DOCTORAL THESIS

SHIBAURA INSTITUTE OF TECHNOLOGY

THE RELATION BETWEEN FLOOD RISK MANAGEMENT AND SPATIAL PLANNING: AN EVACUATION AREA SUITABILITY PERSPECTIVE IN MALAYSIA

2021/MARCH

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ACKNOWLEDGEMENTS

Firstly, I would like to express my sincere gratitude to my thesis supervisor, Professor Dr. Hitoshi Nakamura, for the continuous support of my PhD study. I really appreciate all his patience, motivation and immense knowledge that guide me through in this PhD journey. The PhD journey was hard but his guidance helped me get through it all the time of my research and writing this thesis. No words could ever express how thankful I am to have a supervisor being so patience guiding me in every step of the research process. I could not have imagined completing this study without his supervision. Thank you so much Sensei. Besides my thesis supervisor, I would like to extend my appreciation to Dr. Yasmin Bhattacharya for guiding my research, especially my journal papers. Thank you for reading every paper I wrote, and guide me to make it better. I really appreciate every guidance she gave me throughout it. I too want to extend my gratitude to all the reviewers, Professor Shunji Suzuki, Professor Yukihiro Masuda, Dr. Yasmin Bhattacharya, and Dr. Akito Murayama, for their insightful comments, knowledge and encouragement for me to improve my manuscript. Thank you so much. I really appreciate all the valuable comments to make my thesis better. My sincere gratitude also goes to Shibaura Institute of Technology for funding my research. I am forever thankful receiving the scholarship. To all my colleagues, thank you for all of your support, motivation, help and for all the fun we have had together in the last 3 years. There are so many friends who have helped me throughout the journey, from going to site visit, to collect data or even just saying I can do it to motivate me. Also thank to all the staff of flood-related agencies in Malaysia for being my respondent. Last but not least, I would like to thank my family: my precious husband, my loving mother, my lovely daughter, my helpful sister, brothers and the rest of my family members for praying for me the whole time, for motivating me and for keep on saying I will finish it. Thank you so much.

ABSTRACT

Malaysia is affected by major flood disasters throughout each year. Due of its geographical location, the country experiences seasonal monsoon winds that bring heavy monsoon rains to the north and east coasts. Each year, thousands of people are forced to evacuate to flood shelters (ECs) due to frequent flooding. Because of the significantly high number of flood victims and evacuees each year, the preparation of ECs across Malaysia is one of the most important aspects of the country's flood risk management (FRM). In several cases, ECs themselves have become inundated, forcing evacuees to move to other locations or remain trapped inside.

Close collaboration between multiple disciplines and agencies is required to secure safe EC sites through the integration of FRM and spatial planning and through addressing cross-cutting flood-related issues. It is, however, challenging for multiple disciplines and agencies to collaborate due to the many actors involved. Therefore, identifying the issues and challenges facing flood-related agencies is important, as these issues are addressed by various institutions at different levels through regional programmes overseen by regional entities, national programmes overseen by country governments and city- and local level activities overseen by community-level organisations.

The aim of this study is to identify the issues and challenges facing flood-related agencies when incorporating flood risk management with spatial planning to ensure EC site suitability. A mixed method of qualitative research and GIS-based analyses was used to undertake the investigation. The study used GIS-based multi-criteria analysis to investigate the spatial aspects of evacuation, and integrated GIS and qualitative analyses to identify the issues and challenges faced by flood-related agencies from the perspective of EC site suitability.

The thesis consists of six chapters. Chapter 1 provides context to the study, and presents the problem statement, the study objectives, the research questions, the significance of the research, the scope of the study and a brief outline of the research design. Chapter 2 provides a systematic review of literature related to evacuation site suitability, spatial planning, and FRM, and provides a formulation of the conceptual framework for the study. Chapter 3 examines flood risk governance using content analysis of Malaysia's three-tier spatial plan: the National Physical Plan, the State Structure Plan and the Local Plan. A qualitative thematic analysis of flood-related agencies was conducted to identify the issues and challenges they face. Chapter 4 focuses on a GIS-based multi-criteria site suitability analysis of ECs and the barriers faced by agency to achieving EC site suitability in Kuantan, the largest city on the east coast of Malaysia. Chapter 5 discusses the findings and policy implications of the results from the previous two chapters. Chapter 6 concludes the study and provides recommendations for future research.

The study found a lack of flood management-related legislation to control flood events, leading to a lack of authority and enforcement capability. In addition, at all levels of government there exists a lack declarations of collaborative risk sharing and risk management, and flood-related agencies do not cooperate with each other. An existing institution, the Malaysian Flood-related and Urban Planning Agencies, is decentralised. Furthermore, the agency responsible in selecting and managing ECs is not related to those agencies responsible for urban planning or FRM.

Kuantan has a total EC capacity for only 29,700 evacuees, even though 355,140 residents are at risk of flooding. In addition, since 66% of affected residential areas are outside a 1 km radius of ECs, the proportion of ECs available for affected residential areas and populations is insufficient. It is clear that there is no scientific basis for evacuation siting decisions, meaning that more ECs need to

be built to support disaster-affected residential areas. Based on site suitability analysis, 21% of ECs in Kuantan are located at unsuitable sites, 32% are located at moderate to more suitable sites, 39% are located at very suitable sites and 8% are located at extremely suitable sites. EC sites categorised as unsuitable are situated near industrial areas, near places of low-elevation with some risk of landslide, on steep slopes and near low-elevation streams and beaches with a high risk of inundation and secondary disasters. Overall, only 47% of ECs in Kuantan are located at suitable sites. The network service area analysis revealed that 95% of the ECs located at suitable sites have good city centre road network accessibility. Only 5% have low accessibility by foot, and only 70% of people can reach these ECs within 15 minutes. This means that within 15 minutes, 246,418 people can reach the ECs on foot.

The study found a number of institutional barriers. Agencies and officers lack adequate understanding of the requirements for EC site suitability. None of the development proposals submitted to the local authority make provision for secure evacuation sites, and evacuation procedures are not included in the Kuantan Local Plan. The agency responsible for choosing and managing ECs is not associated with the agencies responsible for FRM or urban planning. Therefore, the selection of ECs is rendered without taking geo-spatial characteristics into consideration. A further problem in Kuantan is the lack of clear evacuation laws and policies at the local level. The Municipal Council of Kuantan should integrate the elements of safe EC sites into its Local Plan and its growth plan. To overcome this shortcoming, amending the current legislation, Planning Guidelines, and the requirement that planning permission applications include EC site suitability criteria will ensure the inclusion of elements of site suitability in spatial planning. The aforementioned must be supported by law, regulation, and enforcement, and can be achieved through the formulation of national policies or the amendment of Directive No. 20, Act 172 of the Town and Country Planning Act and Planning Guideline. In addition to legislation amendments, specific measures to ensure the geo-spatial siting of ECs must be included in the three tiers of spatial planning. To ensure this, executive orders must be issued, directing the state, the district government and local authorities to consider emergency planning in all future development. Spatial plans must include evacuation procedures, especially in flood-prone areas. It is also highly recommended that gazetted safe land and buildings are included as ECs in each Local Plan.

In conclusion, future research will benefit from the findings of this study with regard to detailed investigations of increasing evacuation capacity, identifying suitable EC sites and integrating FRM into spatial planning. I hope this study will provide the guidance to amendments to the National Physical Plan, the State Structure Plan and the Local Plan by including the geo-spatial elements of ECs in spatial planning and for local authorities to take seriously the matter of the suitability of EC sites to ensure and improve community resilience.

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LIST OF ABBREVIATIONS

AHP	-	Analytic Hierarchy Process
BPK	-	Planning Block Kuantan
DEM	-	Digital Elevation Model
DID	-	Department of Irrigation and Drainage
ECs	-	Evacuation centres
FRM	-	Flood risk management
GIRN	-	Government Integrated Radio Network
GIS	-	Geographic Information System
LP	-	Local Plan
MLIT	-	Ministry of Land, Infrastructure, Transport and Tourism
NADMA	-	National Disaster Management Agency
NAHRIM	-	National Hydraulic Research Institute of Malaysia
NPP	-	National Physical Plan
OSC	-	One Stop Centre
SMART	-	Storm Water Management and Road Tunnel
SOP	-	Standard Operating Procedure
SRTM	-	Shuttle Radar Topography Mission
SSP	-	State Structure Plan
WOA	-	Weighted Overlay Analysis

CHAPTER 1

INTRODUCTION

1.1 Background

Climate change and urban development are key contributors to increased flooding and flood damage throughout the world (Mustafa et al., 2018; Poelmans, Rompaey, Ntegeka, & Willems, 2011). In addition, growing populations, especially in urban areas, increase the probability of the overuse of land in flood-prone areas (Larsen, 2009; Ran & Nedovic-Budic, 2016). Globally, floods cause tremendous destruction worldwide. In the twentieth century, flood disasters killed more than 100,000 people and affected more than 1.4 billion (Jonkman, 2005). These effects are attributed to the increased exposure of people and infrastructure to natural hazards, as a result of population growth, limited available space and climate change (Sutanta, Bishop, & Rajabifard, 2010). The number of vulnerable cities and populations continues to grow, emphasising the need for national and local governments to improve disaster operation management efforts to enhance urban disaster resilience (Zhao et al., 2017)

Like many countries, Malaysia is adversely affected by flooding. Fluvial and coastal flooding usually occurs due to heavy rainfall during the monsoon season, while flash floods can occur throughout the year because of uncontrolled urbanisation, water runoff and ineffective drainage systems. As a result, each year, thousands of Malaysians are forced to evacuate their homes and move to safe shelters or designated evacuation areas (NADMA, 2018). Flooding is the country's most prolific natural disaster, affecting 4.9 million people and causing several million Malaysian Ringgit worth of damage each year (Keicho, 2020; Mohit & Sellu, 2013). Therefore, the provision of safe evacuation centres (ECs) or temporary shelter during flooding events is a priority and the primary disaster concern of the Malaysian Government (Padlee, Nik Razali, Zulkifli, & Hussin, 2018).

However, constructing ECs remains a challenge, especially in urban contexts where the availability of appropriate sites is often limited and there is an increased demand for risk-sensitive land use planning, which is often insufficient (Anhorn & Khazai, 2015). The allocation of ECs to suitable locations draws on standards, criteria and guidelines developed by emergency managers and humanitarian organisations in the context of post-disaster assessment (Anhorn & Khazai, 2015; Sphere, 2011, 2015; UN/OCHA, 2010). In addition, candidate EC locations often do not meet adequate standards. In an example from the US, an assessment of Southern Florida found that 48% of existing shelters and 57% of candidate shelters were in geographically unsuitable areas (Chen, Zhai, Ren, Shi, & Zhang, 2018; Soltani, Ardalan, Boloorani, Haghdoost, & Hosseinzadegh-Attar, 2014).

To ensure that ECs are located at suitable sites, integrated flood risk management (FRM) with spatial planning is required. Not only can it supplement risk management, it also avoids or even reduces the risk caused by influencing factors, such as the location of EC, and the type, design and function of urban development projects (Porter & Demeritt, 2012; White & Richards, 2007). In order to increase urban capacity to cope with the impacts of climate change and to prevent or minimise future flood hazards, spatial planning should be part of the dynamic governance of flooding through the identification of suitable types of land use, the coordination of activities across spatial scales and the shaping of the built environment, among others (Meng, Dąbrowski, Tai, Stead, & Chan, 2019; White & Richards, 2007).

However, the close collaboration of multiple disciplines and agencies is essential to securing safe EC sites based on integrated FRM and spatial planning that addresses cross-cutting flood issues (Meng et al., 2019; Storbjork, 2007; Ward, Pauw, van Buuren, & Marfai, 2013). This requires a combination of interventions that include prevention, mitigation and security, and warnings, evacuations and recovery, which each across multiple policy areas, such as town planning and building requirements, water management, land use planning and civil protection (Lindgren & Persson, 2010;

Pettersson et al., 2017; Schmidt, 2013). However, from the perspective of EC sites, there are many multi-level institutional and governance challenges to the incorporation of FRM into spatial planning.

In addition, the management of ECs, FRM and spatial planning in Malaysia has long been a top-down government responsibility, and Malaysians are heavily reliant on a hierarchical government-controlled techno-centric approach to flood management (Chan, 2012). The governance and management of flood risk is divided between federal, state and districts governments (Center for Excellence in Disaster Management & Humanitarian Assistance, 2016; Chan, 1995, 2012; Chong & Kamarudin, 2018). At each of these divisions, FRM is subject to different legal frameworks, rules, policies, procedural standards and work practices. However, primary coordination, disaster funding, order and crisis management responsibilities remain at the federal level.

That is why, in Malaysia, FRM is not merely about flood risk. It also comprises a specific government system that encapsulates management perspectives combining prevention, preparedness, response and recovery. This makes Malaysia a valuable case study for investigating the issues and challenges faced by flood-related agencies. An analysis of flood-related agencies can make a crucial contribution to assessing and strengthening agency capacity to ensure better and more comprehensive FRM. The strengths or weaknesses of related agencies serve to either support or threaten the entire FRM process.

However, there has been limited social science research on the theme of FRM. Therefore, there is scarcity of knowledge on the complexities of flood risk governance challenges and the issues facing flood-related agencies (Dieperink et al., 2016), especially with regard to securing safe EC sites. This study fills this gap by identifying the issues and challenges facing flood-related agencies when incorporating FRM into spatial planning from the perspective of evacuation site suitability.

1.2 Problem Statement

In Malaysia, floods are major annual and year-round disasters. Because of its geographical location, the north and east coasts of Malaysia experience seasonal monsoon winds that bring heavy monsoon rains. In addition, 85 of the country's 189 river systems, are prone to frequent flooding, and approximately 29,000 square kilometres, or 10.1% of the total land area, is flood-prone (Che Ros, Shahrim, & Liew, 2019; DOE Malaysia, 2003, 2020). Specifically, Malaysia experiences two types of flooding: monsoon floods and flash floods. Currently, all of Malaysia's four regions (north, central, east and south) experience flooding during the monsoon season (Mohit & Sellu, 2013) from around May to August (southwest monsoon) and from around November to February (northeast monsoon) (Austin & Baharuddin, 2012; Mohamad Yusoff, Ramli, Mhd Alkasirah, & Mohd Nasir, 2018; Tan, Ibrahim, Duan, Cracknell, & Chaplot, 2015).

Rainfall intensity in Malaysia is extreme year-round, and the country's urban areas are vulnerable to frequent flash floods (Chan, 2012) caused by uncontrolled human activities, such as infrastructure development near rivers and clog drains caused by uncontrolled littering. In addition, 68% of the Malaysian population now reside in urban areas, and since the mid-1990s, flash floods in urban areas have been the most dangerous flooding type, surpassing monsoon floods (Department of Irrigation and Drainage Malaysia, 2007 in Mohit & Sellu, 2013).

Furthermore, changes in land use from forest land to urban land has led to a more than ten-time increase in runoff. Forest runoff averages between 10% and 20% of total rainfall, while urban runoff averages between 80% and 90%. As a result, most rainfall becomes runoff and rivers lack the capacity to deal with this enormous runoff from urban land, thus exacerbating flooding (Chan, 2015b). To add to this problem, the drainage capacity of Malaysia's rivers is greatly diminished because of sedimentation (Chan, 2015b).

Therefore, each year, thousands of Malaysians are forced to evacuate to flood shelters (ECs) due to frequent flooding. In 2014 alone, there were 541,896 flood evacuees (NADMA, 2018), while 95,929 residents had to evacuate because of flooding from 2016 to

2017 (Jabatan Pengairan dan Saliran Malaysia, 2018). Because of the significantly high number of flood victims and evacuees each year, the preparation of ECs across Malaysia is one of the most important elements of the country's FRM.

Schools and government buildings are the most commonly designated ECs because of their capacity to accommodate large numbers of people, and because they are equipped with necessities, such as toilets, electricity, and running water. Such a designation is made because identifying existing structurally suitable evacuation facilities, such as hospitals, recreational buildings and schools is a more cost-effective than constructing new shelters. Since ECs are almost always 'dual-use' facilities, their location in disaster situations can often be less than ideal.

However, in several cases, these ECs have themselves become inundated, forcing evacuees to move to other locations or remain trapped inside. Haryantie, Munirah, Hasinah, and Adnin (2016) report that inundation of ECs has frequently forced evacuees to vacate a second time and seek shelter elsewhere. For example, after floodwaters rose 3 metres to the first floor of the Pahang EC in Kuantan, evacuees had to move to a second EC, while another EC at SK Sungai Ular, was also inundated (Yusof, 2017).

Most of the existing government buildings, such as schools and public halls, currently used as ECs, lack proper flood safety specifications and are built on lands unsuitable for evacuation, because their primary function is not as ECs. The Department of Social Welfare's standard operating procedure for flood disaster management highlights the need to examine the flood susceptibility of ECs, given that they should be located in locations at risk of being affected by floods (Haryantie et al., 2016). The site suitability of existing shelters and available facilities, however, has not been analysed, thus necessitating the identification of suitable evacuation shelters (Kar & Hodgson, 2008). None of Malaysia's existing spatial plans prioritise securing safe evacuation areas. Moreover, FRM and spatial planning have neglected the suitability criteria for safe evacuation sites.

Only a limited number of studies have been published on the site suitability of ECs in Malaysia, and there is a lack of specific guidelines or regulations on what constitutes an appropriate evacuation shelter. To the best of the author's knowledge, there is only one published study on evacuation site suitability in Malaysia by Zahari and Hashim (2018), which focuses on EC fitness and adequacy from a humanitarian, rather than a spatial perspective. Isahak et al. (2018) evaluated Pahang's existing ECs using shelter criteria from the Sphere Project's Minimum Standards in Humanitarian Response. However, this study ignored suitable spatial locations for ECs and, instead, concentrated on improvements to ECs during post-disaster reconstruction. Meanwhile, Mustaffa et al. (2016) conducted the only study assessing the spatial sites of existing ECs. They used remote sensing and geographic information system (GIS) to evaluate the EC site suitability in Batu Pahat, Johor, Malaysia, based on elevation, contour, flood vulnerability and road access. A study by Haryantie et al (2016) also analysed evacuation suitability but only based on flood level.

A scientific evaluation of the sitting of ECs must be included in spatial planning to ensure that selected locations are suitable. In addition, as the effects of floods continue to increase worldwide, experts agree that post-event responses must be more efficient and draw on the best scientific evidence available (Anhorn & Khazai, 2015; Balcik, Beamon, Krejci, Muramatsu, & Ramirez, 2010; Bharosa, Lee, & Janssen, 2010; McEntire, 2007; Rawls & Turnquist, 2010). However, integrating flood risk and climate change science perspectives into spatial planning is a daunting challenge, and planners continue to underestimate the scale of the challenges they face (J. G. Carter et al., 2015; Meng et al., 2019).

To address the increase in flooding incidents, in 2001, the Malaysian government established the National Physical Planning Council, the purpose of which was to control urbanisation. Chaired by Malaysia's prime minister, the council coordinates spatial planning efforts across the country with respect to disaster resilience, from the national level to the level of urban local authorities. The Council, supported by the director general of town and country planning, is also tasked with improving planning mechanisms to achieve sustainable urban growth. However, in Malaysia, disasters are not widely accepted as roadblocks to sustainable urban growth. The Council's actions against disasters are limited to the strict monitoring of land in the highlands to protect human life and the environment, as stated in Policy No. 21. This means that the wider policy statement in the National Physical Plan is inadequate to the implementation of disaster preparedness measures in human settlements (Khailani & Perera, 2013).

