Geographic Information System (GIS) as Tool to Manage the Impacts of Flood in Shah Alam, Malaysia

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Abstract. Floods, common in lowland regions, pose significant environmental, social, and economic challenges, as seen in Shah Alam's severe flooding in 2021. While GIS offers promising solutions, there remain shortcomings in flood disaster recovery efforts. This study investigated how the Geographic Information System (GIS) could help manage the environmental impacts of floods in Shah Alam, Malaysia. Reaserch method for this study using thematic analysis, qualitative methods, an informal interview of experts following the quadruple helix model, were used to select 20 respondents from four key sectors: government, academia, business, and community/NGO, to explore the use of GIS in flood management. While progress has been made, challenges persist, highlighting the need for enhanced flood preparedness and infrastructure. The result shows there is government initiatives, such as CCTV installations by MBPJ, demonstrate proactive measures to mitigate flood impacts. Overall, this study highlights the importance of effective GIS applications in addressing flood vulnerabilities and calls for further improvements in flood management strategies in Shah Alam, Malaysia.

1 Introduction

Flooding is a recurrent disaster in Malaysia, particularly in lowland regions, defined as the inundation of normally dry areas by water [1]. This phenomenon often arises due to elevated water levels in rivers or seas, prolonged heavy rainfall, melting Arctic ice, and annual monsoon winds [2]. Floods can severely affect the environment, society, and the economy. In 2021, Shah Alam, Malaysia, faced severe flooding that disrupted daily life and caused extensive damage. Heavy rainfall overwhelmed the city's drainage systems, worsening the situation [3]. This incident underscored the city's vulnerability to floods and emphasized the urgent need for better flood management measures. Severe floods caused by brief, intense

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precipitation are becoming more frequent globally, with reports of extremely high severity. Climate change is making urban flash flooding more likely, increasing the danger of both non-economic and economic losses [4]. This study investigated how Geographic Information Systems (GIS) could help manage the environmental impacts of floods in Shah Alam, Malaysia. It specifically examined how GIS could reduce flood impacts in areas like Taman Sri Muda, Section 13, and other parts of Shah Alam that have experienced flooding in the past. Shah Alam recently faced a major flood disaster, one of Malaysia's most significant yearly events, causing disruptions to safety and human lives. To address the flood issue, the government and researchers have utilized GIS applications to regulate floods in Malaysia. These systems are utilized by organizations like the National Disaster Management Agency (NADMA), local councils, states, and NGOs.

Fig. 1 Map of Shah Alam, Malaysia
Source: MBSA, 2022

2 Literature Review

Table 1. Literature review for the use of GIS in flood management.

Year	Topic	Study Area	References
2009	Remote sensing and GIS Applications in Flood Management.	India	[5]
2020	Flood vulnerability and risk assessment of urban traditional buildings in a heritage district of Kuala Lumpur, Malaysia	Kuala Lumpur, Malaysia	[6]
2015	Flood Risk Map Based on GIS, and Multi Criteria Techniques	Terengganu, Malaysia	[7]
2012	GIS application in flood management – A case study: Paraiba do Sul Basin, Southeast Brazil	Brazil	[8]
2022	Flood Vulnerability Assessment and Mapping: A Case Study for Australia's Hawkesbury-Nepean Catchment	Australia	[9]

There are several past studies that have been carried out regarding the use of GIS for flood risk mapping in flood management. Among the external studies that have been done in Malaysia are (Dina et al. 2020) and (Renya et al. 2015), while the studies outside of Malaysia are (Shiv P. Aggarwal et al. 2009) from India, (Simoes et al. 2012) from Brazil, and (Schwarz and Kuleshov, 2022) from Australia. According to the study of Dina et al. (2020) and Renya et al. (2015) in Malaysia, the use of GIS dalam flood management is very important and should be taken seriously to solve the problem of flood disasters. Floods in Malaysia also occur frequently, causing negative effects on the population, especially when there is heavy rain for a long period of time. With the use of GIS, it can be essential to inform the feasibility and development of such strategies in implementing disaster management, and the same in Brazil, which is concerned with the use of GIS in dealing with flood problems by producing input models, editing data, running the model, and displaying output results [8]. In India, GIS is used to obtain information about flood inundation areas and flood damage assessment [5], while in a study Nguyen et al. (2023), GIS is used to provide information to stakeholders and decision-makers so they may develop mitigation and adaptation plans for communities that are at risk. Therefore, it can be seen that the use of GIS is used with various interests in controlling the impact of floods, but the use of GIS is very important to be extended to all sectors, especially in flood management to reduce the risk that will occur.

