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ORIGINAL ARTICLE

FLOOD GOVERNANCE: A REVIEW ON ALLOCATION OF FLOOD VICTIMS USING LOCATION-ALLOCATION MODEL AND DISASTER MANAGEMENT IN MALAYSIA

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ABSTRACT – Flood management can be defined as the technique and strategy to reduce the risk and damage from flooding. The efficient strategies for the both short-term and long-term plans is needed in order to minimise losses and damage during disaster happen. Flood governance entails the need of a coordinated system in dealing with this natural disaster. The phases of the flood disaster management cycle such as flood preparedness, flood mitigation, Emergency Response Plan (ERP), and flood recovery helped the federal government and states government to overcome the flood disaster. In Malaysia, the disaster management undergoes three levels, where each level is governed by a committee with specified responsibilities. Flood disaster mitigation is crucial since it is possible to prevent damage that is brought upon by flood disaster. During the flood event, all the flood victims must be allocated to relief center. The allocation process needs to be conducted efficiently to avoid much worse incidents happening. The aims of this paper review are to explore the existing knowledge on flood mitigation and to identify Location-allocation model currently applied to solve allocation of flood victims to relief centre.The paper review is based on secondary data to give comparison and recommendation in achieving the objective. However, lack of coordination remains an issue that could potentially be tackled using a more efficient framework. Further researches are needed to test the effectiveness of this framework in improving flood governance.

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INTRODUCTION

A natural disaster is a major adverse event resulting from the natural processes of the Earth. In recent years, due to the unreasonable development of the ecological environment, abnormal climate events such as Hurricane Katrina, Hurricane Rita, and critical floods have occurred more frequently. Other disasters like earthquakes, tsunamis, and volcanic eruptions are also considered major hazards to millions of lives around the world (Rossello et al., 2020). Flood disaster management is a program that benefits humans. It involves the preparation and planning that must be given more attention before the flooding occurs so that the destruction of property can be definitely reduced.

Governance can be defined as a process of more or less institutionalized interaction between public and/or private entities ultimately aiming at the realization of collective goals (Rutting et al., 2022). Governance is an integral aspect of realizing a nation's goal, encompassing collaboration between the higher authorities and the people below them. It can be divided into centralized governance or decentralized governance. Governance on flood management is a crucial chain which connects the authority and the community. Effective decentralization would lead to a more transparent use of public funds; that funding would be used more efficiently in promoting local development and improving the quality of public service provisions (Hermansson et al., 2019). Local governments, communities, and legislative councils would be empowered, drawing the government closer to the citizenry. On the other hand, centralized governance would enable the flow of command to be top-down and somewhat autocratic. Nevertheless, centralized governance would allow only one authority at the top to give decisions based on the inputs from others, which is much more relevant in disaster situations.

Flood management frequently requires a sophisticated, multi-task approach that must strike a balance between expediency and affordability (Tariq et al., 2020). During disaster events, the allocation process needs to be conducted efficiently to avoid much worse incidents happening. The enhancement of existing allocation procedures by the analytical model can also provide a direction for authorities to implement a better plan and to upgrade the existing mitigation process during a disaster. The allocation process of flood victims is crucial to be investigated due to it is the key factor to keep victims safe and facilitate the recovery and development of a disaster-stricken area (Wang, 2021).

The remainder of this paper is organized as follows: Section 2 briefly presents a related work of natural disaster studies. Section 3 discusses the method of this study. Section 4 explains the types of natural disasters and analytical models applied to solve the problem. Section 5 discusses the flood disaster in Malaysia. Section 6 discusses the impact of flood disasters and Section 7 presents disaster management in Malaysia. Section 8 concludes the paper.

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RELATED WORK

Governance can be defined as a process of more or less institutionalized interaction between public and/or private entities ultimately aiming at the realization of collective goals (Lange, Driessen, Sauer, Bornemann & Burger, 2013). Governance is an integral aspect in realizing anation's goal, encompassing collaboration between the higher authorities and the people below them. During a disaster event, the allocation of victims to a safe place is crucial to be handled efficiently. Based on previous studies, various researchers have conducted research related to flood disaster relief. Cabrera and Lee (2020) have proposed in their study in Davao Oriental, Philippines. The proposed of this study is to identify flood-prone risk areas integrated with multiple indicators. They conclude that the study area is moderately exposed to flood risk. Meanwhile, Praneetpholkrang and Kanjanawattana (2020) have proposed in their study to determine the facility location for flood disaster relief in Surat Thani, Thailand. They conclude that the significance of this study is not only giving advantages to decision makers in determining proper shelter location-allocation but also in designing disaster management strategy.