In addition, a study by Mohamad Amin and Hashim (2014) reported that Malaysia's progress in achieving disaster resilience through spatial planning is hampered by several issues: (1) noncompliance of state and local-level development plans and planning guidelines; (2) lack of data to allow for detailed assessments; (3) ineffective implementation of development policies; and (4) lack of support, commitment and funding from stakeholders (including local and state planning authorities). If all of these issues were wisely addressed by urban planning communities, Malaysia would be guaranteed to succeed in implementing its disaster risk reduction agenda in its urban planning practices (Mohamad Amin & Hashim, 2014; Wan Nurul Mardiah Wan Mohd Rani, Razak, Kamarudin, & Hassan, 2017).

In spatial planning and FRM research, governance is considered critical to creating an environment conducive to effective disaster risk management (Alexander, Priest, & Mees, 2016; Chereni, Sliuzas, Flacke, & Maarseveen, 2020). As a result, many governments worldwide have redesigned their systems to prevent and mitigate flood disasters and to help communities recover. In some cases, this mechanism has resulted in hybridised governance systems (Chereni et al., 2020; Plummer et al., 2018). Improvements in governance have shown some promise in reducing the likelihood of disasters (Castaños & Lomnitz, 2009; Chereni et al., 2020; Matczak et al., 2016; Scolobig, Prior, Schröter, Jörin, & Patt, 2015).

Given the growing consensus that flooding will continue to increase, there is growing demand for improved flood risk governance and the promotion of social resilience through regulatory agendas, multi-level agencies and resource efficiency (Alexander et al., 2016). However, given the dearth of social-science research on FRM, there is a scarcity of knowledge on the complexities of flood risk governance challenges and the issues facing flood-related agencies (Dieperink et al., 2016).

Identifying the governance issues and challenges faced by flood-related agencies is important, as these issues must be addressed by multiple institutions at a variety of levels of government, from regional programmes overseen by regional entities, national programmes overseen by national governments and city-level and local-level activities overseen by community-level organisations (Shaw et al., 2009). Institution-based disaster risk management is a multisector, multi-level participatory process based on a consensus of values which, when integrated into socioeconomic development processes (Shaw et al., 2009), leads to permanence, regularisation and sustainability in a complex governance settings. Furthermore, it is important to examine the challenges faced by flood-related agencies because problematic institutional structures and inefficient institutional capacities hamper the effective implementation of disaster-related policies (Hossain & Huq, 2013).

In Malaysia, flood risk governance is under the auspices of Directive No. 20, an official order from the Prime Minister's Office (Jabatan Perdana Menteri). This is not an act that deals directly with FRM. Hamin et al., (2013) argue that Malaysia lacks an adequate FRM because Directive No. 20 is only ever activated once a disaster has been declared. However, managing flood risk from the perspective of evacuation demands more than simply coping with flooding once the water has begun to rise. In this sense, Directive No. 20 does not address the full cycle of FRM: that includes prevention, preparedness, response and recovery.

Malaysian FRM is concentrated on structural and technological flood control measures (Liu & Chan, 2003), primarily because FRM is dominated by natural and technical science perspectives (Driessen, Hegger, Bakker, van Rijswick, & Kundzewicz, 2016). However, effective FRM requires more than addressing technical issues or technological upgrading. It also requires efficient governance strategies guided by a sound institutional approach that includes effective cooperation between government agencies. Therefore, successful flood risk governance requires strong multi-agency collaboration to deal with a variety of activities at multiple stages of the FRM cycle (Sulaiman et al., 2019).

Effective flood risk governance needs to include resources, responsibilities, instrumental approaches, goals, networks of actors and scales that allow action and interaction (DROP Governance Team, 2013). Alexander et al., (2016) note that successful governance of flood risk must consist of a cycle of networking actors, regulations, resources, discourses and coordinating multi-level strategies. It also requires a combination of interventions, from prevention, mitigation and security, to warnings, evacuations and recovery, covering policy areas such as town planning and building requirements, water management, land use planning and civil protection (Lindgren & Persson, 2010; Pettersson et al., 2017; Schmidt, 2013).

However, for several decades, there has been criticism of Malaysia's governance of FRM. In particular, Chan (2015b, 2015a); Chan & Parker (1996); Leigh & Low (1978) and Shafiai & Khalid (2016) have criticised the country's FRM approach as being predominantly reactive; that is, the government only acts after a disaster has occured and lack mitigation policies to prepare for future. These criticisms are supported by CPPS (2017), which argues that current FRM measures are reactionary, rather than preventative. In addition, Chong & Kamarudin (2018) describe three major challenges faced by Malaysia's disaster agencies as (1) disproportionate disaster management preparation efforts between top-down and bottom-up strategies, (2) a lack of collaboration along the overall disaster relief continuum and a greater focus on disaster emergency response and (3) lack of preparedness for long-term (post-disaster) recovery, resulting in a lack of community and stakeholder responsiveness to disasters.

Saifulsyahira et al. (2016) found that flood management governance in Malaysia is in need of significant improvement. They recommend that all flood-related agencies work together to develop a general flood policy that integrates all relevant agencies. Apart from Directive No. 20, Malaysia has no laws or policies that specifically address the flood issues needed to regulate flood prevention, EC sitting and preparation measures. However, there are many other laws, rules and regulations that can be applied directly or indirectly to flood issues. Among these are the Drainage Works Act 1954, the National Land Code 1965, the Water Act 1920, the Local Government Act 1976, the Land Conservation Act 1960, the Town and Country Planning Act 1976, the Environment Quality Act 1974, the Irrigation Areas Act 1953, the National Forestry Act 1984 and the Uniform Building By-Laws 1984 (CPPS, 2017; Hamin et al., 2013; Mabahwi & Nakamura, 2020; Saifulsyahira et al., 2016).

However, the supervision of these acts is scattered across many government departments, each with its own responsibilities and functions (Mabahwi & Nakamura, 2020). Therefore, effective flood management requires good inter-agency coordination and cooperation (Saifulsyahira et al., 2016). As Priest (2019) concludes, FRM requires effective multi-level governance to better manage shared responsibilities. However, very little attention has been paid to the governance of flood risk in Malaysia, especially from the perspective of evacuation site. As the objectives below set out, this analysis fills that gap.

1.3 Research Objectives

The aim of this study is to identify the issues and challenges facing flood-related agencies when incorporating FRM with spatial planning to assess evacuation site suitability.

1.4 Research Questions

The following research questions were formulated for the study objective:

1. What are the issues and challenges facing flood-related agencies in achieving evacuation site suitability through integrated FRM and spatial planning?
2. What are the institutional barriers facing Malaysia's flood-related agencies?
3. What are the institutional barriers to achieving evacuation site suitability in Malaysia?

1.5 Research Significance

Evacuation shelters are the most effective means of protecting citizens in dangerous areas and circumstances and for reducing the numbers of casualties resulting from disasters (Sritart, Miyazaki, Kanbara, & Hara, 2020). As a result, emergency shelter location and evacuation readiness are key factors in reducing vulnerability and increasing resilience to disaster risk. However, the unsuitable location of the ECs and disparities in the distribution of shelters are critical issues in real-time emergencies.

The goal of this study is to identify the issues and challenges faced by flood-related agencies when incorporating FRM with spatial planning to establish suitable evacuation sites. Therefore, in this thesis, I identify the issues and challenges faced by flood-related agencies and using GIS multi-criteria analysis, evaluate the suitability of flood evacuation sites. The aim of the study is to bring integrated spatial planning knowledge to the field of FRM with a view to securing safe sites for EC. Currently, securing safe locations for EC is neglected in the fields of spatial planning and FRM. In addition, FRM faces numerous multi-agency problems, hindering its collaboration with spatial planning.

Therefore, this study also serves as a starting point for decision-makers to implement new policies and programmes that include EC sites in integrated spatial planning and FRM decision-making. Because the concept of governance has become an important element of urban planning, analysing the challenge facing flood-related agencies in the dynamic governance of FRM and spatial planning is also essential to identifying those areas where substantial change is required. Government is the leading governance body in the policy formulation and evacuation process. The evacuation and emergency planning aspects of FRM are carried out within the framework of specific community and disaster management governance structures. This study provides a basis for government and other stakeholders to work together to develop effective and efficient strategies for incorporating secure evacuation site elements into spatial planning.

1.6 Research Scope and Limitation

In the last 50 years, urban planning that could be described as designing cities with foresight for the future has undergone significant changes as urban areas have been increasingly exposed to major disasters (Celikbilek & Sapmaz, 2016). Now, the most important elements in the planning of disaster resilient cities are precaution and risk reduction (Celikbilek & Sapmaz, 2016), which, in the context of this thesis can be interpreted as ensuring the safe location of evacuation sites.

This study determined the 'safe location of evacuation areas' by examining the site suitability of ECs with a focus on geo-spatial multi-criteria. This is because the decision-making criteria for selecting suitable EC sites are geographical, making the site selection process a spatial decision-making challenge (Rikalovic, Cosic, & Lazarevic, 2014). Spatial decision-making issues also call for the testing of many alternative criteria, since spatial decisions are multi-criteria in nature (Rikalovic et al., 2014).

This study focused on EC site selection in Kuantan District which, under National Physical Plan 3 (NPP3), is listed as a district at high risk of flooding and where, as defined by the Kuantan Local Plan 2035, the majority of residential neighbourhoods are flood risk areas (Majlis Perbandaran Kuantan, 2019a, 2019b). On several occasions in the past, ECs in Kuantan have been inundated and evacuees have been forced to relocate elsewhere. Despite this, to the author’s knowledge and based on an extensive literature review, no previous research has examined the suitability of ECs in the area. This indicates the need to examine the suitability of existing flood shelters in Kuantan in order to increase the area’s resilience to flooding.

This is a study in flood risk governance, with a focus on the institutional challenges faced by flood-related agencies. In the face of an increased number of flood events, local authorities have, among other things, prioritised the provision of emergency shelters for affected populations (Aminzadeh, 2007; Melgarejo & Lakes, 2014), as the construction of flood shelters or urban EC is an efficient way to increase societal resilience (Zhao et al., 2017). In addition, minimum EC requirements should be subject to government regulation and supervision. If the roles and responsibilities of the organisations involved are not clearly defined and understood, the quality of the living environments in ECs can be easily compromised with unintended adverse health and psychological effects on evacuees (Kako, Steenkamp, Ryan, Arbon, & Takada, 2020). In any crisis, such as a severe flooding event, emergency response and the provision of safe evacuation and/or temporary shelter, the priority and main concern of any government (Padlee et al., 2018). In Malaysia, government agencies are responsible for providing safe areas, temporary shelters and assistance to flood victims (Padlee et al., 2018). Therefore, recognising the structural issues that exist among relevant stakeholder is very important to improving flood preparedness and resilience.

In short, the scope of the study was divided into the following research areas:

1. Flood risk governance: From the perspective of evacuation site suitability, the study explores the institutional challenges facing flood-related agencies in the incorporation of spatial planning into FRM;
2. Case study: The site suitability study of ECs in Kuantan, Malaysia was conducted and the issues facing flood-related agencies Kuantan were explored.

1.7 Research Design

A research took a mixed-methods approach that consisted of qualitative and GIS-based analyses. Using this approach, spatial data can be used with other types of evidence to triangulate and better understand complex phenomena (Jung & Elwood, 2010; Teixeira, 2018). GIS is a digital technology that integrates hardware and software for the analysis, storage and mapping of spatial data, allowing users to visualise maps and the geographic aspects of data, including the locations or spatial concentrations of certain phenomena (Teixeira, 2018). In this study, GIS was used to investigate the spatial aspects of evacuation. These findings were integrated with qualitative analysis to identify the issues and challenges faced by flood-related agencies in determining EC site suitability.

1.7.1 Data collection

The study made use both primary and secondary data. Primary data consisted of face-to-face interviews with 27 officials from Malaysian flood-related government agencies conducted in February 2019 and January 2020, and phone interviews with three government officers conducted in July 2020. The interviewees were from the Department of Welfare Kuantan, the Department of Irrigation and Drainage Malaysia (federal, state and district levels), the National Disaster Management Agency (NADMA), the Police Department, district councils, the Malaysia Civil Defence Force, land and district offices, the Fire and Rescue Department, PLANMalaysia, the National Hydraulic Research Institute of Malaysia (NAHRIM), Storm Water Management and Road Tunnel (SMART) and Local Authorities. The February 2019 and July 2020 interviews were unstructured and the January 2020 interviews were conducted using a semi-structured questionnaire. The former provided a more in-depth understanding of participants' perceptions, motivations and emotions (McCombes, 2019).

A site visit to Kuantan Pahang was also undertaken to determine the spatial location of ECs. PLANMalaysia and the Department of Irrigation and Drainage provided GIS-based spatial data for EC site suitability analysis. In addition, secondary data were gathered through a systematic literature review of government reports, research papers, journals and books.

1.8 Analysis Technique

Qualitative thematic analysis and GIS-based analyses were employed.

1.8.1 Qualitative thematic analysis

This study adopted a qualitative method that used thematic analysis. This is a suitable interpretation method that allows the researcher to gain an insider's view of the topic under investigation (Braun & Clarke, 2006). Qualitative methods are used to answer questions about experience, meaning and perspective, usually from the standpoint of the research subject or participant (Hammarberg, Kirkman, & De Lacey, 2016). Qualitative thematic analysis is a method for determining, analysing and reporting themes within a text and is useful for theorising across many cases and for finding common patterns among research participants (Fereday & Muir-Cochrane, 2006; Mohamed, Ragab, & Arisha, 2016; Riessman, 2005). This technique enables the researcher to understand the meanings behind respondents' statements according to their particular contexts (Joffe & Yardley, 2004; Mohamed et al., 2016). The qualitative approach adopted in this study allowed for a comprehensive understanding of flood risk governance.

The interview data were analysed, classified and coded to establish relevant themes for further discussion. The results were considered reliable because general consistency was found across the stakeholder responses. The themes identified were authority, collaboration, cooperation, human resources, logistics, funding and communication.

In addition, a content analysis of government policies was conducted. This research technique is in the family of qualitative thematic analysis and is used to assess the existence of certain words or themes in texts or text collections. Researchers measure and examine the existence, meanings and relationships of certain terms and concepts, and then draw inferences regarding the messages within texts, and the author(s), audiences, communities and time of which they are a part (Colorado University, 2004).

1.8.2 GIS-based analysis

The study integrated GIS analysis with the analytic hierarchy process (AHP) to analyse evacuation site suitability. The GIS-based site suitability analysis was formulated using multi-criteria analysis. Site suitability multi-criteria analysis is a process that combines and transforms spatial and non-spatial data (input) into a resultant decision (output). Multi-criteria methods can be incorporated with GIS to allow for a combination of both data and value judgements (Mighty, 2015). Multi-criteria procedures (or decision rules) define a relationship between input and output layers/maps and include the utilisation of geographical data, decision-maker preferences and the manipulation of data and preferences according to specified decision rules (Malczewski, 2004; Mighty, 2015).

Studies by Mendoza (2000) and Mighty (2015) emphasise the importance of performing GIS multi-criteria site suitability analysis because such an assessment is inherently a multi-criteria problem; that is, land suitability analysis is an evaluation/decision problem involving multiple factors. Therefore, a robust criteria assessment is required to ensure accurate and informed decision-making, which includes AHP (Malczewski, 2004; Mighty, 2015). AHP provides a benchmark on the decision-making hierarchy using a predefined reference scale, the factors affecting decision-making and the importance of decision points with regard to those factors. Value variations can thus be converted into percentages of decision points (Şentürk & Erener, 2017). In addition, GIS was used in this study to perform a network service area. Service area analysis can be used to determine accessibility around any road network location within a certain time limit. The analysis helped to determine accessibility to evacuation shelters within 15 minutes walking distance to explore where the shelters could be reached by foot during the evacuation process.

1.9 Thesis Structure

The thesis is structured as follows:

1. Chapter 1: Introduction

Chapter 1 explains the study background, and includes the problem statement, the study objectives, the research questions, the significance of the research, the scope of study and a brief outline of the research design.

2. Chapter 2: Literature review

Chapter 2 systematically reviews existing research related to evacuation site suitability, spatial planning and FRM. It then formulates the conceptual framework of the current study.

3. Chapter 3: Issues and challenges facing flood-related agencies in Malaysia

Chapter 3 examines flood risk governance by conducting a content analysis of Malayisa's three-tier spatial plans Malaysia: the National Physical Plan, the State Structure Plan, and the Local Plan. Qualitative thematic analysis was conducted on flood-related agencies to identify the issues and challenges they face.

4. Chapter 4: Multi-criteria site suitability analysis and evacuation centre issues facing flood-related agencies in Kuantan

Chapter 4 presents a GIS-based multi-criteria site suitability analysis of ECs and the agency barriers to achieving EC site suitability in in Kuantan, Malaysia.

5. Chapter 5: Discussion

Chapter 5 discusses the findings from Chapter 3 and Chapter 4.

6. Chapter 6: Conclusion and recommendations

Chapter 6 concludes the study and provides recommendations for future research.

CHAPTER 2

LITERATURE REVIEW

2.1 Evacuation Site Suitability

Site suitability is the process of understanding existing site qualities and factors, to determine the location of a particular activity (Jain & Subbaiah, 2007). The preparation of evacuation areas and emergency response actions is the most important factor affecting any metropolitan area's vulnerability to flooding (Kawakami, Shen, Pai, Gao, & Zhang, 2013). Determining site suitability complements disaster preparedness as part by building of disaster resilience (Cavallo, 2014).

Minimum EC specifications should be controlled and supervised by governments, humanitarian agencies and the other organisations that prepare, set up and operate ECs. If the functions and duties of the organisations concerned are not clearly stated and recognised, the quality of the spaces within EC can have adverse health and psychological impacts on evacuees (Kako et al., 2020). In any crisis event, such as extreme flooding, emergency response and the provision of safe evacuation and/or temporary shelter should be the priority of any government (Padlee et al., 2018). In Malaysia, the responsibility for providing safe places, temporary shelters and aid to flood disaster victims lies with the Malaysian Disaster Preparedness Centre (MDPC). Among MDPC stakeholders are the National Security Council and other government agencies (Padlee et al., 2018). Therefore, identifying the issues and challenges facing relevant stakeholders is very important for adequate disaster preparedness and mitigation.

Kolen and Helsloot (2014) point out that when people leave potentially exposed areas or move to relatively safe places, such as shelters on high ground, they are less vulnerable to flooding. The close relationship between safe places for evacuation and resilience is corroborated by Zhao et al. (2017), who argue that determining optimal shelter locations is essential in improving urban resilience. Meanwhile, Dalipe (2020) links ECs with disaster resilience by arguing that safe shelters are indicative of a community's capacity for response and recovery. Theodora (2020) argues that comprehensive FRM of evacuation areas that incorporates spatial planning, or vice versa, enhances resilience.

2.1.1 Definition of evacuation

'Evacuation centre' (EC) usually refers to a temporary form of housing for communities affected by disasters (Kako et al., 2020) and is first-call temporary living space for people forced to evacuate their homes. ECs need to be secure and have basic standards of living and care for the duration of a person's stay (Kako et al., 2020).

In the Malaysian context, and EC is a building or area declared by the District Disaster Management Committee as a relief shelter for disaster-affected people (Jabatan Kebajikan Masyarakat, 2016). The building or area must be equipped with basic amenities, such as living and sleeping space, clean water supply, electricity, and personal care facilities, all of which are safe to be use (APM, 2019; Jabatan Kebajikan Masyarakat, 2016). ECs in Malaysia are usually located in community halls and schools and are chosen based on their location (Padlee et al., 2018) and the services available in these facilities.

