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Geographical Information System (GIS) and Remote Sensing (RS) Applications in Disaster Risk Reduction (DRR) in Malaysia

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Abstract: In a world today, that is highly dependent on information technologies, Geographical Information System (GIS) and Remote Sensing (RS) has become one of advancement in spatial technologies that had been used to tackle the issue of an uncertain world. Primarily functioned with specialized capabilities in manipulating, analysing, and visualizing the massive data from multiagency, has opened new avenues for these technologies to be adopted in disaster management. Taking this into consideration, it leads to achieving disaster management objectives in Disaster Risk Reduction (DRR) which to reduce or minimize the exposure to hazards, lessened vulnerability of people and property, wise emergency preparation, and enhanced preparedness for an unfavourable situation. This paper aims to make a systematic review of literature in highlighting the significant potential of the GIS and remote sensing, integrating the aspect relevant to disasters socially and physically that helps in forming a comprehensive disaster management operation to reduce the vulnerability and strengthen the resilience to disaster. Accordingly, the paper has presented the outcomes and review of several researchers concerning the implementation of GIS and remote sensing in disaster management, specifically on disaster risk reduction.

Keywords: GIS, remote sensing, disaster management

1. Introduction

Malaysia lies in a geographically stable region, relatively free of severe climate catastrophes such as earthquakes, typhoons and volcanic eruptions, because its position is outside the Ring of Fire and south of major typhoon paths [1]. However, the country is subjected to monsoon floods, landslides, forest fires and also manmade disasters, as it happens from time to time, it gave harm to property, the environment and human losses, as well as impacting the regular activities of the local communities. According to [2], there are 39 disasters occurred during 1968 to 2004. From which 49% were natural disasters and most occurred were due to heavy rain and flash floods. Malaysia also experienced 18

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man-made disasters during that time. Floods are the most devastated disasters occurred in Malaysia almost every year with high or low impacts.

Some of the worst floods have occurred in the past 30 years since 2003. Those that were exceptionally bad for Malaysia were in 2006, 2007, 2010, 2014, 2017, and 2020. The majority of the natural disasters occurring in the last twenty years (1998-2018) were floods (38 of the 51). According to [3], Malaysia had the highest percentage (67%) of the population exposed to floods among ASEAN Member States as reported by ASEAN Coordinating Centre for Humanitarian Assistance on disaster management in 2019 [3]. In 2017, flash floods and landslides affected more than 6,000 people and left several roads and infrastructure badly damaged.

The emergence of resilient and agile cities epistemological constructs in DRR research agenda nowadays becoming more critical. Any cities in the world, becoming resilient and agile associated with a lot of risks. The risk of not becoming resilient and agile will lead to serious decline of the economy, resources and ecosystems, and which finally will lead to loss of trust by the people [4].

While disasters are beyond human control, the application of a lot of Fourth Industrial Revolution (4IR) technology in disaster risk reduction appeared in many countries particularly the low medium income countries (LMICs). Many technological efforts can be seen being researched including in Malaysia. For instance, by setting up advanced warning systems, sensor technology, digital platform monitoring these it can help in predicting imminent natural and manmade disasters which finally can minimised the impacts of the disasters. Efficient disaster management, complying with criteria of resilient and agile cities can also reduce the effects of natural disasters. In managing disasters, the latest technologies are used along with the wave of the 4IR to handling disaster in every aspect of disaster management cycle such as prevention, preparedness, response, and recovery [5], [6].

Among the wide used technologies that has a great demand as disaster risk reduction tools is Geographic Information System (GIS) and Remote Sensing (RS). The advantages of them in search geo spatial capability and analysis, demographic analysis, and preparing combined digital maps were useful to solve complex planning in disaster management applications and decision making along with several techniques that helps to reduce massive damage and save human suffering [7], [8].

2. Review Methodology

The aim of this study is to examine and review the various GIS and RS applications in disaster risk reduction plan and management. It is essential to familiarise the workings and their capabilities, so implementing these technologies can be applied in future work. In order to achieve this objective, the researchers followed a systematic approach, and 40 relevant papers were selected from Google Scholar search engines with keywords related to "disaster management in Malaysia", "GIS", "remote sensing", and "disaster risk reduction". The selection criteria were based on the recent research identified in Malaysia for combining GIS, RS and their applications using latest 4IR technologies. This paper is trying to notably discuss: (1) disaster management in Malaysia; (2) technology and disaster risk reduction; and (3) application of GIS and RS in disaster risk reduction.

3. Literature Review

3.1 Disaster Management in Malaysia

Currently, disaster management in Malaysia is governed by the National Disaster Management Agency (NADMA). Disaster management in Malaysia is conventionally based almost totally on a government-centric top-down approach [1]. The disaster management and decision-making mechanism structure during an emergency may be split into three scale levels, Level I, Level II and Level III, as shown in Fig. 1. A Disaster Management and Relief Committee (DMRC) is set up at the Federal, State and District level to deal effectively with the disaster in the prospect of policy, tactical and operational planning levels [9], [10].

