, which makes them effective decision support tools. Therefore, this study fills in the gap by investigating the influence geographic information system on disaster management in the UAE.

2. Prior Literature review

Disaster management is a complex series of activities that include risk assessment, preparedness to cope with future disasters and prevention measures, emergency response to a disaster, recovery and reconstruction. Community preparedness and good development can reduce the impact of a disaster especially for the most vulnerable people, such as those living in hazard-prone areas (Dhanhani, 2010). In addition, a disaster is generally understood as being the interaction between human and human systems "and a natural or artificial hazard. United Nations International Strategy for Disaster Reduction (Pirasteh et al., 2017) defines a disaster as a serious disruption of the functioning of a community or society involving widespread human, material, economic, or environmental losses, and effects, which exceeds the ability of affected community or society to cope using its resources. Pirastehet al., (2017) defines a hazard as a dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health effects, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.

A disaster is normally understood as an event that" overwhelms the capacity to cope with and respond to, the event. Slamet et al., (2018) state that disasters occur when the demands for action exceed the capabilities for response in a crisis. From "this it can be envisaged that even fairly small events can be overwhelming where there is little or no coping capacity. But it should be noted that different views on which constitutes a disaster can be shaped by the type of organization that puts forward a definition. For example, the International Federation of Red Cross and Red Crescent Societies define a disaster as a sudden, calamitous event that seriously disrupts the functioning of a community or society and causes human, material, and economic or environmental losses that exceed the community's or society's ability to cope using its resources. Though often caused by nature, disasters can have human origins. Disaster management scholars have offered definitions of a disaster. For example, Garcia et al., (2018) define a disaster as a singular event that results in widespread losses to people, infrastructure, or the environment. Disasters originate from many sources, just as hazards do natural systems, social systems, technology failures.

2.1. Geographic Information System and disaster management

Geographic Information System (GIS) operations generally involve data acquisition, data management, data query, vector data analysis, raster data analysis, and data display. These operations do not have to be successive. For instance, data display may be conducted for exploring data at the beginning of a project and for presenting results at the end of the project (Chang, 2019). Also, geographic information system applications play a crucial role in mitigation of disasters (Tomaszewski, 2020). Previous studies reported that one of the factors or determents of the effectiveness of the disaster management is geographic information system (Hasan, 2013). In addition, Thomas (2018) pointed that geographic information system is a type of geo-technology in GIS technology, has extensive potential in disaster management; including damage assessment, risk prediction and situational analyses, vulnerability and resilience assessments, and prioritization of mitigation alternatives (Thomas, 2018).

According to Agency (1995) natural disasters such as hurricanes, floods, tornadoes, earthquakes, and volcanic eruptions have impacted the world since the beginning of time. Therefore, the infrastructures of technologies have exponentially improved the worldwide community's ability to respond to the challenges presented by unexpected disasters. Thus, geographic information system is a framework for gathering, managing, and analyzing data. Combining GIS into the disaster response context has improved planning, response times, collaboration, and communication during the most challenging dynamic circumstances (Agency,1995; Dalton, 2016; Havas et al., 2017; Dalton, 2018). Furthermore, developments in GIS have provided organizations with the ability to cooperate more efficiently and effectively. Emergency or disaster management resolution natural disaster challenges using the comprehensive emergency management method (Agency, 1995).

Another study done by Brian Tomaszewski *et al* (2015) on Geographical Information Systems for Disaster Response and Management; Brian Tomaszewski *et al* (2015) concluded that GIS continue to gain important recognition from disaster practitioners and academic researchers during what is debatably the most publicly visible disaster management stage. Therefore, GIS to support situation awareness, the time sensitive nature of disaster response geographic information, and the need for common data sharing collaboration and coordination with various administrations and disciplines (Brian Tomaszewski *et al.,* 2015). During the process of preparedness and response stages, GIS can accurately support better response planning in areas such as determining evacuation routes as well as locating vulnerable infrastructure and vital lifelines (Tran et al., 2009; Sharma & Parkash, 2016). The use of geographic information systems within emergency management has improved the ability of practitioners to plan for respond to and assistance in recovery from natural and human induced risks in a more comprehensive way than ever before (Cutter et al., 2007). Thus, this study aims to examine the relationship between geographic information system and disaster management in the UAE context.