Praneetpholkrang et al. (2020) conducted their study for determining shelter location-allocation in humanitarian relief logistics. This study was conducted in Phan Phin of Surat Thani, Thailand. The objective of this study is to determine the appropriate shelter location-allocation in response to a flood evacuation. The finding of this study indicates that it is capable to assist decision-makers to design appropriate measures for response to shelter location-allocation during flooding events. Ma et al. (2019) proposed in their study to locate emergency shelters during disaster relief in Beijing, China. This study is capable to provide an effective planning strategy with respect to public safety in Beijing.

A location-allocation model that divides the topography of affected areas into multiple layers has been proposed by Baharmand et al. (2019). They applied the model to a real data set from the 2015 Nepal earthquake response. They concluded that a stable time and cost-efficient network in a constrained context as the immediate response phase can be established by the Humanitarian Organizations (Hos) through the help of this model. Ma et al. (2019) proposed a location-allocation study to determine the locations of disaster emergency shelters and the allocation of affected locals. The objective of this study is to consider the transition in candidate shelters and the number of evacuees due to the change in affected areas with the development of a typhoon. The findings indicate that this study is capable to provide a better solution for managers in order to evaluate residents by considering the typhoon conditions.

Shavarani (2019) proposed in his study of multilevel facility location-allocation issues for post-disaster humanitarian relief distribution. The usage of drones as a relief distribution vehicle was previously studied in several studies. The required number of drones and the best locations for the relief centres were investigated in this study. Ma et al. (2019) conducted a study about location-allocation optimization for disaster supply warehouses in the Beijing–Tianjin–Hebei (BTH) area in China. China experiences almost all potential dangers observed worldwide and they all present a high frequency, high intensity, and huge disaster of global disaster losses. The objective of this study is to reduce the total number of and cost of Disaster Supply Warehouse (DWSs) for the facility location problem and the total distance for delivery supplies at all levels for the supply allocation problem. The results provide a scientific reference for DSWs location-allocation planning in the BTH region.

METHODOLOGY

This research carried out its review of the current governance structure in flood management (FM) in Malaysia through analysis of secondary data obtained from documentation such as proceedings or journals. Through the review, the existing structure of FM and challenges faced in FM practices are identified. The research examines the governance structure elements in FM which include the policies introduced and the participation of the government agencies. Based on the comparative study that was conducted, a suitable location-allocation model in the selected countries can be adopted in constructing a better FM governance framework, specifically for Malaysia.

TYPES OF DISASTER AND ANALYTICAL MODELS

Types of disasters in various countries

Large-scale disasters such as earthquakes, floods, wildfires, and hurricanes have grown increasingly frequent in recent years, causing huge amounts of property damage, injuries, and fatalities (Caldera et al., 2022). Bangladesh has been affected by numerous devastating floods due to its geographic setting, heavy monsoon rainfall, and low elevation. Flood has severe implications for livelihoods, food security, and loss of property (Singha et al., 2020). While the occurrence of floods cannot be avoided, damage associated with it can be minimized substantially if flood susceptible areas can be delineated accurately. Hence, flood prediction is an important step in reducing flood damage. In Bangladesh, the study of flood risk management and emergency evacuation is at an early stage.

Earthquakes, one of the gravest natural hazards worldwide, annually cause a consequential number of injuries and death around the world. In 2018, over 4,000 casualties were recorded. Information before, during, and after an earthquake has been found to reduce anxiety and increase resilience (KC et al., 2019). Furthermore, information sharing during every stage of the disaster cycle has been found to be a universal need, leading the Red Cross and Red Crescent Societies to declare that "people need information as much as water, food, medicine, or shelter" (Ikbal et al., 2021).

Typhoon Haiyan, locally known as Yolanda, was one of the most destructive cyclones ever recorded. It crossed the Philippines in early November 2013, causing heavy rainfall, flash floods, and landslides throughout the archipelago but especially in the Visayas regions: Leyte, Samar, Cebu, Bohol, and Panay (Brucal et al., 2020). Despite preparedness measures and evacuations undertaken by the national authorities, the humanitarian impact was colossal. The government has reported over 6,200 dead, some 28,000 wounded and 4 million displaced. Between 14 and 16 million people are considered to have been affected by the disaster, and 6 million are children.