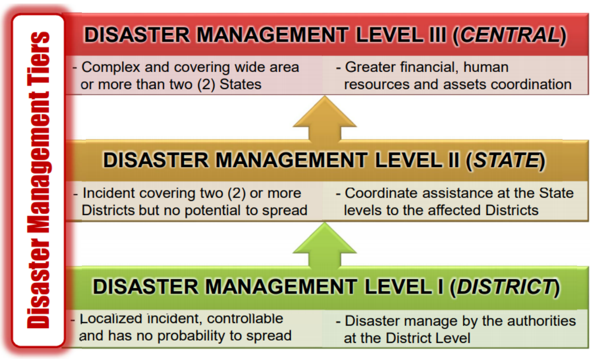

Fig. 1 - Disaster management level in Malaysia [10]

There are two different stages which encompass pre- and post-disaster in managing the disaster event. As in Fig. 2, disaster management is comprised of phases linked by role to all forms of emergency and disaster known as; prevention/mitigation, preparedness, response, and recovery that facilitate activities and accommodate professionals with multi-disciplinary backgrounds [11]. Each of these phases has its own role or target to be achieved. Prevention/mitigation phase is the measures to prevent or reduce the disaster from escalating in a country or civilization. Preparedness phase is focusing on the intention to improve the readiness and information among related stakeholders and agency about the risk and preventive measure for a disaster. The response phase will be the action of protecting the communities that had been affected by a disaster event and providing the essential needs of human and services. The recovery phase has an intent to return the environment to common level after the occurrence of disasters. The effects of natural disasters can be minimized by proper disaster management, as disaster mitigation/prevention cover long-term risk assessment and reduction, disaster preparedness in (1) monitoring and detection; (2) forecasting and prediction, disaster response focus on (1) damage assessment; (2) post-disaster coordination and response and disaster recovery in (1) reconstruction; (2) infrastructure and services restoration [12].

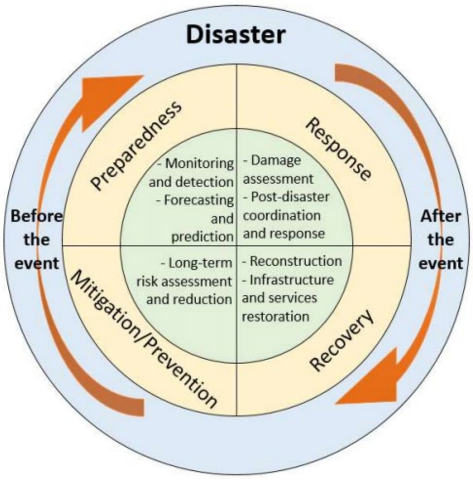

Fig. 2 - Disaster management cycle [12]

3.2 Technology and Disaster Risk Reduction (DRR)

Disaster, in Malaysia National Security Council Directive 20 (MNSC 20), defined as an incident which occurs in an unexpected manner and complex in its nature. It causes a significant effect on communities, infrastructure, and national economies, such as loss of life and enormous damage [13]. So, appropriate disaster mitigation or disaster risk reduction must be taken into account to reduce the effects.

Disaster risk reduction (DRR) is defined as the concept and practice of reducing disaster risk through systematic efforts to analyze and manage the casual factors of disasters. In other words, it can be said that DRR are to reduce the exposure to risk, lessen human and property vulnerability, wise management in disaster, and improve preparedness for an unfavourable situation [14]. In order to reduce a disaster, relying on an organisation alone is not sufficient. Therefore, involvement of many other agencies with their own skills and capabilities are required for creating desirable impacts on communities affected by disasters [1] .

Nowadays, we live in an increasingly volatile and uncertain world. The role of technology in a disaster can be predictable in such a way that it decreases the hazard and helps in the reduction of area vulnerability [15]. Indeed, the technology can go where humans cannot especially at emergency situation front liners life will be at risk to facilitate and help others [16]. In 2017, PricewaterhouseCoopers (PwC) (as official project adviser) and the Stanford Woods Institute for the Environment coordinated with the World Economic Forum on a new global sustainability plan and the Fourth Industrial Revolution (4IR) which the initiative was aimed to highlight the promise of 4IR technologies and their applications to the most urgent environmental problems in the world, including climate change and disaster-related issues [17]. Table 1 below lists the applications of 4IR technology that can be used for managing disaster efficiently.

The utilisation of modern technology by deriving the spatial information focusing on the key vulnerable area, infrastructure and the vulnerability factors are needed in reducing the disaster risk [7]. The technology such as GIS and RS can be the example of the 4IR in the category of Internet of Things and advanced sensor platform, respectively. Both technologies, used the spatial information that can be adapted into DRR for a better understanding and able to communicate with the social and physical complexities of the disasters in more effective way of management [18][1]. For instance, as mentioned by [19], the coordination of flood emergency teams and effective timely dissemination of information is achieved through an internet-based geospatial data exchange system (GEOREX). This system is built on the notion that the efficiency of flood disaster management is very much dependent on access to and exchange of relevant, reliable and up to-date data and information between the various data-producing and flood management agencies. It had been proved by the GEOREX system that using GIS and remote sensing as an advanced flood warning system can provide emergency planners and units with sufficient times to incorporate contingency [19]. There are a lot of other systems and software have been developed using GIS technologies to manage disaster way better as explained by [6], MOBILISE, a collaborative digital platform for building resilient communities, is one of them operated and under research & development by KANZU Research: Resilient Built Environment (RBE) in Universiti Tun Hussein Onn Malaysia for the State of Sarawak as a first case study. MOBILISE digital platform provides an opportunity to overcome the challenging multi agencies collaboration in disaster risk reduction for making the communities more resilient. MOBILISE digital platform provides Spatial Data Infrastructure (SDI) to centralise all risk sensitive data and collaborate disaster management agencies to plan and act accordingly in every cycle of disaster management such as mitigation, preparedness, response as well as recovery.

