Critical success factors for geospatial data sharing in disaster management

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Critical success factors for geospatial data sharing in disaster management

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Abstract. Globally, the rise of disasters has caused billions of dollars lost each year. These include the loss of properties, life and has created a negative impact on socioeconomic level of a country. Currently, geospatial datasets are becoming crucial for situational awareness and management of disasters. The timely and accurate information on disastrous occurrences must be collected, maintained, and managed for efficient management of emergency. These geospatial datasets are from different data provider agencies. Thus, there is a need to focus on the geospatial data sharing that would benefits the authorities in decision making. This initiative entails high commitment and collaboration from the data provider agencies, which can be achieved through the sharing of geospatial datasets approach. This study aims to identify the critical success factors of geospatial data sharing in the context of natural disaster. A preliminary review, focus group discussion and interviews were conducted to get insights of the subject being studied. The findings revealed that there are thirteen (13) critical success factors for geospatial data sharing in disaster management. Technology, Organisation, Social, Environment, Ecology and Economy are the dimensions identified and mapped accordingly to the thirteen critical success factors.

1. Introduction

Disasters cause a hazard to numerous countries, bringing both physical and financial devastation. The worst consequences on a country's socio-economic well-being and economic progress are caused by a variety of natural disasters that occur every year across the globe [1-4]. Unpredictability, a lack of resources in disaster-affected areas, and sudden shifts in the environment are the primary limitations of natural catastrophes. [5]. The fast growth of information technology has resulted in an increased demand for data that is up to date, precise, and simple to interpret. In all phases of a crisis, it is critical to have current and reliable data or information [6]. Data, particularly geographical data, is becoming progressively critical in forecasting and decision making, particularly in the disaster management. Geographic information system (GIS) data can be valuable and significant in decision-making at any level of the risk management process. The use of geospatial data was first limited to ensuring that catastrophe victims received adequate response, but their application eventually expanded to incorporate the full risk management decision-making cycle.

The first stage in disaster prevention is identifying the dangers that exist in a certain location. Another important step would be to do an exposure evaluation of people, facilities, and property. Contemporary geospatial data is a crucial component of government dissemination and retrieval activities of information. Even though geographic data sharing is critical for the daily operation of many government systems, it remains a challenging issue in the field of natural and man-made catastrophe management, particularly in developing

nations [7]. All government needs to have extensive, up-to-date, accurate, and easily accessible geospatial information to appropriately manage the process of national planning and decision making [8].

One of the challenges identified is the geospatial data sharing for decision making and planning in all disaster phases. The efficacy of geospatial data is critical to ensure successful data sharing and dissemination in planning and decision making. Even though government support for catastrophes is endless, the current scenario in Malaysia demonstrates the crucial role of geospatial data sharing in disaster risk reduction. It is more effective and efficient to optimise the sharing and development of data and information on sustainable development and natural catastrophe mitigation efforts [9]. The sharing of geospatial data will assist authorities in making useful decisions during or after a disaster has occurred. Thus, numerous studies have been conducted on the significance of the geospatial data sharing in the context of disaster management and disaster risk reduction. However, most of the previous studies conducted recognise that there is still lacking studies on critical success factors identification in the disaster domain. As a result, it is necessary to identify critical success factors for geographic data sharing, which may result in the development of a framework for geospatial data sharing in disaster management.

2. Related Work

2.1 Disaster and disaster management

As defined by [10], disaster is 'a serious commotion of the operational of a civic or a society at any scale due to perilous events relating with conditions of exposure, susceptibility and capability, leading to social, physical, monetary and environmental damages. Disaster management can be defined as the conceptual preparation and organised strategy to deal and lessen the risks through a systematic approach or efforts to identify, evaluate, observe, forecast and manage the factors and the events of disaster [11]. Commonly, disaster management consists of the combination of many interrelated processes of continual, dynamic management and a plan for responding to emergency events. In addition to that, disaster management may not necessarily eliminate the risks itself, but the prediction and early warning study can minimize the threat to humanity [12].