Globally 800 million people live within 100 km of the world's 1431 active volcanoes in developing countries alone and 722 million are exposed to volcanic hazards (Barclay et al., 2019). However, the conditions that turn a hazardous activity into a volcanic disaster are also a construction of preexisting social circumstances, limited capacities, and inadequate responses, even when good monitoring systems are in place.

Types of location-allocation models applied in various studies

Location-allocation (LA) problem involves locating an optimal set of facilities to fulfil customers' demands at minimal transportation costs from the facilities to the customers (Masudin, 2019). LA model is also defined as a mathematical model used to establish optimal locations for bigger, central facilities such as hospitals, factories, and schools. Based on previous studies, the LA models have been applied in various fields. LA has been applied as a model to solve various problems related to natural disasters not only flood disasters but also hurricanes, typhoons, earthquakes, and other disasters. Table 1 shows the summary of LA model based on the previous study.

Thailand's, Northeast Bangladesh's, and Taiwan's geographical locations made them countries that experienced seasonal flooding due to the monsoon climate and floodplain landscapes. In recent years, cases of flood have been increasing as these countries grow rapidly because of industrialization and urbanization of cities. Based on the previous study, P-Median and Maximal Coverage Location Problem (MLP) have been applied to allocate flood victims to relief centres. Moreover, in Beijing and Iran, natural disasters such as earthquakes happen and P-Median and MCLP have been applied to cater for the allocation of flood victims to relief centres. Additionally, hurricanes and typhoons happen in Beijing, China, and MCLP and P-Median model have been applied to solve the allocation problem.

Table 1. Types of disaster and analytical models applied

Types of disaster	Study Area	**Location-allocation Model A**pplied
Flood	Northeast Bangladesh	P – Median Maximal Coverage Location Problem Location Set Covering Problem
	Taiwan	Location Set Covering Problem Maximal Coverage Location Problem
	Thailand	P – Median Maximal Coverage Location Problem
Earthquake	Beijing, China	P-Median
	South Khorasan, Iran	Maximal Coverage Location Problem
Hurricane	Beijing, China	Maximal Coverage Location Problem
Typhoon	Beijing, China	P-Median

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Previous studies show that the location-allocation model is capable to cater the problem related to natural disasters. The result obtained is useful for planning, decision-making, and organizing especially for the pre-disaster mitigation process. Clearly, the most significant benefit is when the optimal number of relief centres was identified, thus the evacuation process from prone areas to relief centres can be conducted efficiently. Meanwhile, the selection of suitable location-allocation models is crucial to be conducted in order to ensure the efficiency of the allocation process.

FLOOD DISASTER IN MALAYSIA

Every year, Malaysia becomes vulnerable to flood disasters due to the monsoon season and heavy rain. Figure 1 shows the types of Monsoon seasons. Monsoon season can be described as Southwest Monsoon which means from May to September and Northeast Monsoon which is from November to March. The Southwest Monsoon will cause the relatively dry season to entire states except for Sabah and the Northeast Monson will cause the humid season to entire states that lead toward the floods disaster. The monsoon transition period will occur from the end of March until early May and October to the middle of November. This monsoon transition period will cause feeble wind from various directions that lead the entire state to have thunderstorms in the evening.

Flood disasters will occur when inadequate drainage systems are unable to channel the water flow properly. The overflow of the rivers is also a major reason for occurring the flood in the city. The frequency of these events will occur toward the end of the year, northeast monsoon causes massive heavy downpours of rain, particularly in the eastern states.

Due to its relative regularity, flood mitigation, forecasting, and warning system efforts have been undertaken by various agencies to minimise the impacts brought by floods.

On the other hand, flash flood usually happens in the busy city. It is caused by uncontrolled human activities such as infrastructure development near the river areas and uncontrolled littering causing clogged drains and waterways (Mabahwi et al., 2020). This situation is definitely worrying to the public as it has a negative impact on life, property, infrastructure, agriculture, human health, and economic status which are affecting the community's quality of life (Glago., 2021)