2.1.2 Evacuation site suitability criteria

In integrated FRM, emergency management helps to mitigate flood risk by decreasing the magnitude of hazards, preventing the exposure of individuals, their property and their activities to flooding and minimising the susceptibility of flood-prone communities (World Meteorological Organisation, 2011). When choosing the most suitable solution with the least risk, interrelated flood mitigation and emergency planning are required (Dzulkarnain, Suryani, & Aprillya, 2019). For instance, the structural characteristics of dams and reservoirs can reduce the severity of flooding downstream. In other words, emergency planning must consider the operation of water storage and retention facilities, including urban storm water retention basins (World Meteorological Organisation, 2011).

Many studies have examined the different stages of FRM including mitigation, preparedness, response and recovery (Zhao et al., 2017). An indispensable element of the preparedness phase is identifying emergency locations. Such locations serve two primary functions: they provide temporary shelter where evacuees can be safe from secondary damage, and they allow first responders to efficiently conduct rescue operations (Zhao et al., 2017). Ensuring that affected people are evacuated to a safe location is an essential part of urban resilience planning. Therefore, feasible and strategically planned evacuation shelter locations are critical.

One important evacuation preparedness activity is determining the spatial distribution of potential evacuees. This is directly related to the rationality of shelter location and evacuation efficiency and whether urban shelters can provide refuge all evacuees at a reasonable distance and time during a disaster event (Chen, Fang, Zhai, Wang, & Zhang, 2020; Chen et al., 2018; Yu, Wen, & Jiang, 2015).

Shelter demand is estimated through a superposition analysis of potential disaster-affected areas and population distribution (Chen et al., 2020; Chen, Zhai, Fan, Jin, & Xie, 2016). Using census data, Chen et al. (2020, 2018) used current population distribution to predict street-level population density distribution for future urban planning. They then performed a risk analysis to identify areas that may be affected by disasters. Finally, they obtained a shelter demand estimate by using GIS to overlap the results of these two processes.

According to Chowdhury, Watkins, Rahman and Karim (1998), a practical way to mitigate flood risk in developing countries is to build flood shelters in settlements that are highly flood-prone in order to optimally protect planning units and minimise the overall risk to vulnerable communities. This implies that flood shelters should be located within an existing residential areas. Studies by Sanyal and Lu (2009), Anhorn and Khazai (2015) and Kusumo (2016) emphasise the need to construct emergency shelters within a 1 km radius of every residential area. Kusumo (2016) found that the majority of respondents preferred to evacuate within 1 km of their respective residential area and did not favour

ECs beyond that radius. Analysing the radius of ECs from settlements helps to determine the EC coverage and adequacy for affected populations.

At a very basic level, flood ECs should not be built in areas at high risk of inundation and they should be located outside of flood-prone areas, including sites within a 100-year floodplain. These guidelines are supported by many international agencies including the American Red Cross (2018), FDEM (2018), FEMA (2013, 2015), the International Federation of Red Cross and Red Crescent Societies (2011), Sphere (2011, 2015) and The Sphere (2018). Shelters in flood-prone areas will be susceptible to damage from the hydrostatic and hydrodynamic forces associated with rising flood waters (FEMA, 2013, 2015) and may result in additional risk to evacuees (Kar & Hodgson, 2008).

In addition, the area around shelters should not be exposed to potential river flooding that could inundate roadways and impede shelter access (Framingham & Teasley, 2012). Kongsomsaksakul, Yang and Chen (2005) and Kusumo (2016) found that the ideal distance of ECs is within 1 km outside of flood-prone areas. More importantly, the distance of flood-prone areas to evacuation shelters is one of the criteria for safe and suitable EC location (American Red Cross, 2018; FEMA, 2015; Kar & Hodgson, 2008).

The elevation and slope of the EC site must also be considered due to risk exposure and hazard vulnerability (Sabri & Yeganeh, 2014). Kusumo (2016) and UNHCR (2007) have further identified topography and elevation as important characteristics of EC placement. Chen et al. (2018) argue that flood level, terrain and elevation should be the main criteria for determining EC site suitability, as topography affects flood severity, flow size and direction (Kia et al., 2012; Sabri & Yeganeh, 2014; Saini & Kaushik, 2012).

Land at lower elevations is generally more affected by flooding than higher land and water remains for longer on lower land (Kia et al., 2012; Saini & Kaushik, 2012). Low-lying areas are the most vulnerable to flooding because they are inundated quickly. Moreover, because of gravity, water flows towards low-lying areas, creating a significant impact (Sabri & Yeganeh, 2014). Therefore, an important safety criterion when choosing EC sites is that are built on land at higher elevations, or that ECs are elevated through construction (FEMA, 2015; Gol-UNDP, 2006). The International Federation of Red Cross and Red Crescent Societies (2011), has set the standard for flood shelters to be located above the highest estimated flood level.

A number of scholars have emphasised topography and slope as important factors when considering the location of ECs (Geng, Hou, and Zhang, 2020; Hosseini, De La Fuente and Pons, 2016; Kilci, Kara and Bozkaya, 2015; Kusumo, 2016; Li, Nozick, Xu and Davidson, 2012; Trivedi and Singh, 2017; J. Xu, Yin, Chen, An, and Nie, 2016). ECs should not be situated on land with a slope gradient of 30 or higher to avoid the risk of landslides or mudslides (Melgarejo & Lakes, 2014; Sphere, 2011, 2015) and should be sited away from locations at risk of secondary disasters, such as rain induced landslides (Anhorn & Khazai, 2015; Geng et al., 2020; International Federation of Red Cross and Red Crescent Societies, 2011; Sphere, 2015; Wei, Li, Li, Liu, & Cheng, 2012).

In addition, ECs should not be located on or near fault lines, and slopes should be between 2% and 4% and not exceed 7% (Geng et al., 2020; Kilci et al., 2015), although Kusumo (2016) argues that any slope should be less than a 5%. Most importantly, in 'Guidelines for Creating Barrier-free Emergency Shelters for Disaster Preparedness and Disability Nepal' (Handicap International-Nepal Programme, 2009), the slope criterion for shelters is clearly defined as not exceeding 1:15; to ensure that individuals with disabilities and wheelchair users can easily access ECs.

In addition to topography, land use also determines suitable spatial locations for ECs (Kusumo, 2016; Sanyal & Lu, 2009; UNHCR, 2007). Shelters should be built far from hazardous facilities, such as industrial areas, to reduce the risk of potentially fatal incidents, such as fires or explosions (Kusumo, 2016; Wei et al., 2012). Existing research supports this, emphasising that prospective evacuation areas should not include locations prone to other threats or secondary hazards, such as fire caused by the storage or use of dangerous materials (Anhorn & Khazai, 2015; Tai, Lee, & Lin, 2010; Wei et al., 2012). A distance more than 3 km from landslide prone areas is recommended for emergency shelter location (Chen et al., 2018; Q. Liu, Ruan, & Shi, 2011).

In addition, the maximum distance that the at risk population must travel to reach the shelters must be considered (Lalane Nappi, Nappi, & Souza, 2019). Shelter accessibility is a major concern in the field of evacuation modelling (Chen et al., 2018;

Cova & Church, 1997; Kongsomsaksakul et al., 2005). The FDEM points out that populations tend to evacuate to shelters with easy access to evacuation routes (FDEM, 2018). Thus, proximity to highways and evacuation routes is an important factor in evacuation site suitability analysis (Kar & Hodgson, 2008). Wei et al. (2012) and Unal and Uslu (2016) recommend that the time it takes to walk to emergency shelters or evacuation areas must be within 5 to 15 minutes.

However, the selection of multiple criteria should be the principal consideration when evaluating urban EC site suitability. The selection of evaluation indicators should integrate domestic and international experience, the most up-to-date research and the natural geographical features of the area under consideration. Therefore, as Wang (2019) points out, there is no universal 'one size fits all' evaluation model for EC site suitability.

To sum up, any analysis of EC site suitability must ensure that the location is outside areas prone to flooding, situated on a slope preferably between 2% and 5% and not exceeding 7%, built on elevated land, far from industrial areas, at a distance greater than 3 km from areas at risk of secondary disasters such as landslides accessible on foot within 15 minutes from residential areas and within a 1-km radius of settlements, thus ensuring maximum protection for the affected population.

2.2 Planning in Malaysia

Spatial planning in Malaysia is enforced by three-tiers of government: the federal government, the state governments and local authorities consisting of city, municipal and district councils. The powers of each level of government are enshrined in the Acts of the Constitution and Parliament. Planning problems are on the concurrent list, meaning that responsibility lies with both the federal and state governments. At the federal level, PLANMalaysia, which is part of the Ministry of Housing and Local Government, is responsible for formulating and administering all national policies pertaining to town and country planning. Land is a state issue in Malaysia. Therefore, land use planning is a state concern, and the federal government plays a supervisory role in overall land use planning activity. At the state level, State PLANMalaysia is an advisory body to the state governments of Peninsular of Malaysia. At the local level, local authorities are responsible for carrying out the duties of town and country planning as set out in the Local Plan. Each local authority is the planning authority for its jurisdiction and is responsible for coordinating, planning and developing all lands within the boundary of its local plan (Ahmad, Mohd, Maidin, Zainol, & Noor, 2013).

Malaysia's spatial planning system is governed by the Town and Land Planning Act of 1976 (Act 172). The land use planning system implemented by Act 172 expresses the intention of the authorities to initiate, promote and monitor physical, economic, environmental and social change in a given region (Asmawi, 2007; Omar & Leh, 2009). The act provides the legislative framework for the formulation and implementation of development plans. Development plans drafted under Act 172 provide the legal structure for governing and managing land use and development within the jurisdictional area of those plans. PLANMalaysia is responsible for administering Act 172 and is an advisory body responsible for the planning of pertinent issues.

Malaysia practices a plan-led development system (Ahmad et al., 2013). To ensure successful planning, Act 172 requires the development of plans at different spatial and administrative levels (Yaakup, Bakar, & Sulaiman, 2009). These levels include the National Physical Plan (NPP), which creates strategic policies that determine the general direction and pattern of national physical development, the State Structure Plan, which describes policies and plans for the development and use of land in each state, the Local District Plan (RTD), which translates state policies at the local level, and the Special Area Plan, which is a detailed plan prepared by the Local Planning Authority concerning areas of special interest. Table 1 shows the hierarchy of development systems in Peninsular Malaysia.

At the national level, strategic development planning is guided by the Five Year Malaysia Plan, the NPP and sectoral policies approved by the Cabinet (Federal Department of Town and Country Planning, 2016) (see Figure 1). The NPP is formulated in accordance with the goals of urbanisation and other related sectoral policies (Ahmad et al., 2013). Act 172 describes the NPP as a written statement setting out strategic policies for the purpose of determining the general directions and trends for the physical development of the country. It was established through a joint arrangement between the federal government and the states, and Federal PLANMalaysia is responsible for drawing up the plan.

Section 8(3) of Act 172 describes the State Structure Plan as a written statement setting out the policy and general proposals of the State Authority on the development and use of land in that State, including steps for the improvement of the physical environment, the improvement of communications, the management of traffic, the improvement of socio-economic well-being and the promotion of land use. Structure plans are drawn up by each State with that particular State serving as a main unit, while regional plans include projects involving two or more States and are prepared for areas which have priority interstate development problems that need to be addressed (Ahmad et al., 2013). In addition, at the state level, development is driven by the State Structure Plan and the sectoral policies developed by the respective state government, which take into account the strategic policies of the NPP (refer to Figure 1). Under Act 172, local district plans need to be updated to comply with state structure plan guidelines.

The Local Plan is a spatial plan translated from the framework of the State Structure Plan. Section 12(3) of Act 172 describes the Local Plan as a comprehensive land use plan, or map, accompanied by written statements describing regional growth and land use proposals (Ahmad et al., 2013). Local district plans are usually designed for urban areas due to the ongoing pressure exerted on these areas from real estate developers and other construction companies (Khailani & Perera, 2013). A Special Area plan is a development plan for execution, such as a development action plan in the form of a layout plan or a management plan. This is accompanied by comprehensive implementation specifications and an action schedule for development. Such development strategies are concentrated on urban development in the LPA areas of authority and on the needs of local communities.

Currently, efforts are underway to integrate Malaysia's Local Plans with disaster resilient management by identifying hazard types, levels of hazard risk and appropriate measures to reduce urban vulnerability and increase resilience (Rameli, 2020). PLANMalaysia (formerly the Town and Country Planning Department) has formed the

Land Use Planning Appraisal for Risk Areas in Malaysia National Urbanisation Policy, the main objective of which is to provide a holistic approach to sustainable development through a multi-sectoral approach that seeks to improve safe urban planning initiatives, develop robust city programmes and create public awareness campaigns. Other goals of the policy include land use planning protection and sustainability that incorporate appropriate disaster mitigation strategies, general recommendations for the control of risk-prone development control and mitigation measures for affected areas (Mohamad Amin & Hashim, 2014; Shaw et al., 2009).

Meanwhile, the Tenth Malaysia Plan (2011–2015) identified governance as the key priority in tackling climate change and environmental issues. In the previous Malaysia Plan (2006–2015), the government highlighted the management of environmental distress caused by climate change, while the current Eleventh Malaysia Plan (2016–2020), emphasises the strengthening of a climate-resistant growth system and the fostering of climate change and natural disaster resilience (Jamaludin & Sulaiman, 2018). Nevertheless, while the Malaysia Plan includes climate resilience, its primary spatial plans (Local Plans and State Structure Plans) remain limited to identifying flood-prone and flood zoning areas and exclude evacuation initiatives.

Table 1: Plan-led Development Systems in Peninsular Malaysia

Planning level (hierarchy)	**Development plan**	**Responsible agency**
Federal Government	National Physical Plan (NPP)	PLANMalaysia (Federal)
Region	Regional Plan	Regional Planning Committee
State Government	State Structure Plan (SSP)	PLANMalaysia (State)
Local Government (District)	District Local Plan (DLP)	Local Authority (District)
Local Government (District)	Special Area Plan (SAP)	Local Authority (District)

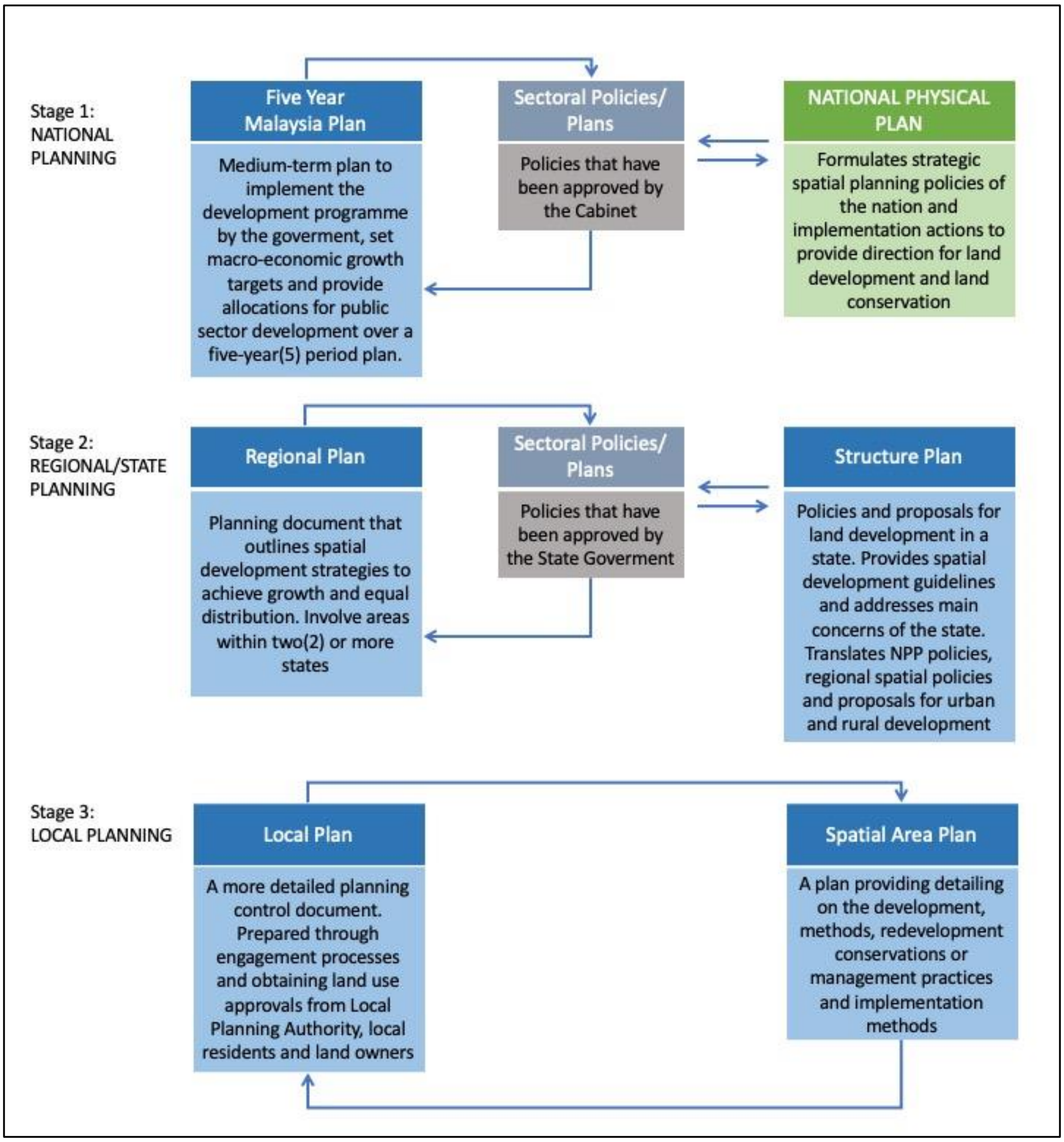

Figure 1: National Development Planning Framework

Source: National Physical Plan 3, 2016

2.3 Incorporating Spatial Planning into FRM Evacuation Planning

Because of climate change, flood events have increased and have become less predictable. The risk of flood exposure has also increased due to demands for development and urbanisation (Larsen, 2009; Poelmans et al., 2011; Ran & Nedovic-Budic, 2016). Existing research shows a significant association between the effects of climate change and urban development on flood risk (Löschner et al., 2017; Zahari & Hashim, 2018). Population growth, especially in urban areas and along rivers and coasts, has increased the likelihood of land overuse in flood-prone areas and progressively exposed people and assets to flooding (Jha, Bloch, & Lamond, 2012; Ran & Nedovic-Budic, 2016; UFCOP, 2017).

Given current climate change predictions and the impact of urbanisation on increasing flood risk, rigorous multidisciplinary collaborative research is needed to address cross-cutting flood issues (Meng et al., 2019; Sayers et al., 2009; Storbjork, 2007; Ward et al., 2013). In the context of climate change, the incorporation of spatial planning with FRM has recently gained attention as an approach to mitigate flood risk (Ran & Nedovic-Budic, 2016). Cilliers (2019) argues that disaster risk managers should use spatial planning as a tool to mitigate the detrimental effects of flooding.

In 1969, Keeble (in Acheampong, 2019) defined spatial planning as the art and science of organising the use of land and the siting of buildings and communication routes to ensure the maximum practicable degree of economy, convenience and aesthetics. In 1997, Healey redefined it as a set of governance practices for developing and implementing strategies, plans, policies and projects and for regulating locations, timing and forms of development. In addition, Kidd (2007) and Larsson (2006) (in Ran & Nedovic-Budic, 2016) have defined spatial planning as a tool that arranges physical space and guides future activities within that space according to suitability and other accepted principles. Simply put, spatial planning is generally referred to as land use planning or urban/regional planning (Ran & Nedovic-Budic, 2016).