2.2 Geospatial data sharing and disaster management in Malaysia

All stages of catastrophe management need up-to-date and correct information [13]. Geospatial data creates the capability to visualise classified geographical areas and analyses the characteristics and entities within them [14]. Geospatial data usage can be grouped into various areas from utilities, transportation, catastrophe management, public care, town development, environmental resources, health, monetary and more. Data sharing is not new to Malaysia and looking at the important of it, Spatial Data Infrastructure was introduced to manage geospatial data and information sharing among government sectors and the private sector (SDI) in Malaysian [15]. Geospatial data sharing is essential for development, ecosystem, planning, data gathering cost reductions and task duplication avoidance between data producers and users in various departments and provide governments ample data room to foresee and solve problems. The nature of emergencies is always dynamic, thus partnerships, data sharing and data exchange are essential to create and update the information needed for disaster management. In addition, various organizations are participating in responding to natural disasters in emergencies. Each year, Malaysia faces natural disasters such as floods, storms, and other extreme weather conditions impose to loss of life and property. Local government officials are the earliest respondents in the occasion of a catastrophe or emergency crisis. When dealing with emergencies, geographical data or geospatial data is essential for preventing or lessening losses. In disaster management, data relating to the disaster is accessed, retrieved, and transferred by every segment. Together, the many departments involved in the response to an emergency must work together to prevent it from becoming a more serious problem. Similar geographic datasets, vital facility information, and typically popular organisational and technological resources are all involved in this process.

2.3 Geospatial data and natural disaster management

Natural disaster management relies heavily on geographical data and information. DRR management currently relies on geospatial information, which includes information of topographic maps, thematic maps, plans, charts, and satellite images [16]. Geospatial information is created and used by a variety of stakeholders, including custodians, data suppliers, users, and vendors. Numerous parties currently rely on geospatial data for disaster management monitoring and decision-making. [17, 18]. Due to the extensive usage of geospatial data, there is a significant demand for and dependence on this information. Due to the time, technology, and financial resources required to process geospatial data [19, 20], only the core and crucial geospatial data were analysed. According

to the different stages of disaster data acquisition, management, analysis and application, there are a range of standards and guidelines as shown in Figure 1.

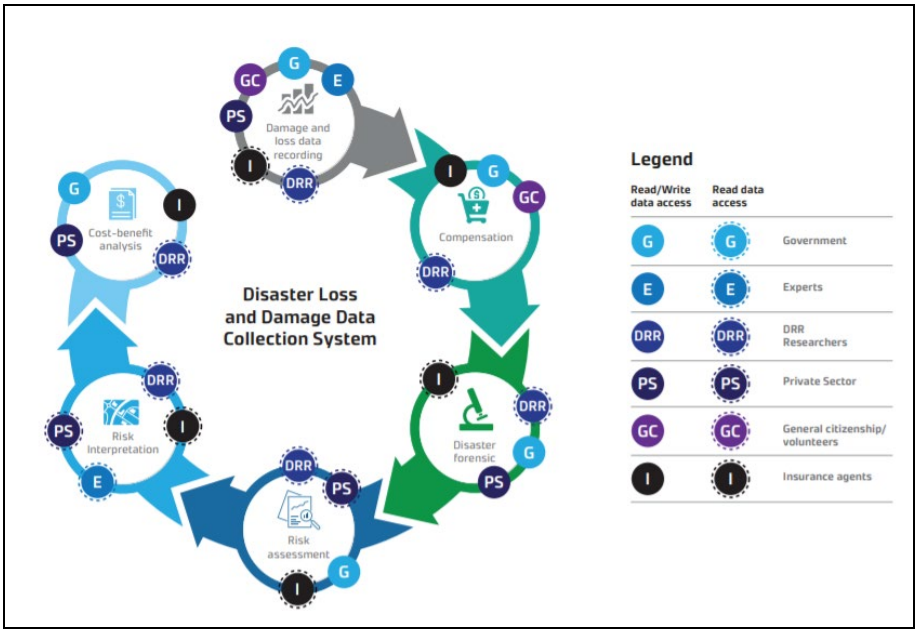

Figure 1: Disaster data collection system ([21])

Due to the diversity in data collection methods, the UN Sendai Framework devised a Data Collection Protocol to standardise the collection of disaster data. Hazard/disaster-related data that is already available is frequently geographically dispersed and stored by a variety of organisations, making it challenging to acquire and use for disaster management objectives. [22].

2.4 Critical success factors in disaster geospatial data sharing

In a recent study by [23], geospatial data sharing issues are among the main areas for planning and making the best decisions in a public emergency to get a complete picture of the situation, expedite scientific research and studies, and save time making decisions. Although most of the data involving geospatial is stored by the authorities, the sharing practices carried out have been found to be ineffective and hindered or slowed down by the lack of clear elements of support for its implementation. Geospatial data exchange on a large scale amongst companies in the GIS community has long been a challenge [24]. Based on past studies and interviews with the data provider there are thirteen (13) factors that have caused the sharing of geospatial data to be implemented comprehensively. Figure 2 depicts the identified critical success factors.