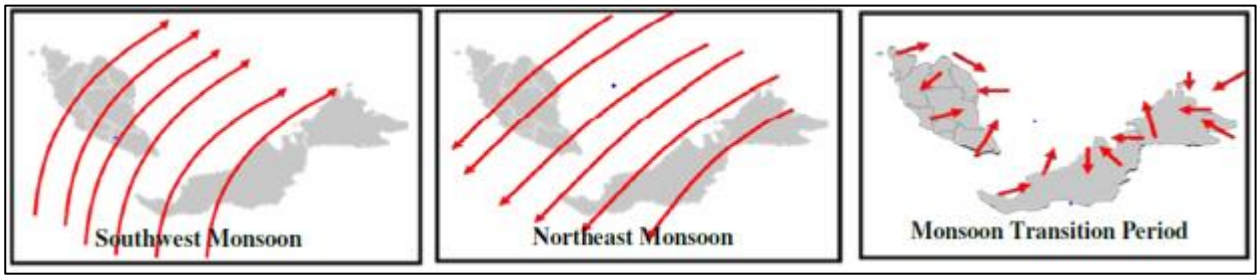

Figure 1. Type of Monsoon Season

THE IMPACT OF FLOOD DISASTER

In Malaysia, flood is influenced by the northeast monsoon taking place from November to March each year, which induces heavy rainfalls, particularly in the east coast states of Peninsular Malaysia and western Sarawak (Safiah et al., 2020). In the year 2022, Malaysia had been severely affected by the seasonal flood, where 66,718 people were evacuated and sheltered at 116 relief centres (Muhamad et al., 2022).

The massive flood that hit Kelantan in 2022 was the worst to record in the state's history, with water levels exceeding the major flood in 1967 (Muhammad et al., 2020). In this event, 516 houses in Gua Musang and 38 houses in Machang were totally destroyed. A total of 142,582 flood victims from 35,814 families were sheltered at 317 relief centres (Abubakar et al.,2021). The gross loss was estimated at around RM200 million for eight districts in the state due to total damages to public assets and infrastructure. Meanwhile, in a more recent incident in the year 2021, Bernama (2021) reported 50,000 flood victims have been evacuated to relief centres following heavy monsoon rains pounding the east coast region of peninsular Malaysia.

Meanwhile, according to Safiah et al. (2020), flood is prone to occur in lowland areas and are triggered by a rapid increase in water volume due to heavy rainfall. In another scenario, flood may take place when the water level is higher than the river bank or dams thus causing water to overflow from the river. For instance, extreme rainfall had caused the overflowing of the Pahang River which has led to the inundation of the nearby lowland areas.

DISASTER MANAGEMENT

Malaysia has seen an improvement in disaster surveillance and preparedness. However, the lack of coordination between parties still becomes an issue. The various agencies often have overlapped goals and roles, as well as poor central data management. Due to this, valuable data such as river overflow rate are detected late due to poor data sharing systems and informatics. By the time flood struck, destruction has occurred. Table 2 shows the agencies involved in flood governance during disaster events.

Table 2. Agencies involved in flood governance in Malaysia

Level	Actors	Responsibility
National	National Security Council	Guidelines & directive
	Disaster Management Relief Committee	Guidelines
Community	Jawatankuasa Kemajuan Dan Keselamatan Kampung	Organizing residents
Public organization	Department of Irrigation and Drainage	Drainage system, river basin,
	Housing department	infobanjir
	Municipal council	Shelter
	Malaysia Meteorological Department	Rainfall monitoring and warning system
	Universities	Relief, research

Level	Actors	Responsibility
	Army, Police	Rescue, safety
	Ministry of Health	Emergency medical response
Private organizations	Takaful	Flood insurance
NGOs	Medical Relief Society Malaysia	Medical aid
International	Voluntary bodies	Help ad-hoc, mainly cleaning supplies
	United Nations Humanitarian Response Depot	Critical relief items and equipment

Flood disaster management in Malaysia is operated based on the National Security Council (NSC) Directive No.20 and Fixed Operating Regulations (PTO), which outline the aims of the Policy and Mechanism on Disaster and Relief Management on Land (Tahir et al., 2021). This directive also describes the purpose of responsibilities and the degree of involvement of various agencies in disaster management. According to the Ministry of Natural Resources and Environment, earlier experience has shown that the most effective approach is through the development of flood management programs using a holistic approach with respect to the following five strategies:

1) Prevention: avoiding construction of houses, properties, and industries in present and future flood-prone areas for preventing damage caused by floods
2) Protection: to reduce the likelihood and the impact of floods in a specific location, with the Government taking structural and non-structural measures
3) Preparedness: to give information to the public about what to do in the event of flooding and about flood risks
4) Emergency Actions: in case of flood, develop the emergency response, formulate plans and actions
5) Recovery and lessons learned: after a flooding disaster, return to normal conditions as soon as possible and mitigate both social and economic impact (Hussaini, 2007).