Spatial planning anchors national visions, objectives, initiatives, strategies and plans for human settlements of various sizes and at different scales. Most countries implement spatial planning to identify and achieve goals such as organising the physical manifestations of sectoral policies and ensuring spatial equity in the distribution of development outcomes while simultaneously addressing the critical contradictions between socioeconomic growth and environmental conservation. Spatial planning profoundly affects the internal layout and functional organisation of land use and its city- and town-level regulation, and ultimately shapes the conduct of the social and economic activities observed in human settlements (Acheampong, 2019).

The integration of FRM and spatial planning is an increasingly important aspect of flood management and prevention and is now seen as a way to enhance urban resilience against growing flood hazards (Meng et al., 2019; Theodora, 2020). In addition, spatial plans that incorporate the management of flood risk are key references to guide land use planning that reduces risk from hazards (UFCOP, 2017). For instance, spatial plans can delineate flood protection and development zones, establish emergency routes and facilities and help ensure that infrastructure investment is mindful of flood risk (UFCOP, 2017).

Spatial planning also plays an important role in improving emergency response actions (Neuvel & van den Brink, 2010). Many pre-disaster studies have highlighted the value of incorporating safety risk issues into spatial planning (Caragliano & Manca, 2007; Cruz, Steinberg, & Vetere-Arellano, 2006; Neuvel & van den Brink, 2010). Sutanta et al. (2010) argue that spatial planning that includes disaster management prohibits future development in disaster-prone areas and protects areas essential to emergency response from detrimental development efforts.

Neuvel and van den Brink (2010) highlight the interrelationships between spatial planning and emergency response activities and, in particular, their influence on the physical characteristics of evacuation areas, such as their location, as these interrelationships and activities greatly influence the possibilities for emergency response. For example, the presence of access routes can increase the speed and efficiency of emergency response. However, if the possibility for emergency response in an area is limited, alternative locations or additional physical measures, such as better emergency access, may be sought. Therefore, collaborative planning and action by spatial planners and emergency managers can increase citizen safety and enhance the coherence of safety measures (Neuvel & van den Brink, 2010).

Theodora (2020) argues that it is important to ensure that flood preparedness and flood management plans are correlated with spatial planning for every locality. That study found that emergency management and evacuation plans should not be drawn up without considering the spatial planning process. From the perspective of spatial planning, the management of flood risk emergency preparedness and response should include the mapping of open spaces or evacuation areas where people can safely assemble during an emergency, in addition to the mapping of danger zones at settlement, city, region and national spatial scales (Theodora, 2020).

Spatial allocation assessment is a fundamental preliminary step in the spatial designation of urban shelters (Yu et al., 2015). Therefore, it is also essential that spatial planning-FRM integration classifies evacuation areas or shelters according to suitability criteria, such as strategic location and appropriate dimensions, availability of roads and emergency routes to and within flood zones, availability of community shelters and health facilities at multiple locations within or near neighbourhoods and the availability of strategic open spaces for response and relief operations, temporary shelters and medical field stations (UFCOP, 2017). High standard levees, or super levees, in Japan are an example of the potentials of integrated spatial planning and FRM in the creation of large evacuation areas (Mabahwi & Nakamura, 2019; Mabahwi, Nakamura, & Bhattacharya, 2019; Nakamura, 2016).

2.3.1 Super levee projects in Tokyo

The Eastern Lowland Districts of Tokyo are at risk of urban flooding because the land in these districts is approximately 5.1 metres below the Arakawa Pail. Since lowlands are prone to flooding, in 1987, the River Council of Japan proposed a solution to protect the lower 58.2 km of the river by constructing high standard levees, or super levees (Mckean, 2013). In a report entitled 'Recommendations on Policies for Protection from Extreme Floods', the River Council proposed a policy for the protection of specific urban areas from extreme flooding (Arakawa Karyu River Office, 2007). These were areas with significant and concentrated property and business functions, such as Tokyo. The policy applied to extreme floods that exceed the design levels of regular flood protection measures (Stalenberg & Kikumori, 2009; Takahasi & Uitto, 2004). This specific policy included super levees projects. The high standard levee improvement project (super levees project) started in Tokyo and Osaka, along the following six large rivers: the Tonegawa, Edogawa, Arakawa, Tamagawa, Yodogawa and Yamatogawa (Nakamura, 2016).

From 1996 to 2010, super levee projects were carried out in 13 districts and, since 2011, projects continue in four to seven districts. As of March 2017, 120 km of river had been improved with super levees. Approximately 14 km (around 12%) of the basic cross-section of the high standard levee. The section where the form is secured is about 3.3 km (about 2.8%), (Ministry of Land, Infrastructure, Transport and Tourism, 2017). The super levees maintenance projects conducted along Edogawa River, Arakawa River, Tamagawa River, Yodogawa River and Yamato River (Ministry of Land, Infrastructure, Transport and Tourism, 2017). Fourteen super levee projects have already been completed on the Arakawa River, at Shinsuna, Komatsugawa, Hirai, Hirai 7-chome, Senju, Odai, Odai 1-chome, Miyagi, Shinden, Shikahama, Kawaguchi, Kita-Akabane, Funado and Toda Koen.

Since low-lying areas are vulnerable to disaster, it is essential to thoroughly research and plan evacuation from such areas. The Cabinet Office of Japan emphasised that the evacuation methods described in the most recent hazard maps of each low-lying municipality were be inadequate in the case of evacuation delays due to public transportation congestion, or if the number of evacuees exceeded the capacity of each designated evacuation area (Nakamura, 2016). It also stated that it was necessary to examine other evacuation methods, such as temporarily evacuating residents to the upper floors of school buildings or to the upland areas created as part of the super levee structures (Nakamura, 2016).

Research by Nakamura (2016) found that, if Arakawa River breaches in Shinden District, which is a super levee area, residents in inundated areas can evacuate to safe areas in the neighbourhood on the condition that an appropriate evacuation system has been established. The study found that the number of estimated potential evacuees (11,280) at night exceeds the number of estimated night time evacuees (3,187), and the number of estimated potential evacuees (11,610) in the daytime exceeds the number of estimated daytime evacuees (2,148). In addition, the number of residents who can potentially evacuate to safe places within an inundated area is only 2,925 at night and 3,256 in the daytime. Without the super levee project, residents would face difficulties in evacuating to higher ground. In other words, the super levee has contributed to the creation of a large-scale neighbourhood evacuation area in Shinden District (Nakamura, 2016).

High standard levees have been built to withstand floods and earthquakes and are built in tandem with urban renovation projects (Arakawa Karyu River Office, 2007). Conventional levees are easily breached during massive flooding events that exceed reasonable forecasts. However, the construction of super levees includes raising the ground level of urban land along the river. Super levees are extremely wide and capable of withstanding extreme floodwaters. They are constructed to have a width 30 times that of their height. For example, a 10-metre-high levee will be 300 metres wide, with a gentle slope ratio of 1:30. Even if the river overflows during significant flooding, the flood waters will spill out over these gentle slopes, minimising damage to nearby urban areas and giving residents ample time to evacuate. Levee height is determined based on maximum flood water level (Luo et al., 2015; Takeuchi, 2002) and, on the Arakawa River, super levees are built approximately 10 metres high to protect Tokyo residents (Ministry of Land Infrastructure Transport and Tourism, 2017a).

Super levees must be constructed to provide easy access to the river, with embankments that link city streets to the riverbank up gently sloping hills with a 3% gradient. Unlike the steep climb required to reach raised levees, super levees allow for a more comfortable walk. They are also developed with emergency road access.

In addition, the levee back slope can be effectively used for urban development. Once the ground level has been raised, the steep banks of the existing levee are transformed into flat open spaces that can be put to use as public roads, parks and evacuation areas. The height of super levees also makes them suitable evacuation sites in the event of flooding (Arakawa Karyu River Office, 2007). The availability of these open space evacuation areas gives residents greater peace of mind during floods and other disasters.

Super levees open up skylines blocked by conventional levees, offering wide open views, reconnecting residents with the riparian environment and creating a pleasant urban living environment. The upgrading of conventional levees to super levees means that the embanked soil and the land around are resistant to flooding and earthquake damage (Nakamura, 2016).

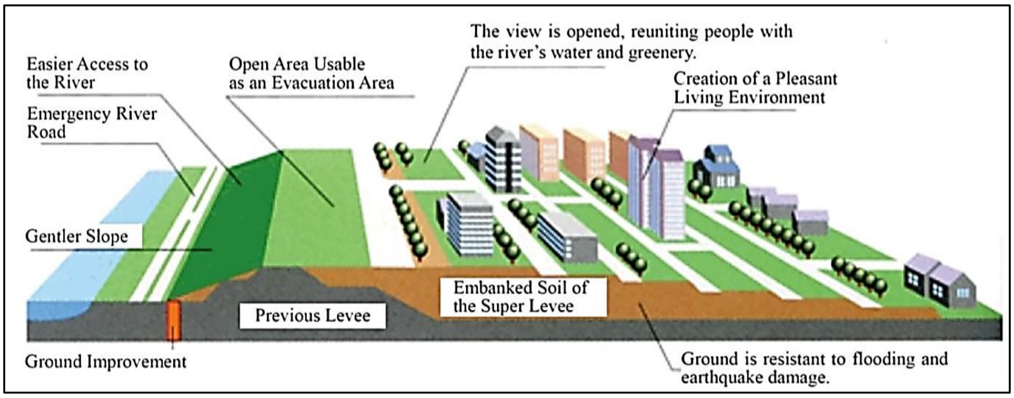

Figure 2: The concept of super levee

(Source: Arakawa-Karyu River Office, 2007)

Overflow, permeation and liquefaction are all problems that can be overcome by the construction of super levees. When floods are unexpectedly large in scale, conventional levees are at risk of breaching. However, super levees mitigate against breaching by allowing water to gently overflow down the levee slope. Conventional levees are also at risk of breaching due to permeation when flooding is on a large-scale. However, due to their greater width to height ratio, super levees avoid breaches caused by destabilisation (Ministry of Land, Infrastructure, Transport and Tourism, 2017c).

Furthermore, urban areas on soft ground can be damaged by the liquefaction caused by earthquakes. Super levees prevent such damage by stabilising the soil. The anti-overtopping function of super levees is due to the gradual slope at the backside of the river compared to the much steeper slope of normal levees. This reduces the water flow rate, thus reducing the likelihood of the levee collapsing due to overtopping (Ministry of Land Infrastructure Transport and Tourism, 2017c). However, the super levee is not intended to be effective when only 120 km of it has been completed. With the basic cross-sectional shape incomplete, the levees will continue to overflow, flood, and be at risk of permeation and liquefaction (Ministry of Land Infrastructure Transport and Tourism, 2017c).

Despite some sections of super levees being well-developed as upland evacuation areas, the remaining sections, that is, those areas that have not been improved by the construction of a super levee, remain at risk of flooding. In this case, there is the possibility that conventional levees will fail. Therefore, in a situation where the surrounding area is submerged, super levees can function as a base for rescue, transportation and emergency supply activities. Even in the event of a large-scale flood, therefore, a super levee cannot be overtopped and can, therefore, be utilised as a large upland evacuation area.

However, the residential zone of a super levee project will exist discontinuously for an extended period of time due to the promotion of urban development projects along the river. The difficulties associated with consensus building, project prolongation, large-scale compensation for removal, and the effects on surroundings, including sunshine exposure, are the main disincentives for the creation of super levees (Nakamura, 2016).

The Arakawa-Karyu River Office is responsible for the operation and maintenance of the Arakawa River and its super levee project. The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) has found that it is important to prepare for large-scale water disasters in advance, and it has struggled with creating its Disaster Prevention Action Plan, collecting important information regarding where, who and what to do in chronological order. Therefore, the Arakawa-Karyu River Office has set up a leading project called the 'Study Committee for Timeline (Preliminary Disaster Prevention Action Plan) Targeting the Arakawa Downstream Area'. The purpose of this project is to prepare for any situation where the Arakawa Downstream Right Bank collapses. The Timeline was formulated in collaboration with stakeholders, including railroad, electricity and telecommunications companies, municipalities and road managers.

In addition, the agency has created the 'System Consolidation for Utilising Disaster Prevention Facilities'. In this disaster-related system, any municipality in charge of a particular river, police, firefighting corps, and so on, can make effective use of disaster prevention facilities, including emergency roads for river areas and emergency ports (river stations) operated under the supervision of the Arakawa-Karyu River Office, as well as flood plans, in order to provide immediate life-saving or recovery services.

The Operational Council for Arakawa-Karyu Disaster Prevention Facilities was formed in 2011 for this purpose. The Council has developed the 'Arakawa-Karyu Disaster Prevention Facilities Utilisation Plan' which lays down guidelines for stakeholders' use of disaster facilities. Coordination between stakeholders can be improved to deal with disasters through ongoing consultation, by enhancing the plan and through joint training. In order to allow emergency ports to operate effectively in the event of a disaster, their use can be extended. The Promotion Council for the Utilisation of Tokyo Low Land Rivers is comprised of experts, local organisations and associations. It explores specific steps and undertakes social studies research to encourage utilisation at normal times.

2.4 Conceptual Framework

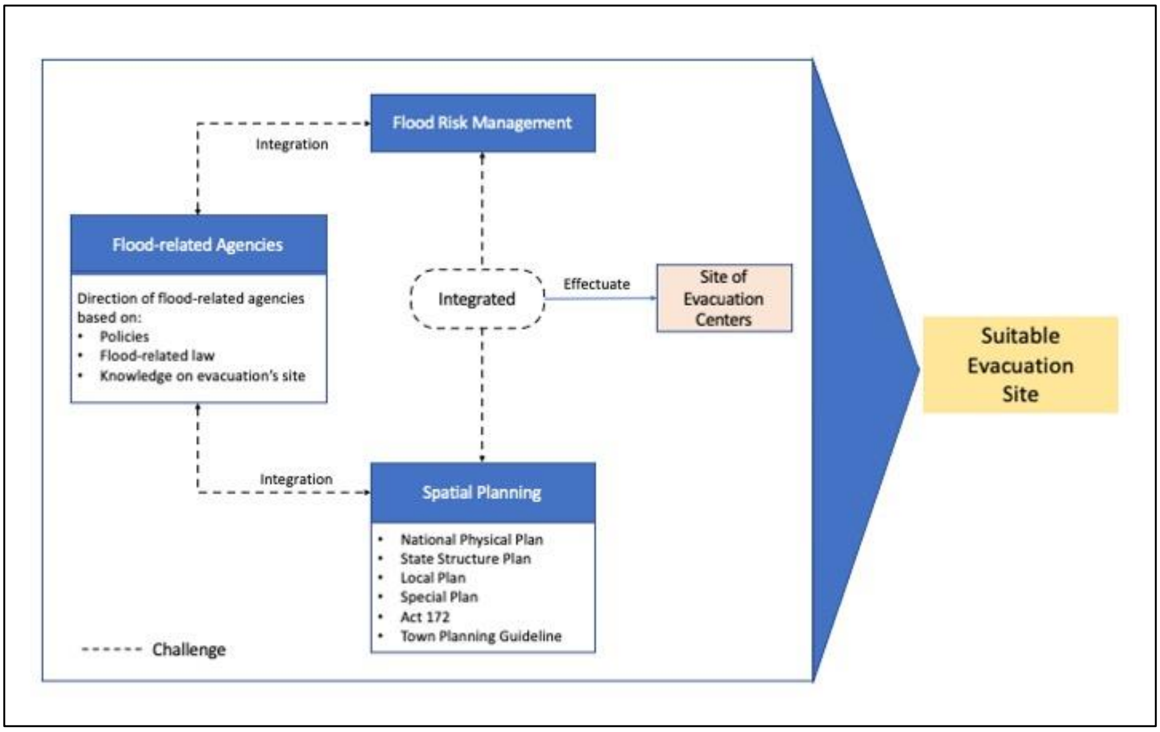

Figure 3: Conceptual framework

In a country, such as Malaysia, susceptible to heavy rainfall throughout the year, flood risk management (FRM) is critical in the event of a disaster, in order to reduce loss of life and limit the effects of the disaster (Wai & Rohani, 2017). The 'management' aspect of FRM is defined as the decisions and actions taken to evaluate, assess and attempt to minimise flood risk (Schanze, 2006). Therefore, FRM deals with a broad variety of concerns and activities, ranging from forecasting flood hazards, assessing their potential societal effects and developing risk reduction steps and tools. Due to this variety of aspects, FRM requires systematisation and integration (Schanze, 2006).

Given the wide range of tasks required of FRM, its implementation requires the effective collaboration of authorities at all levels of government, the private sector, non-governmental organisations and the public, as well as clear communications, and well-defined roles and responsibilities (Traver, 2014). The importance of collaboration in flood risk management is seen as a key point in the professionalism of FRM activities as there is a limit to what any single authority can do (Raungratanaamporn, Pakdeeburee, Kamiko, & Denpaiboon, 2014). Therefore, the government's ability to steer flood-related agencies in a given direction and to ensure collaboration is very important. The framework of this study is based on understanding the issues and challenges facing flood-related agencies in their attempts to steer FRM. The direction that these agencies take is based on national policies, flood-related laws and the knowledge of the officers in charge.

FRM in Malaysia takes a top-down government approach, with shared responsibility between federal, state and district governments. It is regulated by Directive No. 20 under the auspices of NADMA. Directive No. 20 is an executive order issued by the Prime Minister's Office that contains disaster management mechanisms for the periods before, during and after a disaster. Each government agency involved with a disaster must act according to the content of the executive order. Under the directive, there are five stages in the disaster management cycle: prevention, mitigation, preparedness, response and recovery. Each of these requires coordination, corporation and commitment between all flood-related agencies.

This study sought to understand the issues facing flood-related agencies in the integration of spatial planning with FRM. Disaster management defines and mitigates the form and extent of risk and provides guidelines for spatial planning activities. In this context, spatial planning is one of the most important elements of effective disaster management due to its ability to create resilience in the physical, economic and social environment (Celikbilek & Sapmaz, 2016). However, incorporating spatial planning into FRM is complicated, and its operationalisation remains a challenge (Meng et al., 2019).

Both spatial planning and FRM involve multiple actors with often conflicting interests that must be reconciled across fragmented policy domains (Cumiskey, Priest, Klijn, & Juntti, 2019). This is especially so in contexts where different non-governmental stakeholders are beginning to play critical decision-making roles and are, thus, establishing new networks of social actors (Theodora, 2020).

In addition to the various issues caused by the needs and practices of multiple stakeholders, the relationship between spatial planning and FRM is bound up within the complicated process of flood risk governance (Cumiskey et al., 2019). A number of studies have identified a range of institutional government agency barriers to integrating disaster management into spatial planning (Dąbrowski, 2018; Meng et al., 2019; Walker, Neil Adger, & Russel, 2015). Therefore, incorporating the governance insights of FRM into spatial planning remains a challenge, leading to planners underestimating the problems that arise from flooding (Carter, Kreutzwiser, & de Loë, 2005).

An integrated spatial planning and FRM approach must focus on understanding interdependencies across sector objectives and work within governance structures to manage those interdependencies. Systematically addressing challenges, such as the fact that FRM is typically outside the scope of the spatial planning sector, can ensure the recognition of wider causes and the need for potential solutions. In this way, integration could achieve more by jointly aligning objectives and policies, reducing duplication, managing trade-offs and promoting cooperation across interventions (Candel & Biesbroek, 2016; Cumiskey et al., 2019).