H1: There is a positive relationship between geographic information system and disaster management

3. Methodology

The research methodology is a design of a process for gathering, analysing and offering proofs used to test a hypothesis or to fulfil the research objectives. Thus, as this study is an empirical analysis of the influence of geographic information system natural disaster management at the National Emergency Crisis and Disasters Management Authority (NCEMA). Therefore, a quantitative method was adopted and a structured questionnaire with a 5-point Likert scale was used as the instrument for data collection from the total of 329 staff of NCEMA. The items of the questionnaire were adopted from Huggins (2007) and Chou (2008) and therefore, all the items were modified to represent the objective of the study. Structural equation modeling (SEM) Partial least squares (PLS) or also known as PLS-SEM was used to analysed the collected data. PLS-SEM is adequately capable of data cross-examination to explore and reveal relationships among a couple of constructs (Hair et al., 2012).

4. Result

Measurement models are required to explain the variance of the manifest items to achieve convergent validity. It is the assessment of how the measurement model is able to accurately predict or explain the variance of the manifest variables (Wong, 2016). Convergent validity is regarded as the extent to which a manifest variable is related with other manifest variables in the same underlying construct (Hair, Hult, Ringle, & Sarstedt, 2014). The explanation of the manifest variables' variance is assessed by evaluating the Average Variance Extracted (AVE) and items factor loadings and their significance level (Lowry & Gaskin, 2014; Memon & Rahman, 2013; Wong, 2016). Table 1 presented the results of the constructs reliability and validity including factor loadings, Cronbach's alpha, composite reliability and Average Variance Extracted (AVE).

Table 1: Constructs Reliability and Validity

Constructs	Items	Loadings	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)
Geoformation system	GIS1	0.875	0.862	0.896	0.596
	GIS2	0.804			
	GIS3	0.893			
	GIS4	0.837			
	GIS6	0.579			
	GIS9	0.576			
Disaster management	DM1	0.808	0.934	0.944	0.629
	DM2	0.823			
	DM3	0.721			
	DM4	0.860			
	DM5	0.753			
	DM6	0.825			
	DM7	0.763			
	DM8	0.841			
	DM9	0.831			
	DM10	0.688			

As shows in the Table 1 the measurement model based on the disaster management and geoformation system, both constructs' items have succeeded the suggested requirement of the evaluation. Thus, all the measurement model achieved the required convergent validity. Additionally, Table 2 presented the Discriminant validity using Fornell and Larcker Criterion.

Table 2: Discriminant validity using Fornell and Larcker Criterion

	Disaster Management	Geoiformation System

Disaster management	***0.793***	
Geoinformation system	0.746	***0.772***

The diagonally italicised and bolded values are the square roots of the AVEs of the measurement model. The values beneath the diagonal are correlations between the measurement model. The result showed that none of the measurement model has correlation with any other measurement model more than the square root of its AVE. Therefore, the measurement models achieved the required discriminant validity based on Fornell and Larcker criterion.

Table 3: Discriminant validity using cross loadings criterion

Item	Disaster Management	Geoinformation System
DM1	**0.808**	0.655
DM2	**0.823**	0.681
DM3	**0.721**	0.560
DM4	**0.860**	0.654
DM5	**0.753**	0.553
DM6	**0.825**	0.556
DM7	**0.763**	0.524
DM8	**0.841**	0.616
DM9	**0.831**	0.578
DM10	**0.688**	0.487
GIS1	0.696	**0.875**
GIS2	0.559	**0.804**
GIS3	0.697	**0.893**
GIS4	0.655	**0.837**
GIS6	0.333	**0.579**
GIS9	0.388	**0.576**

Furthermore, the results of discriminant analysis using the cross-loading criterion is presented in Table 3. The results shown that of manifest items load more on their constructs that their cross-loadings on other measurement model. Based on this criterion therefore, the measurement model achieves discriminant validity. The discriminant validity of the research measurement model is assessed using two criteria of assessing discriminant validity and cross-loading criterion. All the requirements of the two criteria are satisfied. Therefore, the measurement model of the research has the required discriminant validity.