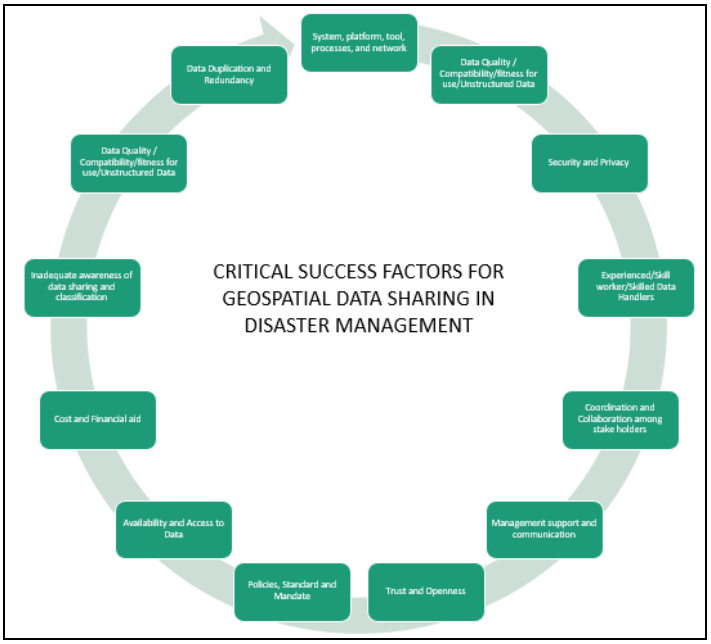

Figure 2: Critical success factors for disaster management

Collaboration across several agencies is essential in disaster management in this environment [25][26]. However, the process of collaboration amongst authorities, on the other hand, is frequently difficult due to a variety of factors, including differences in cultures, methods, and systems [27], among others, differences in motivations and incentives, as well as rivalry for inadequate resources [28], in addition to a insufficient level of coordination among the organisations involved [27][29]. These factors contribute to a lack of collaboration across organisations, which results in unnecessarily high casualties [30] as well as environmental and economic harm. As a result, disaster management's key issue is to increase multi-agency collaboration [25][31]. Recognizing this difficulty, Priority 2 of the Sendai Framework on strengthening disaster risk governance calls on national governments to improve cooperation among relevant stakeholders to manage risks more effectively.

3. Methodology

The primary aim of this study is to explore the CSFs for geospatial data and information sharing in disaster management. The primary data obtained through focus group discussion, literature review and interviews involving senior government staff from major agencies involved in disaster management operations, reveals that certain issues must be addressed to encourage collaboration between multiple agencies in disaster management in Malaysia. In this study, the following actions were taken: -

3.1 Papers selection

The reviews were made on the published or unpublished documents about geospatial data sharing or geodata sharing and dissemination and disaster management or emergency management between years 2014 to present. The papers include journal articles, government reports, and official web portals, as well as interviews and the outcomes of focus group discussions.

3.2 Searching criteria

To stay current with informatics advancements, this research conducts literature review in few prominent databases. Due to the large number of results collected, we narrowed the results using the following criteria: (1) English as language; (2) Articles with related to the keyword of geospatial data sharing, spatial data sharing, critical success factors and disaster management; (3) Articles from 2014 to present and (4) A detailed assessment of the contents to remove articles that are unrelated or out of date. The following phrases were used in the search: 'geospatial data sharing', and 'spatial data sharing', ‘critical success factors' and 'problems' are used interchangeably. The search string is then put together by utilising the Boolean connectors "AND" and "OR" to recognize for synonyms and word class variations of each term. Literature Reviews (LR) and preliminary

research in Malaysia Public Sector were undertaken to identify the CSFs of geospatial data sharing and dissemination for disaster management.

3.3 Data analysis

The data was analysed using the content analysis approach, which included a systematic procedure of data coding and categorising [32]. The data collected were categorised and grouped into components or categories [33]. A category is made up of data that appear to be related to the same subject. Subsequently, each category was assigned a phrase that most appropriately described it. Iterative and continuous methods were used. Following that, based on the revealed criteria, the CFSs of geospatial data and information exchange were determined. The content analysis method was used to code and analyse these factors.