Flood-related agencies face many issues and challenges. A study by Beamon (2004), for example, reveals the challenges in coordinating relief supplies between agencies during disasters. Meanwhile, Shahid, Xinhai, and Muhammad (2014) claim that the challenge of inter-agency coordination during disasters is well known on the ground, but is a neglected area of research. Salmon, Stanton, Jenkins, & Walker (2011) argue that disaster agencies face challenges due to unpredictable outcomes, massive causality numbers, resource shortages, lingering side effects, disruption of public service, collapsed infrastructure, enormous time pressures, high stakes, highly interdependent tasks and communication breakdowns. In addition to these challenges, Malalgoda, Amaratunga, & Haigh (2016) found that disaster management agencies in Sri Lanka face issues of an inadequate legal framework, limited authority, outdated ordinances to support disaster risk reduction, lack of adequate tools, techniques and guidelines, human resource constraints, funding constraints and weaknesses in internal and external systems. These conditions are further aggravated by personal or organisational conflicts regarding authority, interest and motives.

Any study of spatial planning and FRM must consider these challenges to multi-agency flood risk governance. Alexander et al. (2016) emphasise that, in the pursuit of FRM, it is important to build flood risk governance relations between network actors, rules, resources and discourses. Besides governance capacity, policy and practice integration must be realised with tangible FRM outcomes (Cumiskey et al., 2019). Spatial planning can also influence crucial factors at multiple spatial scales, from local level plans to national or even international strategic plans (White & Richards, 2007; Wynn, 2005). Because of this, planning authorities generally have more power than flood risk agencies over land use planning and development in flood-prone areas (Ran & Nedovic-Budic, 2016; White & Richards, 2007).

To better understand the relationship between FRM and spatial planning and the impact of this relationship on evacuation siting, this study examined spatial plans. This is because Malaysia uses Collective Shelter as ECs, meaning that existing public halls and schools are gazetted as disaster ECs. Therefore, an analysis of the siting of ECs must also analyse the siting of schools and public halls, where decisions to use these facilities were finalised in the approval of the State Structure Plan and the Local Plan. This study explores the relationship between spatial planning and EC site suitability by exploring the land use and geo-spatial criteria of the study area.

In Malaysia, the spatial planning instruments that should incorporate aspects of flood risk reduction (in this case, evacuation) in site planning are the State Structure Plan, the Development Proposal Report, the Town and Country Planning Act 1976, the Local Plan, the Special Area Plan and the Town and Country Planning Department Planning Guidelines. Afida, Idrus, & Hashim (2016) have found that there is a need to enhance current urban planning reference tools and access to ensure that urban planning and town planning activities take into account flood risk mitigation. Following the 1995 amendment to the Town and Country Planning Act 1976, in which sustainable development became the central focus of all planning policies and plans, the practice of spatial planning in Malaysia has given greater prominence to environmental issues (Chee, Pereira, & Hashim, 2014).

However, aspects of FRM that should be considered in strategic planning have not been specifically integrated into either urban or rural area spatial plans at either state or local levels. A content analysis by Chee et al. (2014) of national, state and local spatial plans indicates that the overall quality of plans is higher at the national level, but that quality decreases down the scale to lower-level plans. They also found that equal attention has generally been given to climate change mitigation and adaptation. The findings support the argument that spatial planning sustainable development policies provide a forum for organising mitigation and adaptation responses, but rebuilding the country’s spectrum of sustainable development for the purpose of FRM and community resilience through evacuation is essential.

A further loophole in the relationship between spatial planning and evacuation site suitability is found in the formulation of the State Structure Plan. This plan is the policy basis of local authority development programmes and it is a legal requirement that measures to improve the physical environment and environment-related measures are included (Johar, 2003). However, when the state plan is translated into a local plan, these measures are limited to (1) protection and improvement of the physical environment, (2) preservation of natural topography, (3) landscape improvement, (4) tree preservation and planting, (5) creation of open spaces and (6) preservation and enhancement of the character and appearance of buildings. These requirements are complemented and enhanced at the development control stage, but they are not related to the multi-criteria of safe evacuation sites.

To obtain planning permission from a local authority, a development proposal, containing land use analysis and an environmental impact assessment, must include (1) measures for the protection and improvement of the physical environment, (2) measures for the preservation of natural topography, (3) measures for the improvement of the landscape, (4) measures for the preservation and planting of trees thereon, (5) the location and species of trees with a girth exceeding 0.8 metre and other vegetation thereon and (6) proposed earthworks (Johar, 2003). None of these compulsory local authority measures include FRM or evacuation siting measures.

Therefore, when planning or locating the site of a safe evacuation area, the elements of site suitability must be included in the spatial plans. This can be achieved by amending the planning permission rules for development. The 1976 Act gives local planning authorities the power to impose conditions on the granting of planning permission (Johar, 2003). Furthermore, the Local Plan is important for the development of basic local planning authority guidelines and for the identification of those areas of action that need immediate attention (Maidin & Mobarak Ali, 2009). This supports the direction of this study, which is the linking of spatial planning with ECs and pointing out the need for EC suitability elements in the spatial planning of flood-prone areas.

Nevertheless, the construction of a new framework that focuses on EC suitability requires the cooperation of multiple flood-related stakeholders. Therefore, understanding the challenges facing flood-related agencies is important in order to get to the bottom of spatial planning and FRM issues. In addition, in Malaysia, flood-related agencies that are involved in both FRM and spatial planning are the same agencies whose staff make up development review committees. Furthermore, Act 172 confers powers on local authorities to regulate the land use planning, control and conservation of all land and buildings within each local government jurisdiction. The State Director performs this same role for those areas that do not fall within the jurisdiction of any regional or local government (Maidin & Mobarak Ali, 2009).

In short, the framework of this study was formulated by understanding the issues facing FRM through the lens of flood-related agencies. The lack of integration between agencies is a hindrance to the integration of FRM and spatial planning. FRM is also limited to the management of evacuation centres, and the siting or location of ECs is not included in spatial plans. The lack of safe EC sites in spatial planning and FRM has resulted in the unsuitable siting of some ECs.

CHAPTER 3

ISSUES AND CHALLENGE FACING FLOOD-RELATED AGENCIES IN MALAYSIA

3.1 Introduction

The Malaysian government takes a top-down approach to flood risk governance, based primarily on the official strategies outlined in National Security Council Directive No. 20 (Hamin et al., 2013; Shafiai & Khalid, 2016b). This top-down approach means that authority is centralised (Huntjens, Pahl-Wostl, & Grin, 2010). As flood risk governance in Malaysia is the shared responsibility of federal, state and district governments, there are many actors involved and wide legal variances across states that each have their own rules. However, this model makes Malaysia a suitable example for identifying the problems that exist in multi-level institutions, governance and plans. This study argues that there are many hidden challenges to flood-related agencies in ensuring evacuation site suitability. The following flood-related agencies were included in this study:

1. Kuantan Municipal Council (Local Authority)
2. Department of Irrigation and Drainage Federal
3. Department of Irrigation and Drainage State of Pahang
4. Department of Irrigation and Drainage District of Kuantan
5. Pahang Social Welfare Department
6. National Disaster Management Agency (NADMA)
7. Pahang Civil Defence Force
8. Kuantan Civil Defence Force
9. Land and District Office Kuantan
10. PLANMalaysia (Federal)

11. PLANMalaysia Pahang (State)
12. Fire and Rescue Department Pahang
13. Royal Malaysian Police Kuantan
14. National Hydraulic Research Institute of Malaysia (NAHRIM)

3.2 Issues and Challenge Facing Flood Related Agencies

Content analysis and a qualitative thematic analysis of interview data found a variety of issues and challenges facing Malaysia's flood-related government agencies. These are summarised in Table 2.

Table 2: Summary of the issues and challenges

Chapter sub-section	Issues and challenges	Agencies
3.2.1	Absence of evacuation criteria in spatial planning	All agencies
3.2.2	Absence of geo-spatial criteria in planning guidelines	All agencies
3.2.3	Collaborative risk sharing and risk management at all levels of government	All agencies
3.2.4	Lack of establishment of long term, reliable funding mechanisms for flood risk reduction measures at federal, state and local levels	DID, NADMA, Civil Defence, Fire and Rescue, Police Department
3.2.5	Lack of human resources and logistical assets	Civil Defence, Fire and Rescue, Police Department, DID, NADMA
3.2.6	Communication problems	All agencies involved in flood operation

Note: DID = Department of Irrigation and Drainage; NADMA = National Disaster Management Agency

3.2.1 The absence of evacuation criteria in spatial planning

A content analysis of federal, state and local government urban development spatial plans and evacuation plans was conducted. Urban development spatial plans are drawn up by state, local or district planning authorities, depending on the stage of the development plan. These development plans are the basis for directing local authorities to review development projects and to improve government capabilities (Rani, Kamarudin, Razak, & Asmawi, 2020). Each local government is responsible for planning and ensuring that all areas within its boundary are in compliance with statutory planning policy documents.

These documents have the potential to ensure improved urban resilience (Rani, Razak, Kamarudin, & Hassan, 2017; Rani et al., 2020). This analysis focused on the incorporation of relevant flood risk mitigation initiatives through the incorporation of EC site suitability into development plans. Integrating secure evacuation sites as components of a development plan ensures greater resilience to climate change and future disasters.

The National Physical Plan (NPP) is a platform to specify national long term strategic spatial planning policies to guide the general direction and broad pattern of land use, biodiversity conservation and physical development in Peninsular Malaysia (Rani et al., 2020). At the federal level, the formulation of the NPP limits flood risk and disaster risk area management to determining and monitoring risk factors in natural disaster risk areas (in thrust SMP3). Even though the aim is to achieve safer and more resilient development, elements of risk reduction specifically related to safe evacuation sites are not mentioned. Chapter 4, Thrust 2 of the NPP focuses on the planning, management and use of land resources, and includes mitigation and adaptation measures to curb climate change impacts. The strategy highlighted to achieve these goals is holistic land use planning.

Even though the holistic land use aims of the NPP are not directly related to evacuation sites, the NPP states that spatial sustainability and climate change resilience will be translated into spatial management plans at the state level. The NPP states that the focus of spatial sustainability and resilience is ‘ensuring that the management of the country's natural resources takes into account the aspects of climate change, disaster risk and accessibility level, and more effectively meets the needs of the people and assures spatial sustainability. The use of green technology and smart infrastructure is also taken into account in supporting the aspirations of sustainable and low-carbon urban development'. Through this NPP strategy, mapping of flood risk and other disaster areas is compulsory and must be part of planning at State Structure Plan, Local Plan, Special Area Plan and action plan levels.

The NPP categorises the State of Pahang as a flood-prone state and Kuantan is categorised as a flood-prone district, with settlements at risk of flooding. The strategy for Pahang is highlighted in its state plan as follows: (1) implementing new urban storm water management guidelines for urban and rural flood-prone areas, (2) ensuring effective development management in flood-prone areas, (3) implementing flood mitigation measures to protect rural areas from flooding (4) implementing a flood management plan through land use planning (through preparation of the State Structure Plan and the Local Plan) and drainage infrastructure provision, (5) ensuring coastal development planning and protection takes into consideration the impacts of climate change and environmental disasters and (6) Controlling development on hills and highlands (Federal Department of Town and Country Planning, 2016). In reference to the fourth of these strategies, the implementation of a flood plan through land use planning, a content analysis was conducted to examine the safe criteria for ECs in the Pahang State Structure Plan and the Kuantan Local Plan.

The State Structure Plan (SSP), ratified according to Act 172, contains the plans and policies of the state authority on planning and land use. According to the plan, government agencies and public actors shall cooperate with and enforce the policies and recommendations found therein (Jabatan Perancangan Bandar dan Desa, 2002). The objectives of the Pahang SSP are: (1) social progress that considers the needs of every citizen, (2) environmental conservation, including of critical habitats and environmentally sensitive areas, (3) sustainable use of natural resources and (4) high and stable economic growth that creates adequate employment opportunities. However, disaster risk management and resilience are notably absent from the Pahang SSP. In this phase, the aim of the NPP and the SSP were not aligned.

Early development issues and prospects in the Pahang SSP have been categorised into seven municipal sectors, including flooding, upland exploration, border development, mining, logging, forest exploration and infrastructure provision. The district of Kuantan was specifically mentioned with regard to these issues. However, no further details or plans regarding FRM, resilience or evacuation were included in the SSP. The only resilience-related development strategy was the identification of flood-prone areas. Therefore, this study proceeded with a content analysis of the Kuantan Local Plan (LP).

The development aim of the Kuantan Local Plan is to ensure that 'Kuantan maximises its potential as a sustainable and liveable city'. Nine objectives have been set out to achieve this aim: (1) sustainable and balanced land use development, (2) the preservation and conservation of the environment and, in particular, environmentally sensitive areas and logging activities, (3) control activities related to mineral resources in order to improve environmental quality, (4) empower the tourism sector with regard to heritage, natural diversity and water bodies, (5) the development of high-tech industries capable of attracting foreign investment, (6) improving the image and identity of Kuantan District, (7) the provision of commercial facilities and infrastructure, (8) improving the efficiency of traffic systems and (9) improving the drainage system. The aim and objectives of this LP do not include disaster resilience or FRM.

In the Kuantan LP, floods and drainage systems are highlighted as development issues. The LP states that flood disasters in Kuantan occur due to monsoon season rains, heavy rainfall, inefficient drainage systems and water runoff due to rapid development. Kuantan District's development concept strategy consists of (1) ensuring optimal environmental quality, which includes ensuring planned, beautiful, prosperous and efficient physical development that promotes environment quality and fulfils the interests of society, (2) balancing the need for the wise and orderly development and preservation of state resources, (3) ensuring future residential areas are not located in flood-prone areas and (4) reducing flood risk in existing residential areas.

The LP also includes a non-compulsory guideline that new housing development should not be developed in flood-prone areas, while existing residential areas must be equipped with efficient drainage systems. In addition, areas that have already been zoned for housing in Environmentally Sensitive Areas but are yet without committed development need to be rezoned and retained as Environmentally Sensitive Areas. The plan also encourages pillar housing for committed developments in areas identified as at risk of flooding. The plan contains no specific evacuation details. However, it states the need to build an additional 38 schools to meet expected population growth by 2035. Since schools and public halls are gazetted as ECs, this study examines any possible requirements for the safe location or siting of such buildings in the plan. However, the plan contains no specific criteria for site safety.

The Kuantan Local Plan contains the following flood mitigation measures: (1) improvements to the river banks and depth of the Kuantan River, (2) the construction of a flood barn, pump houses and tidal control doors, (3) the construction of flood mitigation dams on several river basins that contribute to the flow rate of the Kuantan River, (4) the development of a temporary retaining basin in the middle of the Kuantan River, (5) the construction of a flood control barn and deepening of the Isap River, (6) the construction of a monsoon drain/main drain, (7) widening and deepening of the Belat River and the Pandan River, (8) stabilisation of the Belat River bank and (9) deepening of the Galing River and the stabilisation of its river bank. These flood mitigation measures are limited to expanding or improving the river without considering either geo-spatial factors or evacuation measures. In addition, Special Area Plans have not been published for the study area or, specifically, for the flood-prone areas of Kuantan or Pahang. Therefore, a content analysis of a Special Area Plan for the study area could not be conducted.

This study concludes that flood-related elements or safe evacuation sites have not been included in Malaysia's three-tier spatial plans. Therefore, at the planning stage, an inability to comply with policy strategies and planning standards at national and local levels, inadequate execution of NPP development resilience policies in the SSP and LP, together with a lack of cooperation and engagement from stakeholders, including local and state planning agencies, are the underlaying reasons for a lack of partnership among flood-related agencies. However, the connection between spatial planning and evacuation sites is complex due to the hierarchical and multi-level status of a variety of government agencies.

The key concern is the lack of evacuation elements in either the policies or the spatial plan. Most notably, the requirements for evacuation sites are also absent from the key policy that directs the physical development of the region. This is due to a lack of understanding among different levels of government regarding evacuation site suitability. This has an impact on the implementation of appropriate criteria in the development of EC sites. This lack of understanding makes it undesirable for local government officials to implement the spatial plan.

3.2.2 The absence of geo-spatial criteria in planning guideline

Criteria for ECs are not included in the Town and Country Planning Department Planning Guidelines, although there are specific guidelines relating to the siting of public halls and schools. In this study, public halls and schools are categorised as flood event ECs, and it is, therefore, acceptable to review the guidelines relevant to these types of buildings to determine EC site suitability. Land use planning proposal guidelines for school development include the following: (1) development must be based on population density, (2) the school must be located in walking distance from residential areas, (3) the school site must not be located on swamp land, hillsides with a slope >25°, areas at risk of disasters, such as flooding, landslides or industrial areas, (4) the site must be far from industrial areas, airports, highways, and other such infrastructure, and must include a buffer zone and (5) the site must be near public transport and not located in such places as crime hot spots (Jabatan Perancangan Bandar dan Desa Semenanjung Malaysia, 2013). Among these guidelines, only location away from disaster-prone areas and steep slopes are relevant EC site suitability criteria.

According to the Town and Country Planning Department Planning Guidelines, the development criteria for public halls are as follows: (1) multi-purpose halls must be developed in areas with a population of 10,000–15,000, (2) public halls smaller than multipurpose halls must be developed in areas with populations of 1,000–10,000 and (3) community halls must be developed in areas with populations of 200–5,000. The only flood-related guideline for the location of public halls is that they 'must not be located in flood-prone areas or landslide areas' (Jabatan Perancangan Bandar dan Desa Semenanjung Malaysia, 2013). Guidelines for public hall siting are also non-specific regarding geo-spatial criteria for site suitability. In general, even though the elements of EC site suitability are not directly included in spatial plans, town planning guidelines for school and public hall development include one EC site suitability criterion, namely, that they not to be located on flood-prone land. However, the findings of this study suggest that these guidelines should be more inclusive and detailed regarding EC site suitability.

3.2.3 Lack of collaborative risk sharing and risk management at all levels of government

The roles and responsibilities of some government entities are in conflict with some private property, historic preservation and environmental interests and in competition with each other. Such conflict and competition impedes effective FRM (Traver, 2014). The findings of this research show that there is no system in place to resolve conflicting priorities between the numerous flood-related agencies and spatial planning departments that each have control of different aspects of FRM. Those interviewed for this study agreed that reducing the risk to one stakeholder might shift that risk to another stakeholder, often leading to the shirking of responsibility.

Representatives of the agencies involved in this study stated that conflict usually occurs when dealing with responsibility for flood mitigation and urban development. In many cases, conflict occurs between the DID, the Local Authority and the Land and District Office. Other weaknesses in collaborative FRM between agencies exist in the approval of development in flood-prone areas. Incorporating elements of resilience into new development requires the involvement of a local authority with jurisdiction over land use development and building codes. However, this is often excluded from consideration due to barriers between federal and state governments and local authorities. Therefore, it is difficult to include new elements regarding evacuation sites into the development planning process.

The Department of Irrigation and Drainage Malaysia (DID) has primary responsibility for flood management. This role is regulated through the Ministerial Functions Act 1969 (amendment 2008) P.U. (A) 170. According to the act, the role of DID is limited to water resources but includes flood planning and development, the management of hydrological data, the management of national water resources, river basin planning and management, planning and development for water management infrastructure for agriculture, flood mitigation planning and management, the development and management of coastal zones to reduce coastal erosion and problems related to river mouth deposition and National Water Council.