3 Method and Materials

This study used a thematic analysis, qualitative method. Qualitative research involves gathering non-numerical data, like words or observations, to understand people's thoughts, feelings, and behaviors. It's about exploring and describing rather than measuring. [10]. The study used a qualitative approach, conducting informal interviews using the quadruple helix model method. Twenty respondents were chosen from four important sectors—government, academia, business, and community/NGO—for primary data collection using the quadruple helix paradigm in order to gather information regarding GIS and flood management in Shah Alam, Malaysia. Since they are the organization in charge of handling natural disasters, particularly flash floods in Shah Alam, Malaysia, a number of respectable authorities participated in this interview, including the District Council, the Malaysia Civil Defense Force, PANTAS MBSA, LUAS, and the Department of Irrigation and Drainage (JPS) Selangor. For academics, several lecturers from different universities, including the University of Malaya (UM), the MARA University of Technology (UITM), the University of Putra Malaysia (UPM), and the National University of Malaysia (UKM), participated as respondents. They were chosen based on their publications and research in the field, which showed their ability in the use of GIS and flood disaster management. In the meanwhile, localities and companies are chosen based on how well they dealt with flash floods.

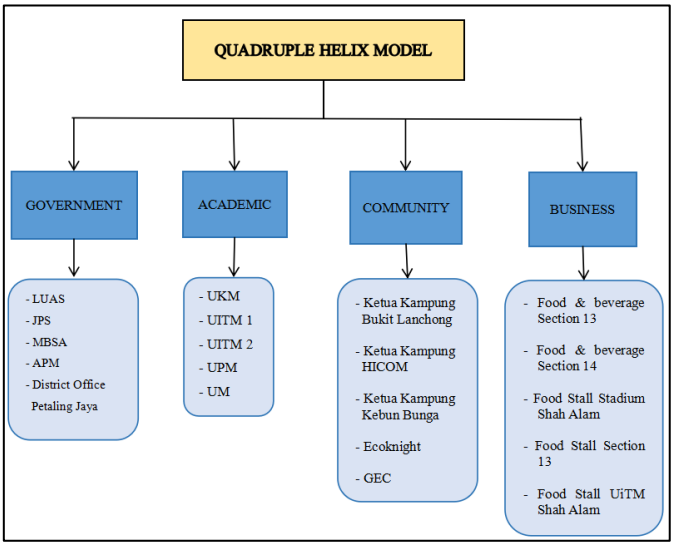

Fig. 2. Informal interview based on Quadruple Helix Model

For this study, the interview data was categorized, coded appropriately, and analyzed to identify the pertinent themes for additional discussion. For data analysis, using Taguette in qualitative thematic analysis was used. Taguette is an open-source, free qualitative research instrument with simple code and text data retrieval capabilities [11]. For the validation of the data analysis, all 20 participants have already been contacted by researchers, who will follow up once more to verify their information and get input on the findings. By following the method described in the study, researchers can fill in gaps about how GIS is used in managing flash floods, improving their findings and reports. This method also helps researchers respond to any concerns from participants, making their research more trustworthy and important.

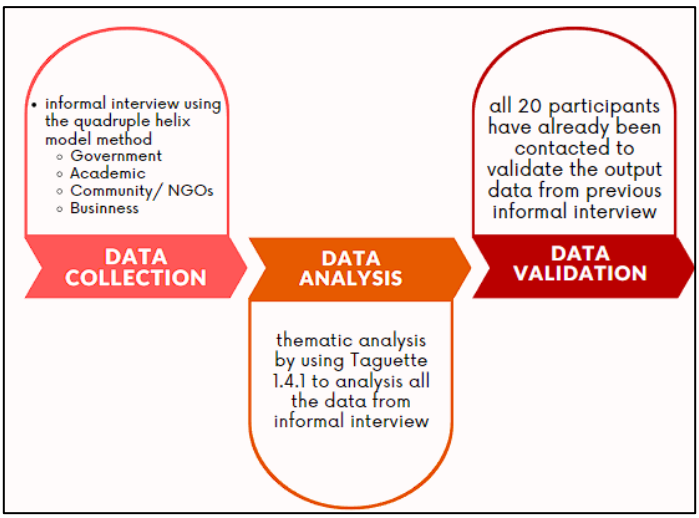

Fig. 3. Flowchart for method and materials.