Table 1 - List and description of 4IR technology clusters most relevant for disaster applications [17]

4IR technology clusters	Descriptions
1. 3D Printing 2. Advanced Materials (including nanomaterials) 3. Artificial Intelligence 4. Robots 5. Drones & Autonomous Vehicles 6. Biotechnologies 7. Energy Capture, Storage, and Transmission 8. Blockchain (and distributed ledger) 9. GeoEngineering 10. Internet of Things 11. Neurotechnologies 12. New Computing Technologies 13. Advanced Sensor Platforms 14. Virtual, Augmented and Mixed realities	The following high-level descriptions are provided as background – they are not intended to be exhaustive. **3D Printing** – Additive manufacturing techniques used to manufacture three dimensional objects based on 'printing' successive layers of materials. **Advanced Materials (including nanomaterials)** – Set of nanotechnologies and other material science technologies that can produce materials with significantly improved or completely new functionality, including lighter weight, stronger, more conductive materials, higher electrical storage e.g. nano-materials, biological materials or hybrids. **Artificial Intelligence** – Computer science learning algorithms that are capable of performing tasks that normally require human intelligence and beyond, e.g. visual perception, speech recognition and decision-making. **Robotics** – Electro-mechanical, biological, and hybrid machines enabled by artificial intelligence that automate, augment, or assist human activities, autonomously or according to set instructions. **Drones & Autonomous Vehicles** – Enabled by robots autonomous vehicles can operate and navigate with no, little or no human control. Drones fly or move in water without a pilot and can operate autonomously or be controlled remotely. **Biotechnologies** – Encompassing bioengineering; biomedical engineering; genomics, gene editing, and proteonomics; biomimicry; and synthetic biology; this technology set has applications in energy, material, chemical, pharmaceutical, agricultural, and medical industries to mention but some. **Energy Capture, Storage, and Transmission** – New energy technologies range from advanced battery technologies through to intelligent virtual grids, organic solar cells, spray-on solar, liquid biofuels for electricity generation and transport, and nuclear fusion. **Blockchain (and Distributed ledger)** – Distributed electronic ledger that uses cryptographic software algorithms to record and confirm immutable transactions and/or assets with reliability and anonymity without a central authority and that allows to automate contracts that relate to those assets and transactions (smart contracts). **GeoEngineering** – Large-scale, deliberate interventions in the earth's natural systems in order to, for example, shift rainfall patterns, create artificial sunshine, or alter biospheres. **Internet of Things** – Network of advanced sensors and actuators in land, in air, in oceans and in space embedded with software, network connectivity and computer capability, that can collect and exchange data over the internet and enable automated solutions to multiple problem sets. **Neurotechnologies** – Enable humans to influence consciousness and thought through decoding what we are thinking in fine levels of detail through new chemicals that influence our brains for enhanced functionality and help us interact with the world in new ways. **New Computing Technologies** – Includes technologies such as quantum computing, DNA-based solid state hard drives, and the combining of 3IR tech (big data, cloud) with the other technologies (e.g. internet of things; advanced sensor platforms). Quantum computers make direct use of quantum-mechanical phenomena such as entanglement to perform large scale computation of a particular class of currently impossible tasks by traditional computing approaches. **Advanced Sensor Platforms (including satellites)** – Advanced fixed and mobile physical, chemical and biological sensors for direct and indirect (remote sensing) of a myriad of environmental, natural resource and biological asset variables from fixed locations or in autonomous or semi-autonomous vehicles in land, in machines, in air, in oceans and in space **Virtual, Augmented and Mixed realities –** Computer-generated simulation of a three-dimensional space overlaid to the physical world (AR) or a complete environment (VR)

3.3 Geographical Information System (GIS)

A GIS is a computer system that is tied to locations for capturing, storing, querying, analyzing, and displaying geospatial data where, disaster management is one of the applications of GIS [20]. GIS is an important tool for supporting development of and providing situation awareness during a disaster, particularly when the information being used is updated in real time [21]. GIS can assist in managing disasters around the potential area in the community. For example, the potentially hazardous area can be specified and targeted for mitigation or stricter management practises by overlaying or intersecting different geographical layers [22]. According to Shad [23], it shows that all phases of disaster management rely on data from multiple sources. It was critical to get the right data logically presented at the right time during a real catastrophe to give responses and take relevant actions. The utilization of GIS gives the capability for all departments to have shared information through databases in one location on computer-generated maps with a GIS. Geographical information related to pipelines, building layout, electrical delivery, sewage networks, etc. can be stored in one database, queried, and presented graphically for analysis [23]. In any disaster situations, disaster management team need to be guided and directed appropriately. For example, in a disaster response, the status of roads for relief supply delivery, the location of response teams and disaster victims, weather conditions, and the conditions of potentially damaged buildings. As one can imagine, the number of factors to be accounted for in a disaster (especially disaster response) could be endless. That is why GIS is an important device for supporting development of and providing situation awareness during a disaster, particularly when the information being used is updated in real time [21]. Fig. 3 shows that GIS can store all the data and come out with estimated damage infrastructure and resources, identify the population at risk and response recovery and sustainability that helps in disaster management.