However, DID has limited authority and enforcement power to steer FRM, especially with regard to the flood mitigation of each new development. Every development in Malaysia must be granted planning permission (Kebenaran Merancang) before the developer can begin work on the project. First, planning permission applications must be submitted to the local authority One Stop Centre (OSC). Second, the OSC requests a technical review from all relevant technical agencies, one of which is the DID. Third, the Planning Department assesses these technical reviews. Fourth, the local authority and then the OSC hold technical meetings. Finally, planning permission is either granted or rejected.

The interview conducted with DID government officials for this study found that local authorities generally overrule DID technical reviews and decisions in relation to development in flood-prone areas. When planning permission applications are for developments in flood-prone areas or when the development increases flood risk, the DID will endorse an official letter rejecting the development application or approve the application with conditions. These conditions may include the construction of a retention pond of a specific size and protecting river reserves or specific ground levels from development. Due to the DID's limited powers, it can only provide technical advice, and it has no authority to reject developments that could lead to greater flooding.

The National Disaster Management Agency (NADMA) manages disasters at the federal level. It has overall responsibility for the implementation of Directive No. 20, and in this capacity, cooperates closely with other flood-related agencies. However, Directive No. 20 is merely a guiding document, and does not include comprehensive FRM directives. NADMA has no authority over the siting of ECs and its role is limited to that of disaster coordinator during a disaster. There are no specific laws that give NADMA the power to influence FRM. In addition, NADMA is not listed as a development plan review agency, and it has no say over urban or rural development, even though some developments will lead to heightened flood risk.

The reason for these limited powers is because FRM and spatial planning in Malaysia, and in Kuantan in particular, are controlled by two groups. One group consists of institutions working in the field of development, such as local authorities and the Land and District Office, and the other group consists of those institutions working in the area of flood risk, such as DID and NADMA. These two groups are in dispute over a lack of mutual risk sharing. This makes the incorporation of FRM into spatial planning difficult. This study also found that evacuation guidelines are not included in any local authority spatial plan, as FRM is neither a priority nor the responsibility of local authorities.

In addition, ECs are under the authority of the Social Welfare Department, which is not connected to either the urban planning group or the FRM group. The study found a lack of knowledge in the Social Welfare Department regarding the suitability of evacuation sites, which affects the implementation of suitability criteria in the development of ECs. This lack of understanding has made it undesirable for local government officials to implement it. The government officials concerned are unaware of the need to review current EC sites due to the absence of EC guidelines or criteria in policies and spatial plans.

Other than spatial planning-FRM issues, collaboration and cooperation issues also arise during flood response. The Civil Defence Force (APM) works with the Fire and Rescue Department to rescue flood victims. However, cooperation with the Fire and Rescue Department is challenging, due to ‘ranking’ in uniform units, as Fire and Rescue

Department personnel usually holds higher rank. This lack of cooperation between agencies during flood response has led to delayed rescue operations.

3.2.4 Insufficient funding

According to Traver (2014), the implementation of good FRM relies on the establishment of long term, reliable funding mechanisms for flood risk reduction measures at federal, state, and local levels. However, interviews revealed that, in a flood-prone country, such as Malaysia, one of the challenges to FRM is the lack of sufficient funding to all flood-related agencies. The DID, in particular, lacks the significant funding it requires to implement structural flood mitigation measures. Interviewees also stated that it is difficult to attain funding from the federal government and neither the scale of the previous year's disaster nor public interest influence the amount of funding received.

Substantial allocations of funding are needed to construct ECs at appropriate sites and to achieve a more resilient built environment. In addition, no special funds are available to create new ECs. Current funding is allocated only for the repair and maintenance of schools and public halls gazetted as ECs. Interviewees admitted that the financial situation does not allow officers to consider flood risk mitigation in the planning phase, and they agreed that the lack of revenue is an obstacle to building resilience in the form of safe ECs.

Meanwhile, the federal government stipulates that state and district governments can only use their funding from March to November each year. Since disaster-related projects take time to plan and develop, this nine-month timeline is insufficient. In addition, no funding is provided for infrastructure maintenance. Therefore, relevant agencies are faced with the challenge of maintaining flood response assets and existing flood-related infrastructure on limited budgets. Funding for non-structural measures is also limited, due to the current government's aim to lower spending and reduce the budget (Sipalan, 2019).

3.2.5 Lack of human resources and logistical assets during flood response and evacuation

The situation is considerably more complicated at the district level, where resources are more limited. All flood-related agency interviewees stated that agencies lack adequate human resources and logistical assets, especially during disaster response at the district level.

At state and district levels, all flood-related agencies are mandated to be on duty during flood response. However, the staff involved are often themselves flood victims, resulting in a lack of manpower. Moreover, the Civil Defence Force and the Fire and Rescue Department do not have enough staff to properly perform their response and rescue duties. Flood-related agencies also have a shortage of transportation assets, creating logistical challenges for humanitarian operations. All interviewees highlighted this as one of the main challenges to performing their FRM duties, especially during preparedness and response phases.

This problem remains unresolved because the relevant agencies are denied approval by the federal government for additional logistics assets, even though the preparation of these logistics activities is crucial to successful disaster response. This clearly shows that emergency preparedness plans in Malaysia lack insight into the logistical requirements of a humanitarian disaster.

3.2.6 Communication during the flood response and evacuation

Effective communication is an essential component of FRM. However, the lack of a clear communication strategy has been identified as a major failing in response (Bradford & O'Sullivan, 2011). In Malaysia, all flood-related agencies meet once a year to prepare for monsoon season flooding. Most interviewees agreed that meeting once a year is not adequate to coordinating a successful flood response plan. Flood-related agencies should communicate early and frequently to ensure agreement on an orderly response plan.

Government officials at the federal, state and district levels use the messaging app WhatsApp for government-to-government communication. However, WhatsApp requires an internet connection to send and receive messages and, based on interviews, officers on flood response duty in Kuantan face challenges to communication due to internet 'slow-down' when it is raining, resulting in delayed flood response. In this case, WhatsApp is not the most appropriate medium for government-to-government communication.

A second communication medium is the Government Integrated Radio Network (GIRN). All government agencies involved in the response phase of a disaster use GIRN to communicate with each other. However, this study found that GIRN is often jammed during flood response, resulting in delayed communication between agencies and delayed flood response. The lack of frequent communication and the instability of communication channels between flood-related agencies shows a clear gap in the flood communication plan, which can lead to failure in the flood response. It is crucial that communication capacity between agencies is improved so that chaos can be minimised and coordination between agencies run smoothly once floods occur.

3.3 Discussion

FRM in Malaysia is a top-down government responsibility, and Malaysians are heavily reliant to flood-related government agencies to manage floods. Figure 4 depicts the direct and secondary impacts of the challenges faced by flood-related agencies.

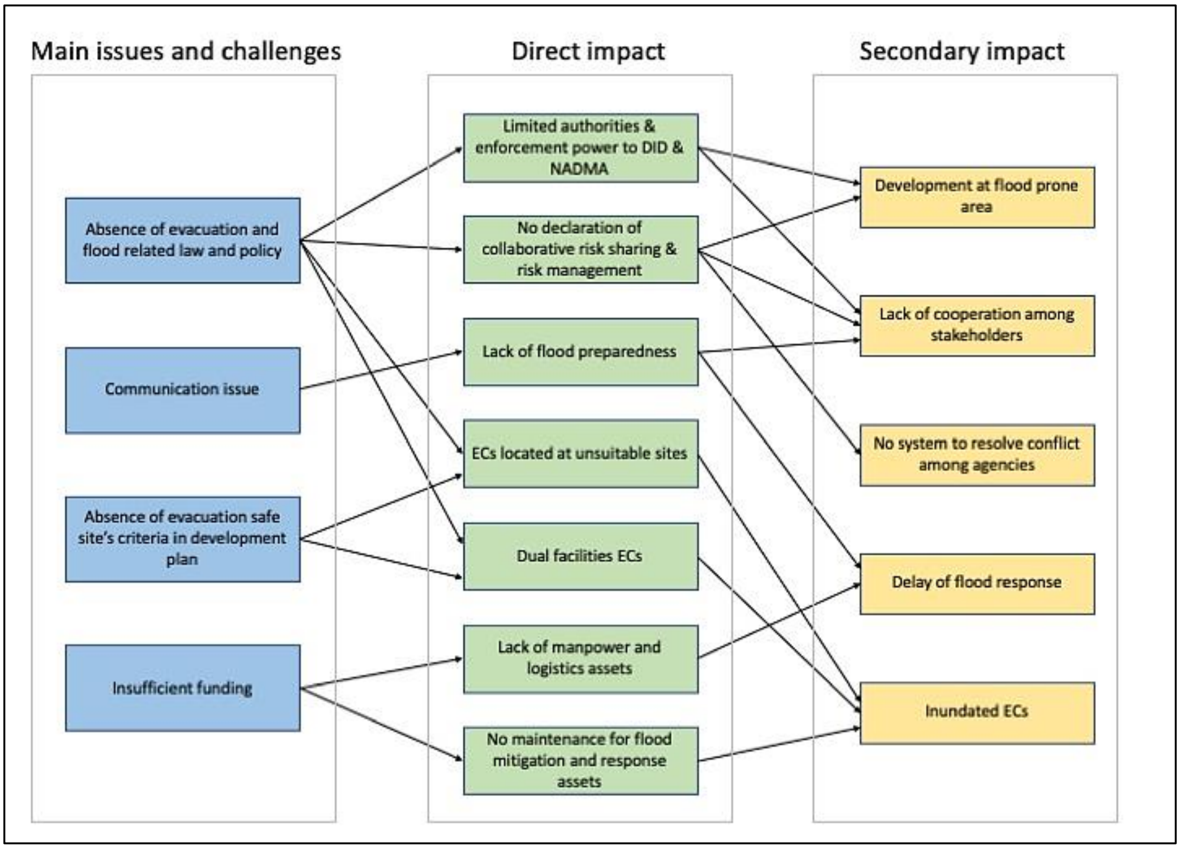

Figure 4: The flood-related agency challenge and issues

The key concern is the lack of evacuation-related elements in the policies and the spatial plan. Most notably, evacuation site requirements are also absent from the key policy that directs the physical direction of the region. This is due to a lack of understanding within government of the suitability of evacuation sites, thus impacting the implementation of appropriateness criteria in the development of ECs. Local government officials are unwilling to implement appropriateness criteria due to this lack of understanding.

In addition, there is a lack of flood management-related legislation to control flood occurrences, resulting in inadequate authority and enforcement capability. Of the following acts, not one deals directly with flood protection or flood control: the Land Conservation Act 1960 (which seeks to protect soil erosion and silting and, therefore, prevent downstream flooding), the Town and Country Planning Act 1976, the Environmental Quality Act 1974, the Environmental Quality Order 1987, the National Land Code 1965, the Irrigation Areas Act 1953 amendment 1989, the Water Acts 1920, the Drainage Works Ordinance 1954, the Street, Drainage and Building Act 1974, the Irrigation Areas Ordinance, and the Housing Development Act (Licensing and Control) 1965. There is, therefore, the need to pass a new Flood Act, Flood Enactment or River Law to deal directly with flood protection and flood control (Chan, 2012). Specific evacuation policies are required and the government must adjust executive actions, legislation and flood control policies to better manage flood risk.

One direct impact of the lack of specific flood laws and policies is the lack of authority and enforcement power among relevant agencies to steer FRM. The government (i.e., the Cabinet) must take proactive measures to give relevant authority and enforcement powers to DID or NADMA to overrule development proposals that are unsustainable and that enhance flood disaster risk. Amending the existing law to ensure that every new development must prepare emergency shelter according to safe site criteria is essential to ensuring resilience in the face of increased flood risk. Although NADMA’s coordinating role might, from the outside, suggest smoothly-run FRM, in reality, the agency lacks the authority to steer well-coordinated and cooperative FRM between the relevant agencies.

Another issue is the lack of declaration of collaborative risk sharing and risk management at all levels of government. Collaborative risk sharing and risk management are important aspects of FRM and many countries have adopted collaborative risk sharing as a part of good flood risk governance. Malaysia should adopt collaborative risk sharing that links different organisations and agencies, and directly establish collaborative FRM mechanisms to reduce the current problem of shirking responsibility. Collaborative risk sharing and risk management at all levels of government and by all stakeholders is required to promote effective FRM and to ensure that risk is reduced and not simply transferred elsewhere (Traver, 2014). Such a declaration would also directly support cooperation between agencies.

Yet another problem is the lack of cooperation between agencies when granting development planning permission. Incorporating safe evacuation and resilience into new development projects requires the involvement of local authorities with jurisdiction over land use development and building codes. However, these are often excluded from consideration due to barriers between federal, state and local authorities. Malaysia lags behind other countries with regard to disaster risk reduction, and it is important to focus federal, state and district governments on the same aim, namely, disaster reduction. In the current situation, the success of FRM rests with state governments and local authorities, and upon individual property owners in flood-prone areas. Unfortunately, since Malaysia has no specific laws or policies that deal directly with floods and collaborative FRM, sustainable strategies that require coordination between stakeholders are almost impossible to implement. Therefore, the federal government should issue an executive order directing state and district governments and local authorities to consider flood hazards in all development planning applications. In so doing, cooperation between flood-related agencies will begin to develop both directly and indirectly.

Currently, Malaysia's Flood-related and Urban Planning Agencies are decentralised. Furthermore, the agency responsible for selecting and managing ECs is not involved in either urban planning or FRM. Therefore, agencies face many challenges, including, as this research has found, the matter of urban development in flood-prone areas. Institutional heterogeneity has an impact on the effectiveness of arrangements to control flood risk. Fragmentation can cause disputes between flood management stakeholders, create negative environmental impacts, or lead to unequal resource allocation and poorly defined accountability lines. Institutional heterogeneity, including contradictions between national and local objectives or strategies, and overlapping or contradictory policies, make the integration of spatial planning with FRM all the more difficult.

The issue of funding has been neglected by the government. Government expenditure and actions to reduce flood damage are evident in the matter of insufficient funding faced by flood-related agencies. Since Malaysia experiences massive flooding every year, expenditure should be more extensive, and dedicated funding should be budgeted for holistic FRM. Malaysia's decision-makers must understand the risks of flooding and take these into account when developing policies and actions. Without sufficient funding, relevant agencies cannot adequately perform the mitigation, preparedness, response and recovery actions of FRM. Malaysia's use of dual-purpose ECs is also the result of insufficient funding. This has resulted in the less than ideal location of ECs. A lack of investment funding for flooding is key to what appears to be limited success in Malaysian FRM.

There are additional logistical issues, such as the challenges agencies face when transporting rescued flood victims to places of safety. This clearly demonstrates how the federal government has overlooked the preparation of well-maintained assets and how logistics considerations are essential to effective flood preparedness and response. In other words, the relevant stakeholders have paid little attention to logistical flood emergency planning. Other scholars have pointed out that the government needs to play a key role in the logistical preparations necessary for effective disaster response (Leeuw, Vis, & Jonkman, 2009; Moe & Pathranarakul, 2006).

Good communication is a vital element of disaster response. The current annual flood preparation meeting is inadequate and demonstrates a lack of responsibility for flood risk communication. Furthermore, agencies must find alternative means of communication. As the current communication issues reveal, the use of GIRN and WhatsApp is inadequate and unsafe. Moreover, in 2013, major flooding and continuous heavy rain in Pahang led to a major electricity blackout, because Malaysia's primary electricity supply provider generally shuts off supply when water levels become dangerously high (Sean, 2013). Since the current methods of communication depend on electricity and the internet, alternative means of communication are urgently needed. The relevant agencies also face many problems with the jamming of GIRN during major flood events. Given that Malaysia experiences major floods annually, the government should provide effective means of communication for flood preparedness and response.

The interview and content analysis conducted for this study has several strengths. First, it identified the current challenges and issues faced by flood-related agencies in Malaysia. Second, it proved how the lack of legislation and authority and weaknesses in collaborative risk sharing and FRM at all levels of government have resulted in the under-performance of flood-related agencies. Third, it found that insufficient funding, a lack of logistic assets and a lack of cooperation from local authorities show a lack of effort by the government to boost flood resilience. Fourth, these findings can be used to assess areas in need of comprehensive and effective FRM. The in-depth interviews enabled a deeper exploration of the challenges facing flood-related agencies. However, the study was limited by the relatively small number of interviewees. This may also limit the transferability of these results to more complex contexts.

The results are consistent with Malalgoda et al.s' (2016) findings in Sri Lanka. Chong and Kamarudin (2018) have, so far, published the only article detailing the issues and challenges facing disaster-related agencies in Malaysia, although their study was not flood specific. Therefore, this study adds to attempts to understand the institutional weaknesses that threaten the FRM process.

CHAPTER 4

MULTICRITERIA SITE SUITABILITY ANALYSIS AND EVACUATION CENTRE ISSUES FACING FLOOD-RELATED AGENCIES IN KUANTAN

4.1 Introduction

As the effects of flooding continue to increase worldwide, experts agree that post-event response must become more scientific and efficient (Anhorn & Khazai, 2015; Balcik et al., 2010; Bharosa et al., 2010; McEntire, 2007; Rawls & Turnquist, 2010). With the increase in flood risk, the number of vulnerable cities and populations grows worldwide, emphasising the need for local governments to develop disaster operation management efforts to enhance urban disaster resilience (Zhao et al., 2017).

Aminzadeh (2007 in Melgarejo and Lakes, 2014) explains that, when confronting a higher number of climate-related disasters, local authorities should prioritise the provision of safe shelter to affected populations, while ensuring that urban flood shelters or ECs effectively increase societal resilience (Zhao et al., 2017). Meanwhile, Dalipe (2020) connects ECs with disaster resilience by stating that safe shelters characterise a community's capacity for response and recovery.

The preparation of evacuation areas, as part of disaster preparedness, is complemented by enhanced disaster resilience because of its bottom-up and top-down approaches (Cavallo, 2014). Lindell and Prater (2007, in Lim et al., 2013) argue that such preparation efforts are an important aspect of emergency planning. However, the mere creation of ECs is not enough, and other important factors must be considered, such as geo-spatial location. Nevertheless, the most important aspects of the preparedness phase of emergency planning are the identification of suitable shelter locations and the reasonable allocation of evacuees to these sites (Zhao et al., 2017). This is supported by many studies that emphasise the importance of improving disaster preparedness by recognising and providing appropriate areas to serve as emergency shelters before disasters occur (Anhorn & Khazai, 2015; Chandler, 2007; Chien, Chen, Chang, Chiu, & Chu, 2002; Tai et al., 2010).

However, placing ECs at appropriate sites remains challenging, especially in urban contexts where the availability of suitable sites is often limited and there is an increased demand for risk-sensitive land use planning, which is often insufficient (Anhorn & Khazai, 2015). Allocating ECs to suitable locations draws on standards, criteria and guidelines developed for emergency managers and humanitarian organisations that, for the most part, focus on post-disaster assessment (Anhorn & Khazai, 2015; Sphere, 2011, 2015; UN/OCHA, 2010).

The selection of EC sites is another key aspect of shelter planning because the location of candidate shelters may not meet certain standards. For example, an assessment of Southern Florida found that 48% of existing shelters and 57% of candidate shelters are in physically unsuitable areas (Chen et al., 2018; Soltani et al., 2014). Keicho (2014) argues that, in a disaster-prone developing country such as Malaysia, ECs should be placed in safe locations, because flooding is the country's most common form of natural disaster, affecting 4.9 million people and inflicting several million Malaysian Ringgit worth of damage each year (Mohit & Sellu, 2013).

4.2 Research Methodology

This section explains the research methodology and provides context to the study area, including the chosen site and its population. The research methodology discussion consists of data collection and analysis procedures. Figure 5 shows the overall methodology. The following sections discuss methodology and analysis techniques and section 4.2.1 describes the study area.