4 Results

The investigation into how the Geographic Information System (GIS) manages the environmental impacts of floods in Shah Alam, Malaysia, has shown significant progress in flood disaster recovery efforts in the area. However, there are some factors that need to be resolved, such as Malaysia's gaps and deficiencies in flood risk management [12]. The sudden and severe flooding caused by heavy rain and inadequate drainage resulted in the government and the people being unable to take early action, leading to significant social and economic consequences. This showed how vulnerable the area is to floods and why better flood plans and infrastructure are needed. Based on the feedback from 20 respondents from four important sectors: government, academia, business, and community/NGO., Figure 4 below points out the advantages and difficulties of using GIS in flood management.

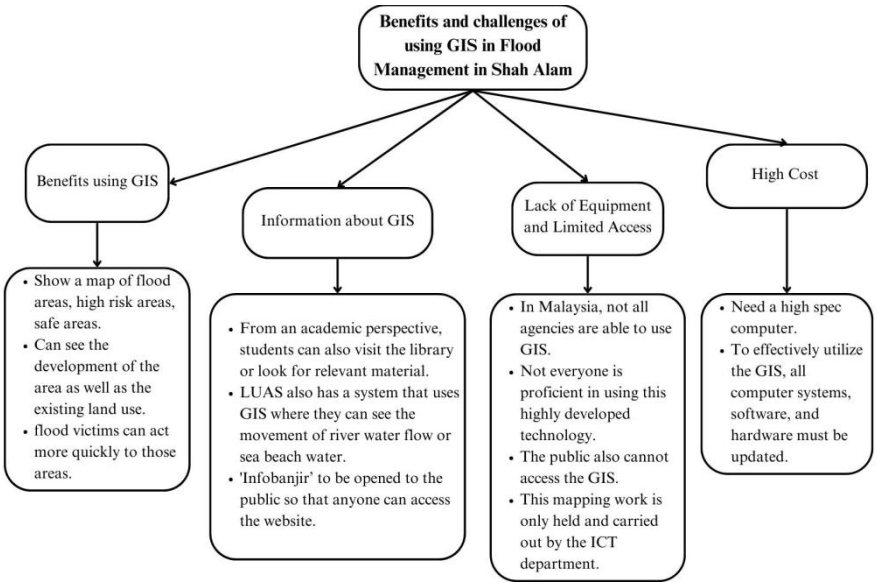

Fig. 4. Benefits and challenges of using GIS in Flood Management in Shah Alam

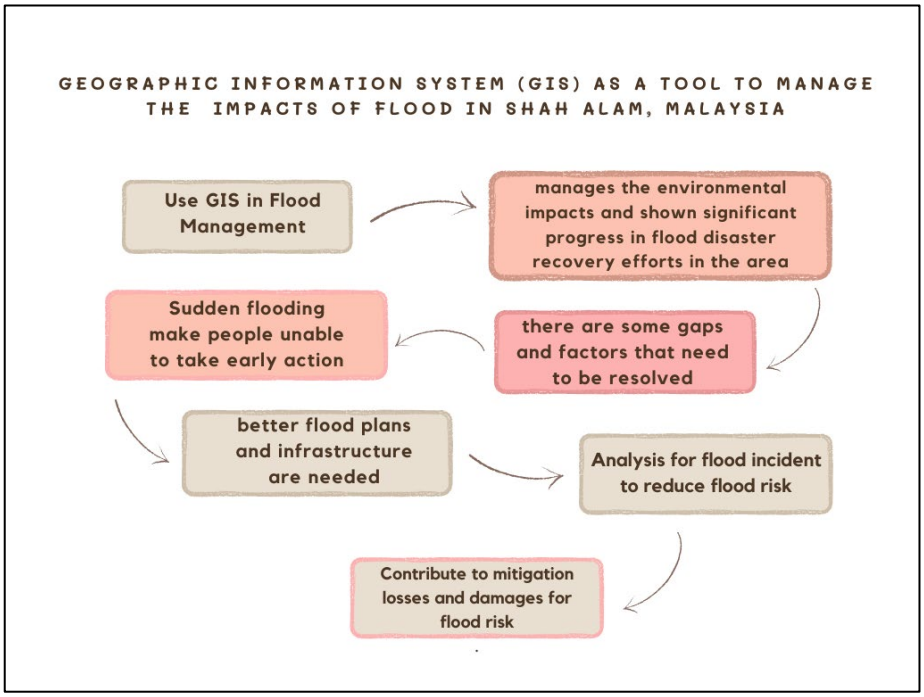

Fig. 5. Flowcart GIS as a tool to manage the impacts of flood in Shah Alam, Malaysia.