According to this strategy, the collaboration of government, the private sector, Non-Governmental Organizations (NGOs), and the community, in general, is the most important factor in managing floods as a whole. Apart from that, the success of disaster management depends on its implementation in the local areas as this can reduce the impact of disaster on the affected communities. The government established the Natural Disaster Management and Relief Committee (NDMRC) in 1972, bearing the task of coordinating flood relief operations at the national, state, and district levels with the combined aims of reducing flood damage and preventing loss of human life (Tang et al., 2019). Flood disaster management in Malaysia is based on the National Security Council (NSC) Directive No.20 and Fixed Operating Regulations (PTO). These were outlining the aims of Policy and Mechanism on Disaster and Relief Management on Land. This directive also describes the purpose of responsibilities and determines how the various agencies should be involved in disaster management (Che et al., 2019).

Agencies involved in managing flood disasters in Malaysia

Collaboration between the community and the respective agencies is necessary for the management of floods in order to ensure that each aspect of flood control can be implemented equally (Muzamil et al., 2022). In Malaysia, there are a few agencies involved and are responsible for flood management including the National Security Council (NSC), the Police Department, the Fire and Rescue Department, the Civil Defence Department, the Welfare Department, the Public Works Department, the Meteorology Department, as well as Department of Irrigation and Drainage (Abd Rahman., 2022). Each agency has different roles and responsibilities for different situations. Normally, in the prevention/mitigation phase, the Department of Irrigation and Drainage is the most important agency that will be responsible and this agency has done an extensive program of flood control and mitigation (Abd Rahman et al., 2022). However, Shariff et al. (2019) claimed that most of the agencies are frequently focused on the activities involving a warning, emergency relief, and rehabilitation which are done during the disaster. Table 3 provides the roles of agencies involved in flood management in Malaysia as stated by Othman et al. (Shariff et al., 2019).

Table 3. Agencies involved in managing flood disasters in Malaysia

Roles	Agencies
search and rescue: Search and Rescue of victims	• Fire and Rescues Department • Royal Malaysia Police • Malaysia Armed Forces • Special Malaysia disaster assistance and rescue team (SMART) • Emergency medical services • Atomic Energy Licencing Board • Civil Defense Department
Health and medical Management of emergency treatment Management of forensic management of public health	• Emergency medical services • Malaysia Armed Forces • Malaysia Red Cresent Society • St John Ambulance
Welfare: Evacuation victims Preparing foods for victims' duty/officer Provide managed places of evacuation Providing first aid and counselling services	• Welfare Department • Emergency medical services • Malaysia Red Cresent • St John Ambulance • RELA • Civil Defense

CONCLUSION

This study analyzed the flood management governance framework in Malaysia and the location-allocation model applied to solve the allocation problem in Malaysia. The governance framework may include the involvement of government in flood management, levels for flood management, and policies introduced for it. The findings of this study indicate that a governance framework for flood management is necessary for controlling the flood crisis. Through this framework, a special arrangement will provide valuable information for disaster management to better organize other related sources such as medicine and sanitation, sufficient sources of food and water, transportation, and secure accessibility.

Moreover, Information systems (IS) are important instruments used to improve the efficiency and effectiveness of disaster-handling activities during a disaster, and a better mechanism to share and coordinate the information is needed to build a good flood management framework. Therefore, it can be concluded that a country must establish and design an appropriate flood management governance framework, complete with roles and responsibilities of agencies involved for proper coordination, the introduction of policy or law as well as an information system to support flood management, and the involvement of federal government as the centre of the framework.

Previous studies show that the location-allocation model is capable to cater the problem related to natural disasters. In Malaysia, the P-median model is suitable to be adopted in the allocation procedure during a disaster since Thailand which have a similar characteristic of flood to Malaysia had successfully applied this model. The result obtained is useful for planning, decision-making, and organizing especially for the pre-disaster mitigation process. Clearly, the most significant benefit is when the optimal number of relief centres was identified, thus the evacuation process from the prone areas to the relief centre can be conducted efficiently. Thus, the finding of this study will provide valuable information for disaster management teams. Meanwhile, the selection of suitable location-allocation models is crucial to be conducted in order to ensure the efficiency of the allocation process. The application of the location-allocation model can support relief organizations to prepare relief supplies in the pre-disaster phase of a natural disaster.

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CONFLICT OF INTEREST

The author(s), as noted, certify that they have NO affiliations with or involvement in any organisation or agency with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, jobs, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, expertise or beliefs) in the subject matter or materials addressed in this manuscript.

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