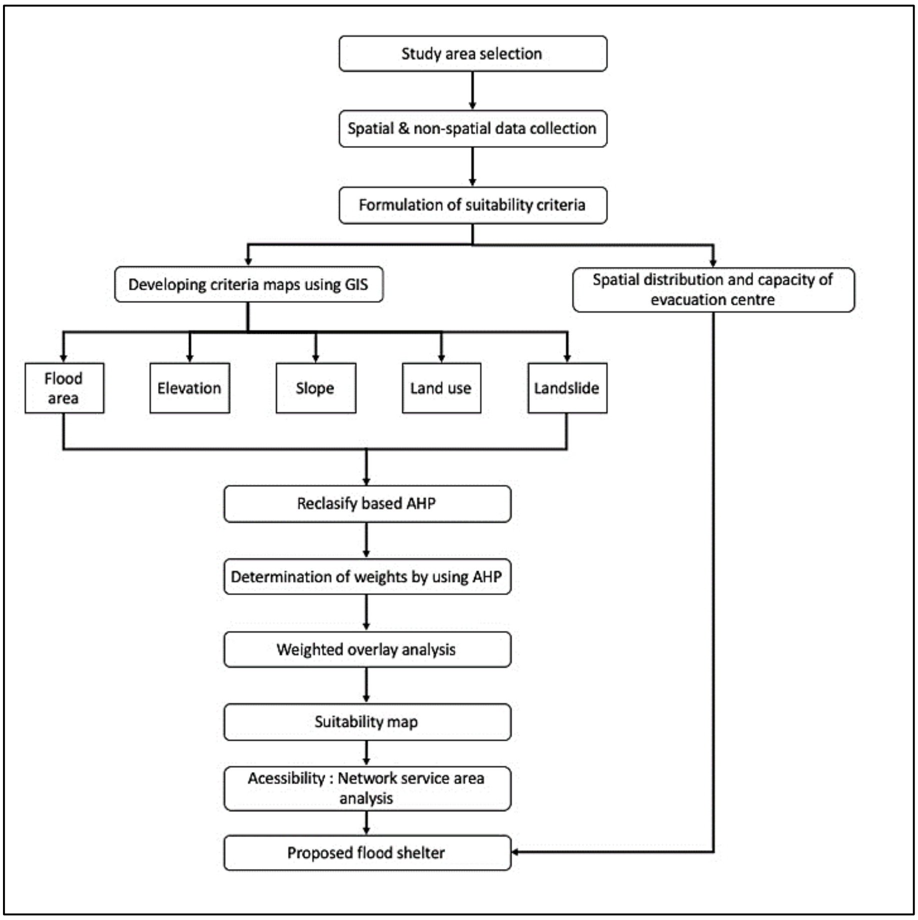

Figure 5: Research methodology

4.2.1 Study area

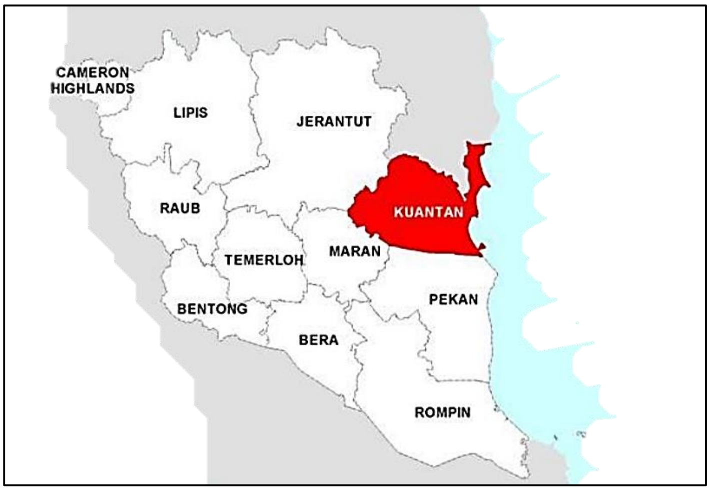

Figure 6: Location plan

Source: Majlis Perbandaran Kuantan, 2019

Kuantan District, in the State of Pahang, was chosen as the study site because it is classified by the NPP 3 as a district at high risk of flooding, and the city of Kuantan has been identified as a flood-prone area (PLANMalaysia, 2018). In addition, the majority of residential areas in Kuantan were identified in the Kuantan Local Plan 2035 as being at risk of flooding (Majlis Perbandaran Kuantan, 2019b). This highlights the need to examine the suitability of existing ECs in Kuantan with a view to increasing the area's resilience.

Kuantan District covers 296,042.09 hectares or 8.20% of the State of Pahang. Kuantan City is the capital city and administrative centre of the State of Pahang. The district has a population of 443,796 (Majlis Perbandaran Kuantan, 2019b). Land use in the study area is dominated by forest reserves (158,244.82 hectares, 53.45%) and agriculture (111,989.15 hectares, 37.83%), and 5.3% of the district is built land, of which 1.94% is residential and 1.32% is institutional and public facilities. At 0.2% to 1%, other land uses, including commercial areas, industry, infrastructure and utilities, are considered minor. Urbanisation in the district is centralised in the city, while the west of the district is dominated by forests and agriculture.

4.2.2 Planning in Kuantan

The Local Plan is the foundation for spatial planning in Kuantan. Only Local Plan 2035 can be legally used as a planning tool, and it lists all of Kuantan District's comprehensive land and physical development plans. The district plan is structured on the following criteria: (1) the completion of the National Physical Planning System, which includes three hierarchical levels, including the NPP, the SSP, and the Local Plan, (2) the translation of policies and strategies formulated by the government, such as the 11MP, the economic transformation programme, the national tourism policy, and the city's strategic plans, (3) the translation of the NPP3 and State Structure Plan Pahang 2002–2020, (4) the establishment of guidelines for the development of Kuantan District (5) the identification of suitable areas for development, taking patterns of development into account and (6) the identification of the natural environment and natural resources.

Another development structure in Kuantan is the division of Planning Blocks (BP). The purpose of this is to plan Kuantan District land use up to 2035. Accordingly, at the LP level, proposed maps, written statements and land use groups are generated according to the BP. The district is divided into six main BPs and 39 small BPs. The basis for the determination of BPs is: (1) the formation of BPs according to sub-district boundaries and (2) the formation of small planning blocks according to physical boundaries such as rivers, highways, railroads and land use uniformity. Figure 7 shows the planning blocks for development in Kuantan District. Table 3 lists each BP in Kuantan, the number of small planning blocks it contains and their size.

By referring to the LP and BPs, every new development must submit a planning permission application to Kuantan Municipal Council (the local planning authority). Planning permission is the written permission of the local planning authority (LPA) and is required after approval has been obtained to alter the status of land and must be obtained as the first stage of the development plan process. All planned new construction in Kuantan, whether permanent or temporary, must comply with the area's current development plan. Planning applications must follow the development plan, regardless of whether or not the plan has become a gazette (Yusup, Arshad, Marzukhi, & Abdullah, 2018).

In addition, all development projects in Kuantan District must be planned in compliance with Development Control Guidelines. The planning elements in these guidelines include the environment, community infrastructure, open and recreation areas, transport and communications, utilities and disaster risk. The content analysis in the following sections provides a review of planning guidelines in order to identify elements of EC site safety.

Table 3: List of planning blocks

BP	Planning Block	Number of Small Planning Block	Size (Hectare)
1	Kuala Kuantan	14	79,446.92
2	Beserah	4	3,102.72
3	Sungai Karang	11	27,248.80
4	Penur	5	22,286.16
5	Ulu Kuantan	3	88,616.53
6	Ulu Lepar	2	75,340.96
	Total	**39**	**296,042.09**

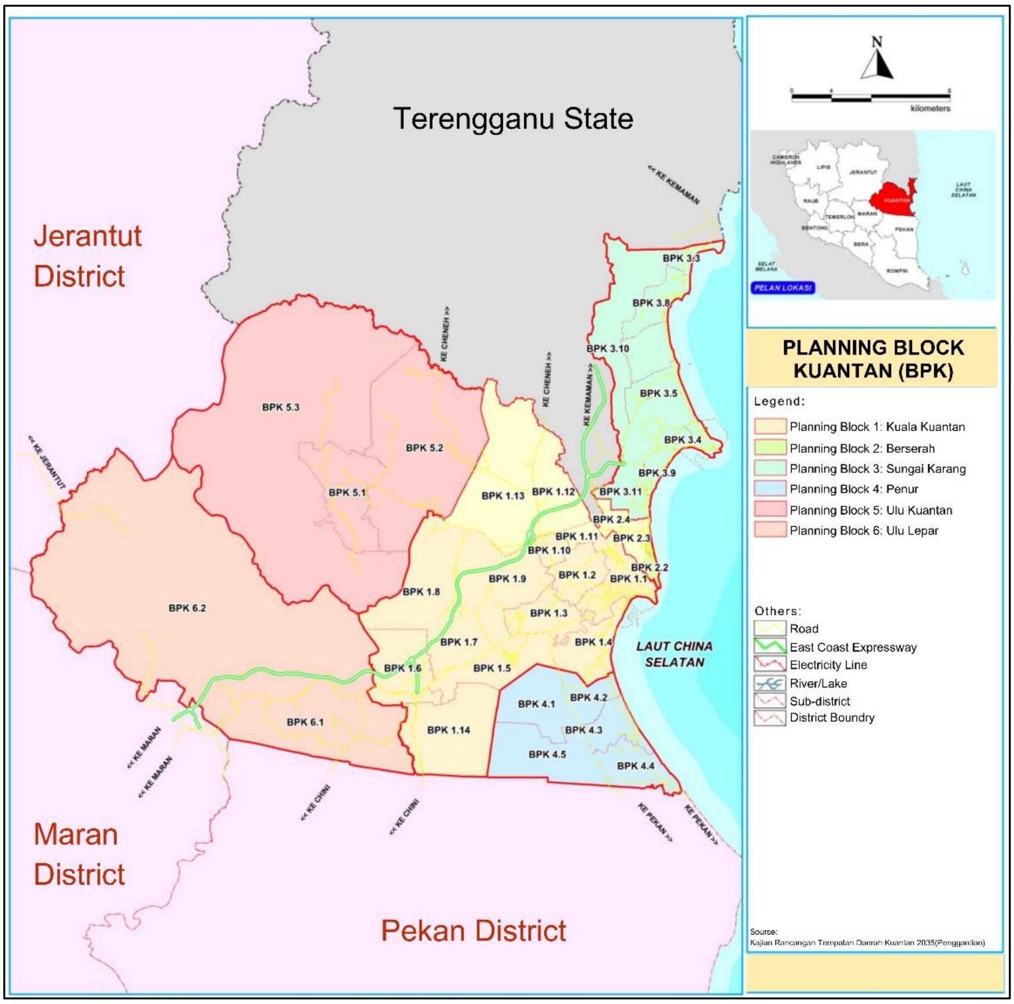

Figure 7: Planning Block in Kuantan District

Source: Kuantan Local Plan, 2019

4.2.3 Data Collection

This study used primary and secondary data.

4.2.3.1 Primary data collection

The number of flood evacuees to ECs in Kuantan was collected via a telephone interview with a member of Civil Defence Kuantan in August 2020. A site visit to Kuantan was conducted in January 2020 to determine the spatial location of ECs. Spatial data, which were later processed in GIS, such as land use, flood-prone areas and landslide locations, were collected in GIS 'shapefile' during interviews with employees of PLANMalaysia and the Department of Irrigation and Drainage in February 2019 and January 2020.

4.2.3.2 Secondary data

Secondary data were gathered through a literature review of government reports, research papers, journals and books. This literature review assisted in the formulation of site suitability criteria. The variables (criteria) for this analysis were (1) ECs outside flood-prone areas, (2) ECs sited away from secondary disaster sites, such as landslides, (3) ECs on elevated land and on slopes preferably between 2% and 5%, and not exceeding 7% and (4) ECs far from industrial areas. Data on the highest recorded flood levels were collected by reviewing Department of Irrigation and Drainage flood reports. Elevation and slope data were not available locally during data collection and were, therefore extracted from NASA's Shuttle Radar Topography Mission (SRTM) in GPX format and converted to an ArcGIS feature to create a digital elevation model (DEM) and slope map. Population data for this study were retrieved through the open-source site WorldPop (2013) in TIFF format. The study used Open Street Map as the road network dataset (in QGIS). All analyses were carried out using ArcGIS and QGIS.

4.3 Analysis Techniques

GIS analysis was integrated with the analytic hierarchy process (AHP) to analyse evacuation site suitability. The GIS-based site suitability analysis was formulated using a multi-criteria analysis, a process that combines and transforms spatial and non-spatial input data into a resultant decision or output. Multi-criteria methods can be incorporated into GIS to combine both data and value judgements (Mighty, 2015). Multi-criteria procedures, or decision rules, define a relationship between input and output layers/maps and include the utilisation of geographical data, the decision-maker's preferences and the manipulation of data and preferences according to specified decision rules (Malczewski, 2004; Mighty, 2015).

Studies by Mendoza (2000) and Mighty (2015) emphasise the importance of using GIS to perform multi-criteria site suitability analysis, because such assessments are inherently multi-criteria in nature. In other words, land suitability analysis is an evaluation/decision problem involving multiple factors. Therefore, a robust criteria assessment, such as AHP, is required to make accurate and informed decisions (Malczewski, 2004; Mighty, 2015). AHP provides a benchmark on decision hierarchy using a predefined reference scale, the factors that affect decision-making and the importance of decision points in terms of those factors. Value variations are thus converted into percentages of decision points (Şentürk & Erener, 2017).

In addition, GIS was also used to perform a network service area analysis. Service area analysis can be used to determine accessibility around any road network location within a certain time limit. The analysis helped to determine accessibility to evacuation shelters within 15 minutes walking distance to ensure that ECs can be reached on foot during the evacuation process.

4.3.3 GIS-based multi-criteria suitability analysis

ArcMap was used to create the map and boundary of the study area. The complete land use layer for the entire Kuantan District was acquired from the Malaysian government, making this part of the analysis both extremely accurate and smooth.

The first step in the analysis involved plotting all ECs on a map. Having calculating the affected population to determine population demand, EC evacuation capacity and adequacy were judged as being located within a 1 km radius of residential areas to provide maximum coverage to populations in flood-prone areas. Topographic mapping of the district was derived from a DEM to investigate elevation variations and slope. Using the GPX to Feature conversion tool, SRTM elevation data were extracted to ArcMap at the point of elevation. These data were then processed using the Raster Interpolation analysis tool and IDW to create the DEM, which was processed to a slope map using 3D Analyst – Raster Surface – Contour.

Flood-prone and landslide area layers were obtained from the government. However, the original shapefile was not in raster format and, therefore, unfit for processing using GIS reclassification techniques and WOA. Therefore, to identify whether ECs were located inside or outside hazard-prone areas, Spatial Analyst Tools – Distance – Euclidean Distance were used. This was the most suitable method for converting the layer into raster format and identifying the siting of ECs in relation to hazard areas. The Proximity tool was used to identify the distance between ECs and landslide areas. Buffer analysis was used to analyse the proximity and radius of ECs within 1 km of residential areas and intersect overlay analysis was used to determine the residential size within the selected radius.

Population data were extracted in TIFF format from World Population (WorldPop, 2013) and Zonal Statistic and Clip were used to extract population data for each grid cell of the base map. The size of ECs was calculated by measuring polygon size using ArcMap and a service area analysis in QGIS using Open Street Map as the road network was used to determine walking accessibility. The results of the suitability maps were derived from criteria based on the significance of weight criterion derived from AHP.

4.3.4 Integration of multi-criteria analysis by weighted overlay with AHP

Multi-criteria evaluation is an operational instrument that uses multiple criteria to address decision-making issues (Grima, Singh, & Smetschka, 2018; Malczewski, 2004, 2006; Zabihi et al., 2019). GIS can be used to assist in the categorisation, examination and appropriate organisation of accessible information regarding spatial planning options (Krois & Schulte, 2014; Zabihi et al., 2019). To construct a GIS-based multi-criteria analysis, weighted overlay analysis (WOA) was integrated with AHP. Since every different layer or criterion was analysed using GIS tools, this section will explain each technique.

WOA was implemented to estimate EC site suitability. This is a method commonly used in GIS-based studies of site suitability, selection and evaluation analysis (Basnet, Apan, & Raine, 2001; Kar & Hodgson, 2008; Malczewski, 2000), and can use both quantitative and qualitative approaches. The rule-based weight selection technique depends on selected criteria. In this study, the weight was calculated based on flood shelter suitability standards. In the qualitative phase, an opinion-based subjective technique may be used to develop weights for each variable (Kar & Hodgson, 2008).

Meanwhile, AHP is an effective multi-criteria decision-making method that helps the decision-maker to address a complex problem with multiple conflicting and subjective criteria (Zabihi et al., 2019). AHP can be used to rank alternatives and estimate criteria weights through pairwise comparisons (Ramanathan, 2006). In WOA, weight determination is crucial. Therefore, decisions must be validated through multiple decision-making analyses (Şentürk & Erener, 2017). AHP criterion weights are defined at a range of 1–9 where 9 is 'extremely suitable', 7 is 'very suitable', 5 is 'more suitable'; 3 is 'moderately suitable' and 1 is 'not suitable' (Mu & Pereyra-Rojas, 2017). In GIS, the scale can be further reclassified to include 0 for 'no data' or 'restricted', if certain criteria need to be excluded.

4.4 GIS-based Multi-Criteria Analysis

ECs were first plotted on a map. After calculating the affected population to determine population demand, the evacuation capacity and adequacy of ECs were judged based on their location within a 1 km radius of residential areas, as this would provide maximum coverage for populations in flood-prone areas.

The following section explains the findings for each criterion and the final outcome of the EC suitability analysis. Using data provided by PLANMalaysia, this section outlines the suitability results of the GIS-based analysis through the production of a final suitability map. The multi-criteria analysis included land use, hazard and topography.

The variables (criteria) for this analysis are (1) ECs outside flood-prone areas, (2) ECs sited away from secondary disaster areas, such as landslides, (3) ECs on elevated land and on slopes preferably between 2% and 5%, and not exceeding 7% and (4) ECs far from industrial areas. The results of the suitability maps were derived from criteria based on the significance of weight criterion derived from AHP. The last section of the analysis determines EC accessibility. This section uses service area analysis to determine road accessibility by walking.

4.4.1 Spatial distribution and capacity of evacuation centres

Eighty-five flood shelters were identified from the collected data. Since EC distribution was sporadic and scattered, a significant spatial location pattern could not be detected (Figure 8 and Figure 10). Most shelters were located in Kuantan City. The number of ECs consistently decreases with increased distance from the city centre.

Sanyal and Lu (2009) stress that emergency shelters must be located where they can serve the maximum number of vulnerable residents, that is, within a 1 km radius of settlement areas. This section identifies those settlements exposed to flood risk and EC capacity spatial distribution. Figure 8 and Figure 9 show the distribution of the 85 ECs across the district while Figure 10 shows residential areas at risk of flooding. As Table 4 shows, most government-designated ECs are schools and public halls.

Using intersect overlay analysis in ArcGIS, the study found that 4,226 of Kuantan's 5,748 hectares of residential land (73.51%) are flood-prone (Figure 10). Existing ECs are concentrated in densely populated residential areas. Buffer analysis identified if ECs are within a 1 km radius of residential areas. The study found that 2,476 hectares (59%) of flood-prone residential land is within the 1 km range (Figure 11), and 41% is outside of that radius.