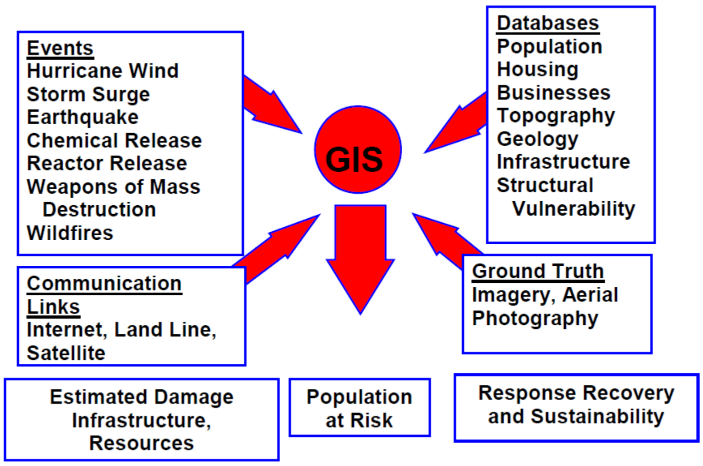

Fig. 3 - GIS in disaster management [24]

3.4 Remote Sensing (RS)

Remote sensing technology, most notably aerial photography and satellite imagery has been developed in attention to map the large area with short time of period or even near-real time data capturing. In Fundamental of Remote Sensing, [25] defined remote sensing as the science of acquiring information, without necessarily being in contact with the Earth's surface. It is performed by sensing and recording, processing by reflected or emitted energy, analysing and interpreting the data. Fig. 4 shows the remote sensing mechanism involving an interaction incident radiation and targets of interest [26]. This technology involves the usage of existing satellites that track the resources of the planet and natural disasters. Different satellites have different types of sensors on-board that have disaster reduction applications by reacting to the electromagnetic characteristics of objects on Earth and the existence of the disaster itself [27]. Table 2 shows sample of related types of satellite/sensors with their application.

As a bespoke technology, remote sensing can provide satellite data on different aspects of disaster management, from risk detection to early warning and damage assessment [27]. When the satellite data combined with GIS, it can produce a critical analysis and modelling risks in particular zones. In addition, remote sensing overcomes the limitations imposed by limited networks on meteorological and ground-based observation stations, particularly in areas with harsh climates. The benefit of remote sensing is the ability to obtain homogeneous and consistent information at a spatial and temporal resolution appropriate for various types of applications across large areas [28]. Adding to that, the technique of detecting the Earth's surface from space utilising the properties of electromagnetic waves produced, reflected, or revealed by identified objects for the goal of enhancing natural resource management, land use, and environmental protection also known as remote sensing [29].

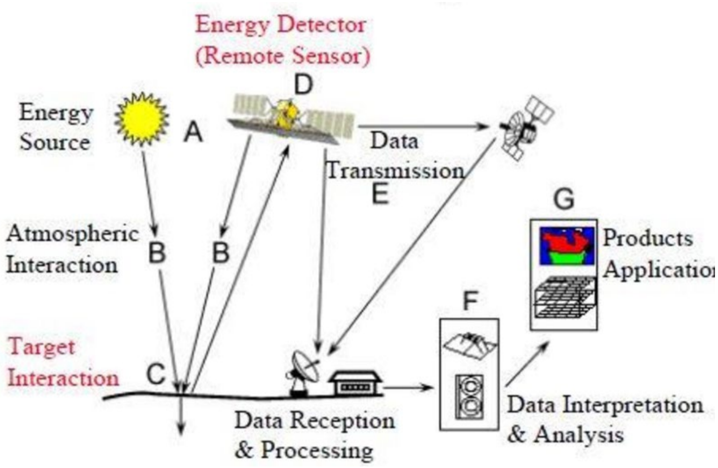

Fig. 4 - Remote sensing process [26]

Table 2 - Sample of related types of satellite/sensors with their application

	Types	Satellite/Sensors	Application
1.	Weather	NOAA/AVHRR	• Cloud, snow, and ice monitoring • Water, vegetation, and agriculture surveys • Sea surface temperature, volcanoes, and forest fire activity • Soil moisture
2.	Land	Landsat/TM	• Soil/vegetation discrimination bathymetry/coastal mapping • Green vegetation mapping (measures reflectance peak); cultural/urban feature identification • Vegetated vs. Non-vegetated and plant species discrimination (plant chlorophyll absorption) • Identification of plant/vegetation types, health, and biomass content; water body delineation • Sensitive to moisture in soil and vegetation; discriminating snow and cloud-covered areas • Discrimination of mineral and rock types; sensitive to vegetation moisture content
3.	Marine	Nimbus-7/CZCS	• Measure chlorophyll absorption • Measure chlorophyll concentration • Measure Gelbstoffe (yellow substances) • Measure surface vegetation • Measure surface temperature