Table 4: Path Coefficients

Paths	Path Coefficient	T Statistics	P Values	Hypothesis
Geographic information system -> Disaster Management	0.573	19.596	0.000	Supported

In the structural model, as presented in the Table 4 the hypothesis was significant with t-values exceeding the t-critical value of 1.96 and p-values value less than 0.05 as recommended by Cohhen (1989), Chin (1998) and Hair *et al* (2014). This implies that there is a positive the relationship between geographic information system and disaster management and therefore, the hypothesis was supported

5. Discussion and Conclusion

The objective of the study was set to investigate the influence of geographic information system on disaster management. To achieve the stated objective, questionnaire survey was used to seek the response of individual respondents on the extent of their perspective on contribution or the influence geographic information system on disaster management activities and effectiveness. Thus, the result of the analysis showed that there is a significant positive influence between geographic information system and disaster management. This implies that geographic information system plays a crucial role in the disaster management effectiveness. This outcome is in line to that of Tomaszewski (2020) who found geographic information system applications play a crucial role in mitigation of disasters. Similarly, Hasan (2013) pointed that the most factor or determents of the effectiveness of the disaster management is geographic information system. Also, the present study supported by the findings of Abdalla (2017) and Pirasteh & Li (2017) who mentioned that the applications of GIS in disaster Management are increasingly becoming an integral element of disaster and emergency management activities globally.

According to Thomas (2018) geographic information system is a type of geo-technology in GIS technology, has extensive potential in disaster management; including damage assessment, risk prediction and situational analyses, vulnerability and resilience assessments, and prioritization of mitigation alternatives. Another study done by Brian Tomaszewski *et al* (2015) on Geographical Information Systems for Disaster Response and Management; Brian Tomaszewski *et al* (2015) concluded that GIS continue to gain important recognition from disaster practitioners and academic researchers during what is debatably the most publicly visible disaster management stage. Therefore, GIS to support situation awareness, the time sensitive nature of disaster response geographic information, and the need for common data sharing collaboration and coordination with various administrations and disciplines (Brian Tomaszewski *et al.,* 2015).

Yagoub (2015) also stated that GIS experience and social media usage were regarded as factors that could impact user evaluation of this information system. However, although geo-informatics technologies and earth observation satellites have already demonstrated a strong flexibility in providing data, analyzing data, and modeling for a broad range of applications (Pirasteh & Li, 2017). The geo-informatics for natural disaster management and Earth Observation Global Changes events have been struggling in establishing a platform for scientists, researchers, practitioners. Another study done by Abdulrahman (2014) on the GIS as a high performing computing tool for disaster management and control. Concluded that it is important to understand that while GIS can enhance the existing disaster management programmes, its integration requires broader management and institutional issues be addressed. Technological advances and extensions of geographic information systems have opened the way for several applications in disaster management. Thus, as the result from this study has confirmed that geographic information system pays an important role on the effectiveness of the disaster management, thus, it is highly recommended for the National Emergency Crisis and Disasters Management Authority (NCEMA) and other agencies involving in the disaster management might consider the contribution of the geographic information systems.

6. Contribution

This study contributes to both the empirical and theoretical literature on the area of geographic information system and disaster management. Empirically the choice of geographic information system implementation on disaster management as the focus of the study provides a novel context for the analysis of an emerging issues and shifts the emphasis away from the constricted financially inclined viewpoint that dominates much of the use of natural disaster management. This study has identifying the factors that have direct influence on disaster management and therefore, this will contribute in both theoretically as it will add value in the existing literature and help expertise to understand more on the effect of the geospatial technology on disaster management.

7. Limitation of the research

This study solely focusses on quantitative method, future researchers can use a mixed method such as quantitative and qualitative approach, by interviewing expertise who engage on disaster management execution. In addition, the findings highlighted very crucial issues on the natural disaster management in the UAE context. However, the current research did not cover all the factors that influence or have effect on the natural disaster management; therefore, this could be also a limitation on the present study.

8. Recommendation

The outcome of the study revealed that geographic information system has significance positive effect on disaster management at the National Emergency Crisis and Disasters Management Authority. Thus, the study does not only contribute to knowledge in developing/proposing a new model based on the relationship between the geospatial technology and disaster management in UAE but also create awareness and update managers who involve on disaster management activities. Thus, future researcher can study on the mediating influence of the training in the relationship between the geospatial technologies and disaster management. Also further research on the mediating effect of national culture in the relationship between geospatial technologies and natural disaster management is needed.

References

Abdalla, R. (2017). Status of Spatial Analysis for Urban Emergency Management. *Global Changes and Natural Disaster Management: Geo-Information Technologies*, *Springer International Publishing AG 2017*, 1–228.