4. Results and discussion

The findings revealed that there are thirteen (13) major critical success factors for geospatial data sharing in disaster management, as depicted in figure 1. These 13 CSFs were gathered accordingly, thus six (6) major components: technology constraint, organisational management constraint, social constraint, economic constraint, environmental constraint, and ecological restriction emerged. These 13 CSFs were then mapped accordingly to Technology, Organisation, Social, Environment, Ecology and Economy. Qualitative data from interviews and focus groups were transcribed and then coded. The codes were then classified into code groups and analysed thematically using content analysis. Technology, Organisation, Social, Environment, Ecology and Economy are the components identified and mapped accordingly to the thirteen CSFs. This study takes into consideration of the established TOSEEE framework, in general there many Disasters Management framework available yet lacking the focus on management of critical data in disastrous situations. TOSEEE Based on TOSE-Technical, Organizational, Social, And Economy [34]; And TOSEEE-Technological, Organizational, Social, Economy, Environmental and Ecological [35]. This framework will help to determine the CSFs of disaster data sharing. Table 1, lists the critical factors affecting the sharing of geospatial data, as determined by a review of the literature, a focus group discussion (FGD), and preliminary interviews.

Element	ID	Factor	Description	Sources	Methodology		
					FGD	LR	Interview
Technology	**TGY1**	System, platform, tool, processes, and network	These components include software, applications, infrastructure, and platforms, as well as network connectivity and a system for sharing geographical data.	[36][37][38][39] [40][61]	√	√	√
	TGY2	Data Quality / Compatibility/fitness for use/Unstructured Data	For integration purposes, criteria such as the projection, compatibility, accuracy, format, and timeliness of the data itself.	[41][42][43]	√	√	√
Organisation	**ORG1**	Security and Privacy	Additional safeguards should be developed as part of the data sharing architecture to enable the sharing of sensitive data while minimising the risk of loss.	[55][56][57][58]	√	√	√
	ORG2	Coordination and Collaboration among stake holders	The Coordination and Collaboration among stake holders should be encouraged, rewarded, and coordinated (either top-down or bottom-up, depending on the context).	[55][56][63]	√	√	√
	ORG3	Management support and communication	A collaborative, interactive environment should be fostered, and stakeholders should be encouraged to cooperate.	[60][61][62][65]	√	√	√
Social	**SOC1**	Trust and Openness	Providers of data and data operators should have mutual trust and be transparent with one another when it comes to data sharing.	[69][70][71]	√	√	√
	SOC2	Policies, Standard and Mandate	Often, data sharing occurs within the confines of pre-existing contractual agreements, competition regulations, and intellectual property rights frameworks.	[49][50][51][52]	√	√	√

Element	ID	Factor	Description	Sources	Methodology		
					FGD	LR	Interview
Economy	**ENY1**	Availability and Access to Data	Data providers should assist data users, where to find the data, and how to access it.	[44][45]	√	√	√
	ENY1	Cost and Financial aid	Geospatial data, infrastructure, storage, platforms and networks require massive financial aids.	[39] [54]	√	√	√
Environment	**ENV1**	Inadequate awareness of data sharing and classification	It should be clear to data providers in the data ecosystem how data can be collected and shared.	[65][68][69]	√	√	√
	ENV2	Experienced/Skill worker/Skilled Data Handlers	The skills, experiences in handling the disaster data by the data suppliers and data consumers should be considered.	[63][64]	√	√	√
Ecology	**ECL1**	Data interoperability	The presence of standards that permit data interoperability is a critical factor in determining the quality of data.	[41][42][43]	√	√	√
	ECL2	Data Duplication and Redundancy	It should be obvious to actors that data is collected once and then shared with a large number of other users.	[66][67]	√	√	√

Table 1: CSFs of Geospatial Data Sharing in Disaster Management

5. Conclusion

The paper has discussed the critical success factors for geospatial data and information sharing in disaster management for the effective initiatives towards the disaster risk reduction for better decision making and planning in all disaster phases. Effective geospatial data and information sharing will result in saving and reducing the duplication of high-cost digital data activities. To confirm the use of geospatial data and information in disaster management, needs to be emphasized on aspects of acquisition and processing to ensure the availability of geospatial information, management, and dissemination to the community. The findings of this study could be used to improve geographic data exchange frameworks while launching robust and sustainable services. Hence, the identified thirteen (13) CSFs for geospatial data sharing in disaster management are the base for the study by the researchers to be aligned with the agenda of the Malaysia public sector towards developing one stop platform for the sharing of geospatial data in disaster management. The six (6) domains that were identified were mapped according to the thirteen (13) CSFs to develop the conceptual framework.

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