4.1 Benefit of using GIS

Based on the table above, there are also various challenges and benefits to the use of GIS when a flood incident occurs. When everything is thought out, the advantage of using GIS is that it creates excellent and helpful mapping, particularly for the locals, as it allows authorities to pinpoint areas that are at high risk of flooding and highlight the locations that are critical flood victims, enabling them to take faster action there. For example, the City Council provides maps and access to all parties to see each surrounding area when there is a flood. Subang Jaya City Council (MBPJ) has installed CCTV cameras in several areas across Petaling Jaya, enabling people to monitor flood situations during rainfall, thus increasing awareness and preparedness.

4.2 Information about GIS

In addition, government agencies like NADMA, JPS, and local councils provide GIS data mapping and information through platforms such as Instagram, Twitter, and their websites. For instance, JPS offers information on water flow, rainfall, water levels, and temperature on their website. Some data from JPS is confidential but can be accessed through applications for research purposes. LUAS also provides a GIS-based system for monitoring river and sea water flow, available on their LISS website. Additionally, the "InfoBanjir" app and website offer the public up-to-date flood information. With that, people can access information quickly and more easily, so they are more aware of the situation around them.

4.3 High Cost

The following item focuses further on the difficulties and barriers associated with employing expensive GIS systems for flash flood disaster management. The cost of all the equipment required to create mapping with GIS applications is high. High-spec hardware and software are required for GIS operations, such as when someone wants to run a video. Because hackers and viruses attempt to take over the system and data, the software and system must also be updated constantly. There are numerous types of equipment that must be installed in the proper zones and locations. Since every person uses a different GIS format, it would be expensive to obtain all of the formats needed for GIS mapping.

4.4 Lack of equipment and access

Then, a lack of equipment will also cause access to decrease because there is not enough equipment to use during management. For example, JPS employs almost every one of their employees who work for this GIS. To operate the application, GIS needs a computer with high-end, complex software. Only specific parties from certain agencies have access to and can receive the GIS data and information, thus not all parties can utilize it in their operations. Due to a lack of access and equipment, village leaders frequently rely on WhatsApp for information. Government websites limit access to some data, and not everyone can quickly learn advanced GIS technology. For instance, flood hazard mapping is created by JPS headquarters for federal use, but it is not publicly accessible. In addition, MBSJ offers public access to GIS, while MBSA does not. As a result, the public frequently looks on the government to handle flash flood emergencies in their communities.

5 DISCUSSION

The use of GIS in managing floods can provide various advantages. One of the advantages of GIS is being able to produce maps that help users see flood-prone areas in their area so that they can act before a flood disaster occurs. For example, in Subang Jaya, MBPJ has given the community access to the use of CCTV throughout the subang area, which monitors flood-prone areas, which helps the community to be alert when heavy rain occurs to avoid flooding. Government agencies such as JPS, MBSA, NADMA, and many more will spread information about floods as well as maps of floor-prone areas as well as real-time information on water flow to provide exposure to the use of floods. However, all the good things that happen will still have their bad sides. GIS technology is expensive to implement. The software and equipment required are costly, needing constant updates to protect against cybersecurity threats. Additionally, different agencies use various GIS formats, which increases costs, and specialized equipment must be deployed across multiple flood zones. Access to GIS data is also limited, as only certain government bodies and trained professionals can use the technology, while the public often has restricted access to critical data. Therefore, other users cannot fully access the use of the GIS and only rely on powerful agencies to provide flood-related information. A few agencies are still lacking in the use of GIS and rely on other agencies to get the information. If these problems are overcome, there will be a big impact on flood management in Shah Alam, Malaysia, which is a more systematic management system. Residents will be more aware of the surrounding conditions and will be able to reduce the risk and impact of flood events.

6 CONCLUSION

In conclusion, government agencies in Shah Alam, Malaysia, face several challenges in using GIS to manage flood disasters. Despite preparations and precautions, Shah Alam frequently experiences annual flooding. Data from informal interviews with experts indicate that ineffective inter-agency management and a lack of public awareness are major factors contributing to these floods. While GIS is a valuable tool for mapping and guiding flood management efforts, it has limitations such as restricted information access and equipment shortages. Addressing these challenges requires a comprehensive approach involving advanced technology, detailed data management, and effective stakeholder collaboration. Advanced methods like real-time monitoring, predictive modeling, and community involvement can help overcome GIS-related difficulties and improve flood control.

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