Abdalla, R., & Li, J. (2010). Towards effective application of geospatial technologies for disaster management. *International Journal of Applied Earth Observation and Geoinformation*, *12*(6), 405–407.

Abdulrahman, I. R. (2014). *GIS as a High Performing Computing Tool for Disaster Management and Control: The Nigerian Challenges*. 157–160. https://doi.org/10.15242/iicbe.c0314095

Agency, U. S. (1995). *National Mitigation Strategy: Partnerships for Building Safer Communities. Washington D.C. : FEMA.*

Almarzouqi, I. (2017). *An analysis of disaster vulnerability in the United Arab Emirates. Doctoral thesis, Northumbria University.*

Carlos Granel, O. E. & F. O. O. (2016). *Beyond data collection: Objectives and methods of research using VGI and geo-social media for disaster management*. *74*(1934), 535–546.

Chang, K.-T. (2019). Geographic information system technology. *Pit and Quarry*, *85*(12).

Dalton, J. C. (2016). *Flood Inundation Mapping. Washington D.C. : U.S. Army Corps of Engineers* .

Dalton, S. (2018). *Teamwork and Technology: Game changers for the U.S. Army Corps of Engineers. Retrieved from DVIDS*. https://www.dvidshub.net/news/302851/teamwork-and-.

Dhanhani, H. A. G. (2010). *Evaluation of the response capability of the United Arab Emirates (UAE) to the impact of natural hazards*.

Dhanhani, H. A. G., Duncan, A., & Chester, D. (2010). United Arab Emirates: Disaster management with regard to rapid onset natural disasters. *Advanced ICTs for Disaster Management and Threat Detection: Collaborative and Distributed Frameworks*, *June 2019*, 65–79.

Hasan, S. (2013). *Sound practices in space technology applications for disaster risk reduction and inclusive and sustainable development*. 1–23.

Havas, C., Resch, B., Francalanci, C., Pernici, B., Scalia, G., Fernandez-Marquez, J. L., Van Achte, T., Zeug, G., Mondardini, M. R. R., Grandoni, D., Kirsch, B., Kalas, M., Lorini, V., & Rüping, S. (2017). E2mC: Improving emergency management service practice through social media and crowdsourcing analysis in near real time. *Sensors (Switzerland)*, *17*(12).

Herold, S., & Sawada, M. C. (2012). A review of geospatial information technology for natural disaster management in developing countries. *International Journal of Applied Geospatial Research*, *3*(2), 24–62.

Pathirage, C., & Al-Khaili, K. (2016). Disaster vulnerability of Emirati energy sector and barriers to enhance resilience. *Built Environment Project and Asset Management*, *6*(4), 403–414.

Pirasteh, S., & Li, J. (2017). Global changes and natural disaster management: Geo-information technologies. In *Global Changes and Natural Disaster Management: Geo-information Technologies* (Issue October).

Ruwaithi, A. A. Al. (2019). *A Critical Review of Emergency and Disaster Management in the United Arab Emirates*. *11*, 23–35.

Sharma, A. K., & Parkash, S. (2016). *Geographical Information Systems for Disaster Response and Management*. *January*.

Thomas, D. S. K. (2018). *The Role of Geographic Information Science & Technology in Disaster Management*. *16*, 311–330.

Tomaszewski, B. (2020). *Geographic information systems (GIS) for disaster management. CRC Press.*

Tomaszewski, Brian, Judex, M., Szarzynski, J., Radestock, C., & Wirkus, L. (2015). Geographic Information Systems for Disaster Response: A Review. *Journal of Homeland Security and Emergency Management*, *12*(3), 571–602.

Tran, P., Shaw, R., Chantry, G., & Norton, J. (2009). GIS and local knowledge in disaster management: A case study of flood risk mapping in Viet Nam. *Disasters*, *33*(1), 152–169.

Yagoub, M. M. (2015). Public Perception On Disaster Management Using Volunteered Geographic Information (VGI): Case of UAE. *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, *2*(2W2), 241–246.

Yagoub, Mohamed Mohamed. (2015). Spatio-temporal and hazard mapping of Earthquake in UAE (1984–2012): Remote sensing and GIS application. *Geoenvironmental Disasters*, *2*(1).