3.5 Application of GIS & RS for Disaster Risk Reduction

In recent years, GIS and RS technology had gained a lot of growth in its application on disaster management [30]. Integrating GIS and RS with experts' judgement helps disaster management in a way to reduce the risk of damage. There are many examples of powerful GIS and RS applications which are forecasting and tracking flood status, visualisation, demographic analysis, utility planning and response, command and control, evacuation and rescue, and damage assessment [31]. From the stated application, we scheduled 20 articles based on the disaster types, and applications with the use of GIS as in Table 3.

3.6 Latest Research and Development Integrating GIS, RS and Digital Platform in Malaysia

In Malaysia the latest research integrating GIS, RS and DRR can be seen available in many research institutions. In Malaysia, KANZU Research: Resilient Built Environment (RBE) collaborating with University of Salford, UK under the funding agencies by Global Challenge Research Fund (GCRF), UK and Engineering and Physical Sciences Research Council (ESPRC), UK for MOBILISE project and Global Challenge Research Fund (GCRF), UK and Economic and Social Research Council (ESRC), UK for TRANSCEND project to mitigate disasters in Malaysia and make communities resilient [32], [33]. MOBILISE, A Collaborative Multi-Agency Platform for Building Resilient Communities focuses on digital platform for Spatial Data Infrastructure (SDI) to enhance multi-agency collaboration among all stakeholders [6]. TRANSCEND, Technology Enhanced Stakeholder Collaboration for Supporting Risk-Sensitive Sustainable Urban Development, is the second phase of MOBILISE to carry on research on adaptive & agile governance, equitable resilience, empowering communities and climate change adaptation for urban development. In TRANSCEND research project MOBILISE digital platform will be used as technology artifact as a bridging tool to overcome the gap [34].

Table 3 - Group of reviewed studies by disaster types, application fields and its sources

	Disaster Type	Reviewed Application Fields	Source
1.	**Disease**	**COVID-19** 1. An Interactive Web-Based Dashboard to Track COVID-19 in Real Time (2020).	[35], [36]
		2. Assessing Resilience of Healthcare Infrastructure Exposed to COVID-19: Emerging Risks, Resilience Indicators, Interdependencies and International Standards (2020).	[37], [36]
		3. COVID-19 and its Impacts on Environment: Improved Pollution Levels During the Lockdown Period – A Case from Ahmedabad, India (2020).	[37]
		4. The Impact of the Control Measures during the COVID-19 Outbreak on Air Pollution in China.	[39]
		5. Covid19 UTHM Tracker for Students	[40]
		6. Covid19 website for disseminating timely and correct information to the community	[41]
		7. MOBILISE digital platform for building resilient communities	[34]
		8. The Role of Autonomous Robots in Fourth Industrial Revolution (4IR) as an Approach of Sustainable Development Goals (SDG9): Industry, Innovation and Infrastructure in Handling the Effect of COVID-19 Outbreak.	[42]
		9. Geospatial Dashboards for Mapping and Tracking of Novel Coronavirus Pandemic.	[36]
		10. Accessing the need for Resilience in Healthcare Facilities Management (RHFM) for Malaysia's Public Hospitals.	[43]
		11. Systematic Literature Review of Role of Applied Geomatics in Mapping and Tracking Corona Virus	[44]
		Dengue 12. Distribution and Spatial Pattern Analysis on Dengue Cases in Seremban District, Negeri Sembilan, Malaysia.	[45]
		13. GIS For Dengue Surveillance: A Systematic Review	[46]
		14. Integration of GIS-Based Model with Epidemiological Data as a Tool for Dengue Surveillance (2017).	[47]
		15. Application of Geographical Information System-Based Analytical Hierarchy Process as A Tool for Dengue Risk Assessment.	[47]
2.	**Flood**	1. Flood Susceptibility Mapping Using GIS-Based Analytic Network Process: A Case Study of Perlis, Malaysia.	[47]
		2. Exploring the Managing of Flood Disaster: A Malaysian Perspective (2018).	[48]
		3. Use of GIS and Remote Sensing Technology as a Decision Support Tool in Flood Disaster Management: The Case of Southeast Louisiana, USA.	[49]
		4. GIS Analysis for Flood Hazard Mapping: Case Study; Segamat, Johor, West Malaysia.	[50]
		5. Spatial Information Technology in Flood Warning Systems: An Overview of Theory, Application and Latest Development in Malaysia.	[51]

	6. The Use of Geographic Information Systems for Disaster Risk Reduction Programmes in Africa.	[52]
	7. A Review on the Application of Remote Sensing and Geographic Information System in Flood Crisis Management.	[36]
	8. Multi-Agency Collaboration in Flood Disaster Management in Sarawak Malaysia.	[53]
	9. MOBILISE digital platform for building resilient communities in Sarawak, Malaysia	[34]
	10. Vulnerability factors causing flooding in Sarawak, Malaysia	[54]
	11. Role of information technology in disaster management for building resilient future in Malaysia	[6]
3. Landslide	1. Three Oversampling Methods Applied in a Comparative Landslide Spatial Research in Penang Island, Malaysia.	[55]
	2. Landslide Occurrences in Malaysia Based on Soil Series and Lithology Factors.	[53]
	3. Landslide Occurrences in Malaysia Based on Soil Series and Lithology Factors.	[56]
	4. Multi-agency Platform for building resilient communities in Sarawak, Malaysia	[33]
4. Forest Fire	1. Forest Fire Susceptibility and Risk Mapping Using Remote Sensing and Geographical Information Systems (GIS).	[57]
	2. GIS Modelling Approach for Forest Fire Risk Assessment and Management.	[58]

3.6.1 Disease

GIS and RS had been used a lot to analyse the geography disease, particularly in analysing the relationship between the factors related to pathogen and their geographical environments. The evolution of medical GIS had been leveraged from early detection to respond to a disease outbreak. In this recent situation, the GIS has widened their usage in COVID-19 outbreak for the visual representation of COVID-19 data [44]. Research done by Dong, Du & Gardner [35], used GIS for the online dashboard and near-live tracking of COVID-19 cases and had been created and maintained by the John Hopkins University. Then, GIS was also applied to determine the nearest health care facilities using spatial analysis. These capabilities, enable the level of accessibility of the area to the health care facilities analysis thru indirect recording of the level of resilience for any cities [37]. Research related to COVID-19 had studied the effect of lockdown through the Suspended Particulate Matter (SPM) concentrations using the satellite image. It studied the atmospheric pollution level, and this will help in planning the future to control pollution [38], [39]. In Malaysia for pandemic Covid19, UTHM has developed MOBILISE-Covid19 by adding Malaysia hotspots for all districts along with case numbers. Other information was also added using GIS data for screening hospitals, admitting hospitals, quarantine centres, ambulance locations and other important infrastructure for the agencies to get the updated information [36] (See Fig. 5). In Malaysia, Universiti Tun Hussein Onn Malaysia (UTHM) also using MOBILISE system for Covid19 to track students inside and outside the campus. The UTHM tracker has Covid19 health info form which is connected to MOBILISE system to track students' health. MOBILISE system can send alerts through UTHM tracker related to movement control orders and all other activities. Also in Malaysia, KANZU Research: Resilient Built Environment, a focus research group in UTHM also developed a website for locals living in Parit Raja. The objective of this website is to provide latest and critical information to the local community. It includes all the information needed to know during Covid19 pandemic like news updates, official documents, online shopping database for daily items and services, Covid19 map and statistics, charity, donation, new research, and emergency alerts for the UTHM community and the residents in the area [41].

There is no exception to dengue cases, the research reveals that GIS had been applied for a better understanding of dengue outbreak to identify the spatial pattern of dengue disease. The evaluation of the spatial pattern, whether it is randomly distributed or tend to be a cluster, is very crucial to deploy control measure and develop effective dengue monitoring and surveillance [46]. Research by Majid, Nazi & Mohamed [45] on the spatial pattern and distribution analysis which was carried in Seremban District to understand the factors that affect the occurrence of this fever. The Average Nearest Neighbour (ANN) method was used for the analysis of dominant pattern and adapted for mitigating the spread of the disease by taking extra precaution to the hotspot dengue area. In addition, research by Dom et al. [47] had the purpose in design the sustainable control program to fight the dengue in Malaysia by using GIS in developing dengue risk zonation in Subang Jaya. This study used Analytical Hierarchy Process (AHP) that incorporate the influential factors of dengue such as type of housing, the density of populations, land use and elevation. Later, in 2017, the researcher designed the model of the epidemic forecast for risk management planning and controlled the spread of dengue.

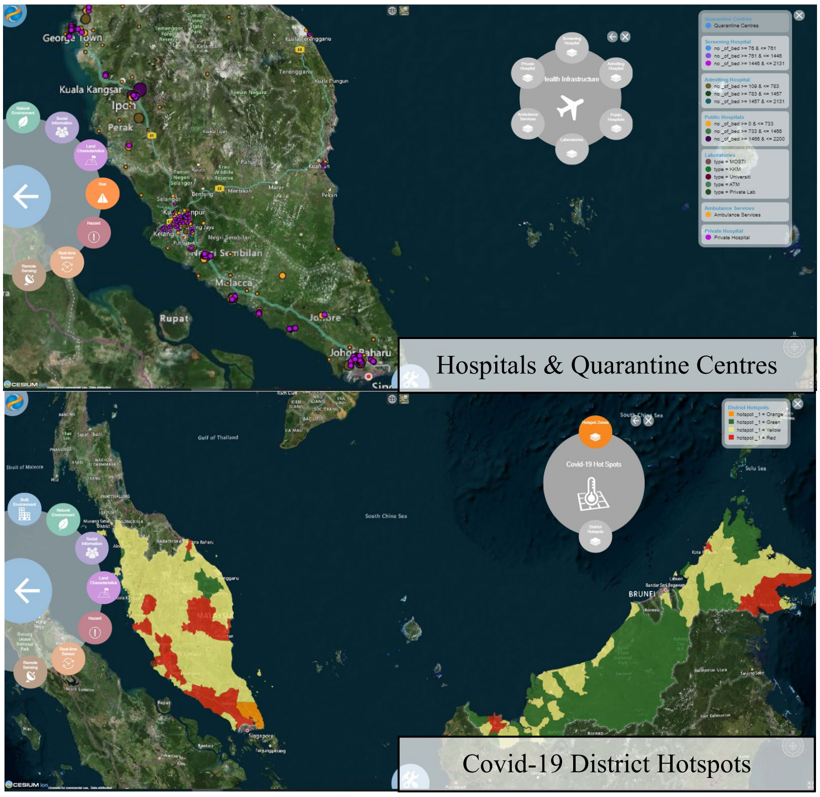

Fig. 5 - MOBILISE platform for Covid-19 Malaysia [34]

3.6.2 Flood

GIS and RS had been used to analyse the flooding vulnerability area, as shown in Fig. 6. Additionally, it is also capable of identify the topography and landcover factor that can be related to flood, floodplain mapping, mitigation, and control. Moreover, it helps in estimating the cost for property damaged in the disaster [50]. Research by Dano [59] had used this technology to forecast the disaster in Perlis by mapping the flood using Analytic Network Process (ANP) Model where factors that influence the flood had been identified based on land use of the surrounding area. The area that had been flooded was then detected using RADARSAT images and site surveys.

Other than above mentioned, a research had been carried out whereby GIS is used in flood monitoring by creating an interactive map overlay which gives graphical representations of a community area that may be in danger of flooding. The map can help the mitigation before the disaster and also recovery after the disaster event. Displaying real-time information such as rainfall and the river water level was claimed to be an effective way to spread the flood warning for the public [48]. Through its capability to create Three-Dimensional (3D) topographical mapping and terrain modelling in the form of Digital Elevation Models (DEM) and Digital Terrain Models (DTM), this technology is also particularly useful in flood analysis and flood estimation [51].

Research by Twumasi [49] had used remote sensing technology in order to determine the flood-prone zones using a collection of different spatial data, namely, elevation data and satellite data. The study then revealed notable flood risk zones and watercourses and further action could be taken to reduce the risk for the flood disaster [42].

In Sarawak, Malaysia flood disaster is the highly occuring hazard almost every year with different impact. Flood disasters are natural or man-made, in both cases its difficult to cope with it without collaboration and community engagement. MOBILISE research project provides that platform in which all disaster management agencies can work collaboratively and make communities resilient towards flood disaster. Flood mitigation is crucial as it can be seen in Fig. 6, flood extent in Kuching city, Sarawak is captured from MOBILISE platform using GIS and RS technology for the last 100 year flood extent. The left side shows the region before flood and the right side shows the situation after flood hazard. In Fig. 6 due to the flood extent a lot of population, buildings and vulnerable areas are exposed. MOBILISE providing aid to the agecnies to work collaoratively through which flood disaster can be mitigated timely and a lot of vulnerable community and properties can be saved.

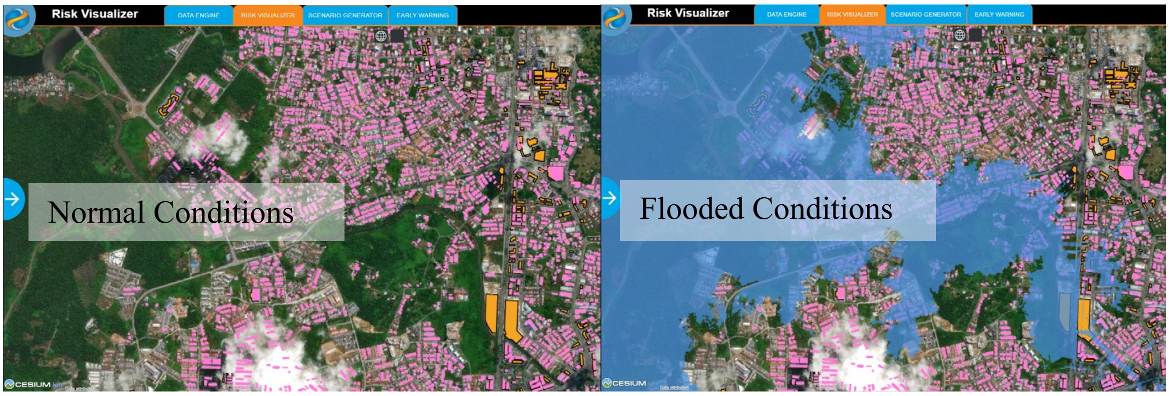

Fig. 6 - Flood delineation in the region of Sarawak using MOBILISE platform [34]

3.6.3 Landslide

Landslide is also a type of disaster that is related to change in land slopes that happens because of subsequent development activities. Integration between GIS and RS, aerial photo interpretation helps in analysing of the landslide occurrence. A research by Hassan and friends [60] has shown that these technologies can produce density and susceptibility analysis. The triggering factor that had been identified to become the source of landslides were slope, curvature, lithology, aspect, land use, lineament density and rainfall. All these factors were then intersected separately to produce the map and conducting further analysis. Apart from this, there was a research that had used GIS to determine the landslide susceptibility by figuring out the relationship between the soil series and landslide as the types of soil texture determine the level of erosion of soil [53].

Research by Gao [55] had use three oversampling methods to relate the spatial research with landslide in Penang Island. With the purpose to augment the landslide sample data in an effective way and to assign proper unequal cost, this research had come out with the results of landslide susceptibility mapping to conduct landslide spatial assessment. The difference between non-landslide and landslide samples had been considered as useful and valuable information to make prediction in future occurrence.

Besides that, remote sensing had also been used for soil erosion assessment and its correlation with landslide events in Penang. This study was applied to the satellite-based temporal changes of land used to indicate the significant changes, whether there is an increase or reduced area of forest, urban, bare land, or agricultures. From the analysis in land-use change detection, the potential area for soil erosion can be determined [56].

As mentioned above in flood about MOBILISE and TRANSCEND project. In 2020, MOBILISE and TRANSCEND research projects are also focusing on landslide disaster though drone data using GIS and RS technologies to make the communities sustainable and resilient.

3.6.4 Forest Fire

Recently, forest fire became one of the disasters in Malaysia. Forest fire gives severe impact to the environment such as degradation of flora and fauna habitat, air pollution crisis and haze. Utilization of GIS as a powerful tool for managing spatial information has been applied in forest fire management. A research had been carried out by using GIS modelling approach for forest fire risk assessment and management. Forest fire risk modelling gives results in fire risk zonation model of the study area and gives valuable information for disaster risk reduction. It showed that GIS was a very efficient tool to understand and predict the fire behaviour [58].

A study on the evaluation of forest fire also made use the remote sensing technology. The data were collected from satellite using sensors for last five years. It was then used to measure the surface area and the number of red zones in the selected area. This study is also valid for awareness in order to take effective preventive measures during the forest fire based on the susceptibility map for the forest fire that specifies the severeness of forest fire danger zones [57].

Also, for forest fire disaster, MOBILISE platform Early Warning System (EWS) can be used to genrate an early warning to the authorities timely and mitigate the and control the disaster situation [34]. The most challenging task in MOBILISE project is the availability of technology layer through which its true objectives can be achieved. MOBILISE Platform can provide the inteligence only if the technology layer provides the risk sensitive data to feed in the system.

4. Conclusion

It is crystal clear that the GIS and RS technology has been proven to minimise the damages in assisting the decision makers especially during sudden disaster events. The applications of GIS and RS has been applied across the devastated disaster events in particular, Malaysia. However, we cannot rely solely on the effectiveness of GIS and RS technology to resolve the disaster issues, because these technology needs supporting devices such as sensor, internet, software, database and most importantly the interpreter. Without these supporting devices, the GIS and RS are not able to be working properly. For example, using GIS and RS applications for COVID-19 pandemic, the information needs to be supplied by the third party. Similarly, during flood disaster the information of rainfall distribution need to be obtained from the rainfall sensors (rain gauge), while in landslide application, the characteristic of the earth's surface is needed. Furthermore, during the time of forest fire, we need the interpreter to supply and analyse the situation for the application. Despite the dependency to other, the GIS and RS can model, predict, and send warning to the effected individual, community, or decision maker for a head plan in evacuating and sending rescue team to the affected area. For instance, in dengue outbreak GIS application, the prediction of potential housing areas being affected by dengue is determined using GIS technology. In GIS application for flood disaster, the flood extent can be visualised and analysed using modelling techniques, while for landslide, the slope can be analysed and calculated for further mitigation process. The advancement of monitoring the disaster activities that addresses the risk using GIS and RS via indicating the vulnerability factors and exposure, as stated in the disaster risk reduction frameworks, will enhance the success rate along with the effective disaster management strategies. This technological advancement benefits to the major key stakeholders such as planners, policymaker, decision maker and most importantly the government organisation to generate an effective strategy, proper planning, decision making, communicating and lots more. GIS technology can also be used as analysis and as an infrastructure tool for climate change adaptation impacts. The greatest challenges exist since the inception of GIS & RS in Malaysia is in coordination, sharing information, silo management attitude and interoperability of GIS & RS resources such as data and trained staff and lack of comprehensive infrastructures for data sharing across local, state, federal resources. On top of that, issues such as disaster responders and agencies faced issues such as a lack of standardised and centralised GIS and RS information, a lack of data-sharing agreements in place, and a lack of common communication protocols between disaster management agencies in Malaysia could also become impediments to the efficient disaster management collaboration and coordination. Applying resilient and agile governance model, continuous research & development (R&D) approach and strengthening multi-agency collaboration are very important in maximising the functions of GIS and RS technology in disaster risk reduction.

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