The intersection of population grid cells in GIS revealed that 119,548 of 355,140 residents in flood-prone areas are within a 1 km radius of an EC. However, the total capacity of all ECs is only 29,700 people at one time (refer to Table 4). This capacity is decided by the government. In the event of a large-scale flood, existing ECs could only accommodate 25% of the affected population within a 1 km radius. The imbalance between shelter capacity distribution and the affected population is due to improper shelter allocation in the emergency planning process. In addition, to the author's knowledge, no research has yet examined the demand for flood shelters in Malaysia.

Kuantan, and elsewhere in Malaysia, makes use of what is known as 'collective shelters'. These are existing buildings, usually schools and public structures, that are used as ECs. Therefore, spatial planning related to risk reduction or disaster management has not been conducted in relation to these buildings.

By looking at capacity and population alone, EC capacity may seem inadequate. However, during interviews with Civil Defence Force Kuantan staff, data on the numbers of people who have evacuated to these centres in recent years were revealed. There were 842 evacuees in 2017 and 8,388 in 2018. Kuantan experienced no flood disasters in 2019, so there were no evacuees. Unfortunately, Kuantan's Civil Defence Force has no record of evacuee numbers prior to 2017.

In conclusion, given the number of people living in floodplain areas, the EC capacity is inadequate but, given the number of evacuees who have used the ECs in recent years, the capacity would appear to be sufficient. An interview with a staff member of the Kuantan local authority revealed that the local authority follows a policy of 'shelter in place', which permits residents to add extra storeys to their houses to escape flooding. However, given the climate change emergency and the possibility of inundation beyond reasonable forecasts, increasing the capacity and number of ECs is highly recommended.

Table 4: Capacity of evacuation centres

No.	Evacuation centres (flood shelters)	Building type	Capacity/person
1.	SJK (c) Chung Ching	School	1000
2.	SMK Tanah Putih	School	300
3.	Dewan JPS Kemunting	Public hall	300
4.	Dewan MAKSAK	Public hall	200
5.	Dewan KRT Kemunting	Public hall	300
6.	SEMSAS	School	1500
7.	SMK Sri Mahkota	School	200
8.	SK Fakeh Abdul Samad	School	200
9.	Dewan Orang Ramai Sri Damai	Public hall	100
10.	Dewan Orang Ramai Jaya Gading	Public hall	100
11.	SMK Gudang Rasau	School	1000
12.	Kolej Kemahiran Tinggi MARA	College	1000
13.	SUKPA	Stadium	1500
14.	SBP Integrasi Kuantan	School	500
15.	SK Sg. Talam	School	250
16.	SK Indera Mahkota Utama	School	100
17.	SK Tengku Azizah	School	100
18.	SJK (Tamil) Indera Mahkota	School	50
19.	Dewan Indera Mahkota Jaya (IM2)	Public hall	300
20.	SMK Pandan	School	1000
21.	SK Pandan	School	250
22.	Wisma Belia	Public hall	500
23.	SMK Panglima Perang	School	300
24.	SMK Cenderawasih	School	1000
25.	SK Pendidikan Khas Indera Mahkota	School	1000
26.	SK Bukit Setongkol	School	1000
27.	SK Indera Mahkota 2	School	300
28.	SK Bukit Sekilau	School	300
29.	SK Bunut Rendang	School	500
30.	SK Mat Kilau	School	500
31.	SMK Mat Kilau	School	500
32.	SK Cherating	School	300
33.	SK Sungai Ular	School	300
34.	SK Kempadang	School	100
35.	SK Sungai Isap Murni	School	300
36.	SK Sungai Karang	School	100
37.	SK Berserah	School	200
38.	SK Kg. Padang	School	100
39.	SMK Tanjung Lumpur	School	100
40.	Dewan PAKR Panching	Public hall	150
41.	Dewan Orang Ramai Kg. Semangat	Public hall	100
42.	Balai Raya Kg. Chendor	Village meeting house	30
43.	Dewan Orang Asli Kg. Bakong	Public hall	300
44.	Dewan Orang Ramai Kampung Kolek	Public hall	315
45.	Rumah Pengerusi JKKK Kampung Seberang	Village meeting house	30
46.	SK Sungai Lembing	School	50
47.	Dewan Semai Bakti Bukit Kuantan	Public hall	100
48.	Dewan Orang Ramai Orang Asli Kg. Sungai Mas	Public hall	670
49.	SJKC Chung Ching 2	School	300
50.	SK Belukar	School	200
51.	SMK Bukit Rangin	School	1000

52.	SMK Sungai Isap	School	300
53.	Dewan Orang Ramai Balok	Public hall	250
54.	Dewan Melati Penjara Penor	Public hall	500
55.	SMK Berserah	School	300
56.	SK Cherok Paloh	School	100
57.	SMK Padang Garuda	School	300
58.	SK Galing	School	200
59.	SK (LKTP) Bukit Kuantan	School	100
60.	Dewan Kg Pandan 1	Public hall	200
61.	Polisas	College	600
62.	SK Cenderawasih	School	300
63.	Bahagian Teknologi Pendidikan Negeri Pahang	Government building	150
64.	Balai Polis Sungai Lembing	Government building	500
65.	Dewan SJKC SG.Lembing	School	300
66.	Dewan Orang Ramai Peramu	Public hall	300
67.	SK Kuala Penor	School	100
68.	SJKC Kwang Hwa	School	250
69.	PSDC	Government building	500
70.	SMK Abdul Rahman	School	300
71.	SK Kg Nadak	School	315
72.	SMK Paya Besar	School	1000
73.	SK Kampung Ubai	School	700
74.	Sekolah Agama KAFA Aman	School	30
75.	Balairaya Kampung Melayu Sg Lembing	Village meeting house	70
76.	Tadika Perpaduan Sri Mahkota Aman	Kindergarten	50
77.	Dewan Orang Ramai Kg. Kempadang	Public hall	200
78.	Balairaya Bukit Kuin 1	Village meeting house	50
79.	Pusat Kegiatan KRT Sri Mahkota Aman	Village meeting house	30
80.	Dewan Orang Ramai Cherok Paloh	Public hall	100
81.	Dewan Orang Ramai Kg. Paya Bungor	Public hall	150
82.	SK Balok	School	300
83.	Pusat Bina Insan Jaya Gading	Village meeting house	30
84.	Balairaya Kampung Kubang Ikan	Village meeting house	30
85.	Dewan Orang Ramai Kg Gelugour	Public hall	200
		Total	**29,700**

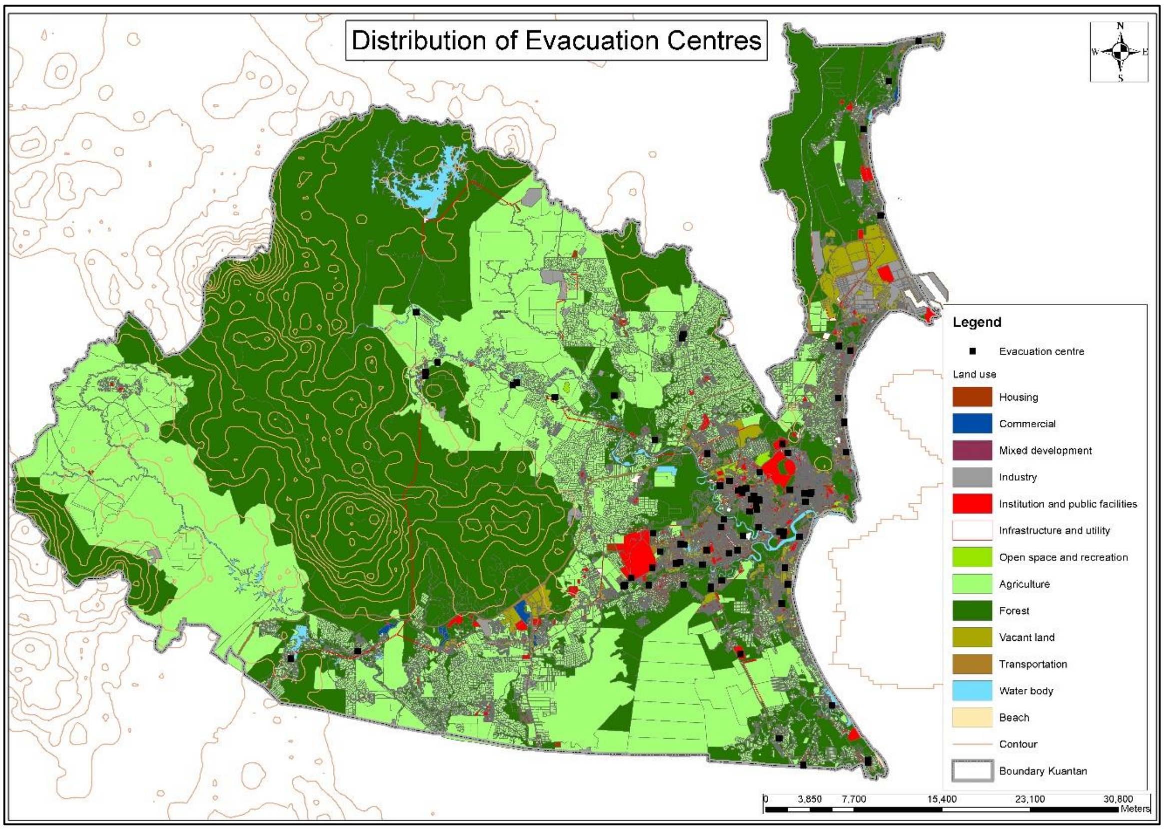

Figure 8: Spatial distribution of evacuation centre

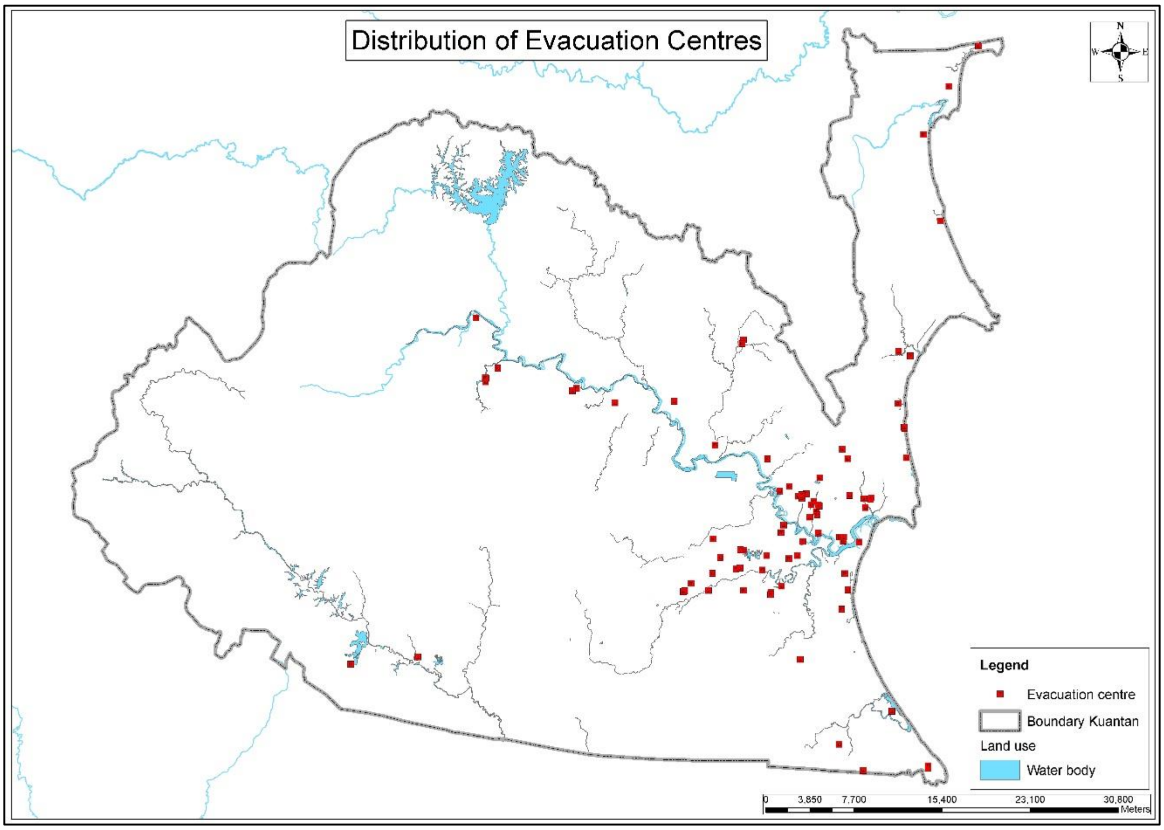

Figure 9: Distribution of evacuation centres

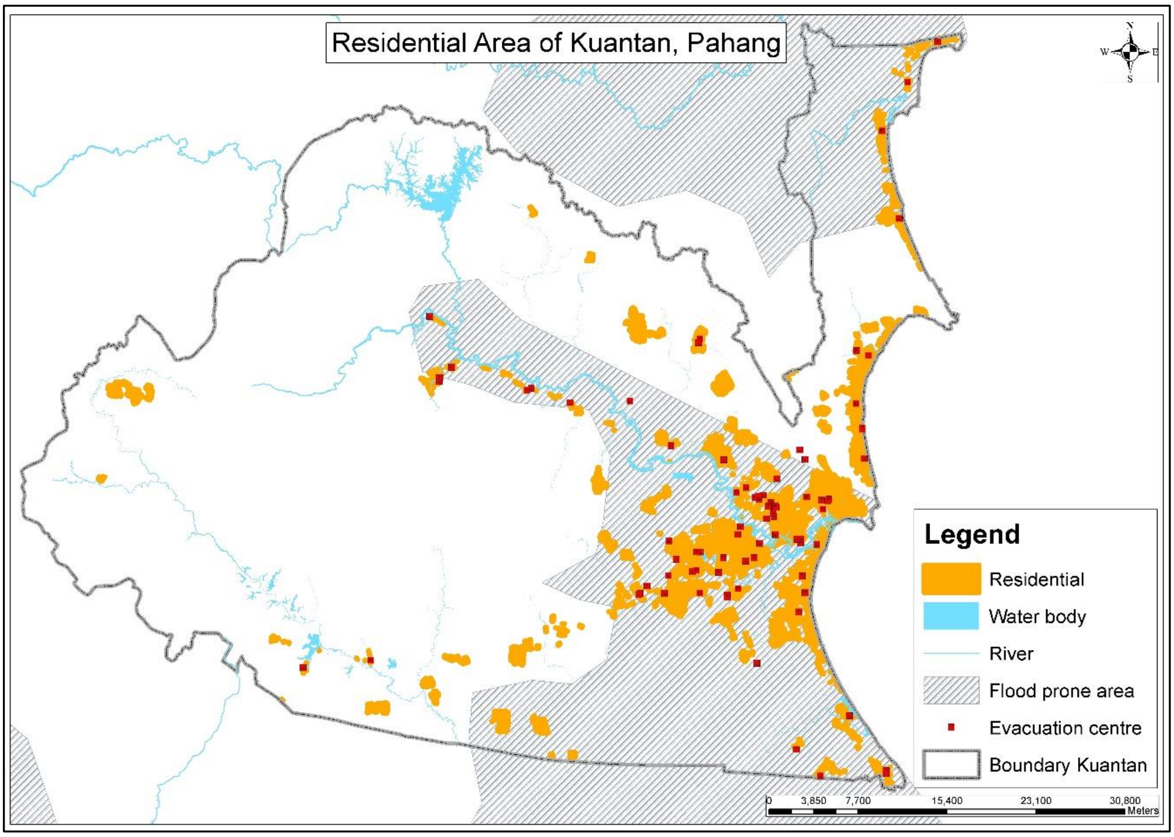

Figure 10: Residential area in Kuantan

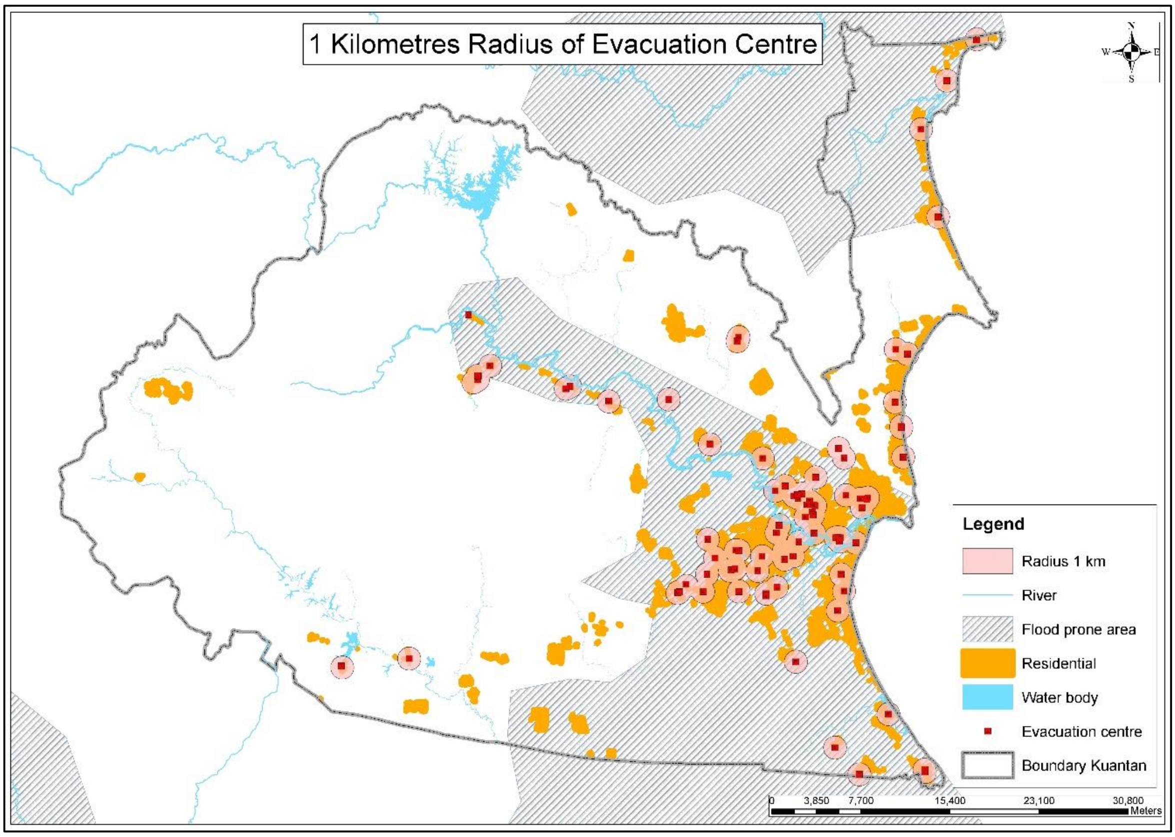

Figure 11: Buffer 1 kilometre radius

4.4.2 Site suitability layer 1: Flood-prone areas

Eighty-five ECs were identified in Kuantan. A flood-prone layer was used to analyse the locations of flood-prone land across the district. An intersect overlay in ArcGIS was used to determine the size of the resident population in flood-prone areas. Of Kuantan District's 296,042 hectares, 168,292.9 hectares (56.8%) are at risk for flooding. Intersection analysis revealed that 355,140 people (80%) live in these flood-prone areas and are vulnerable to flooding. Using flood-prone areas as the lone suitability variable, with no consideration for other indicators, revealed that only 18% of existing shelters are located at appropriate sites, while the remaining 82% are located in flood-prone areas (Figure 12).

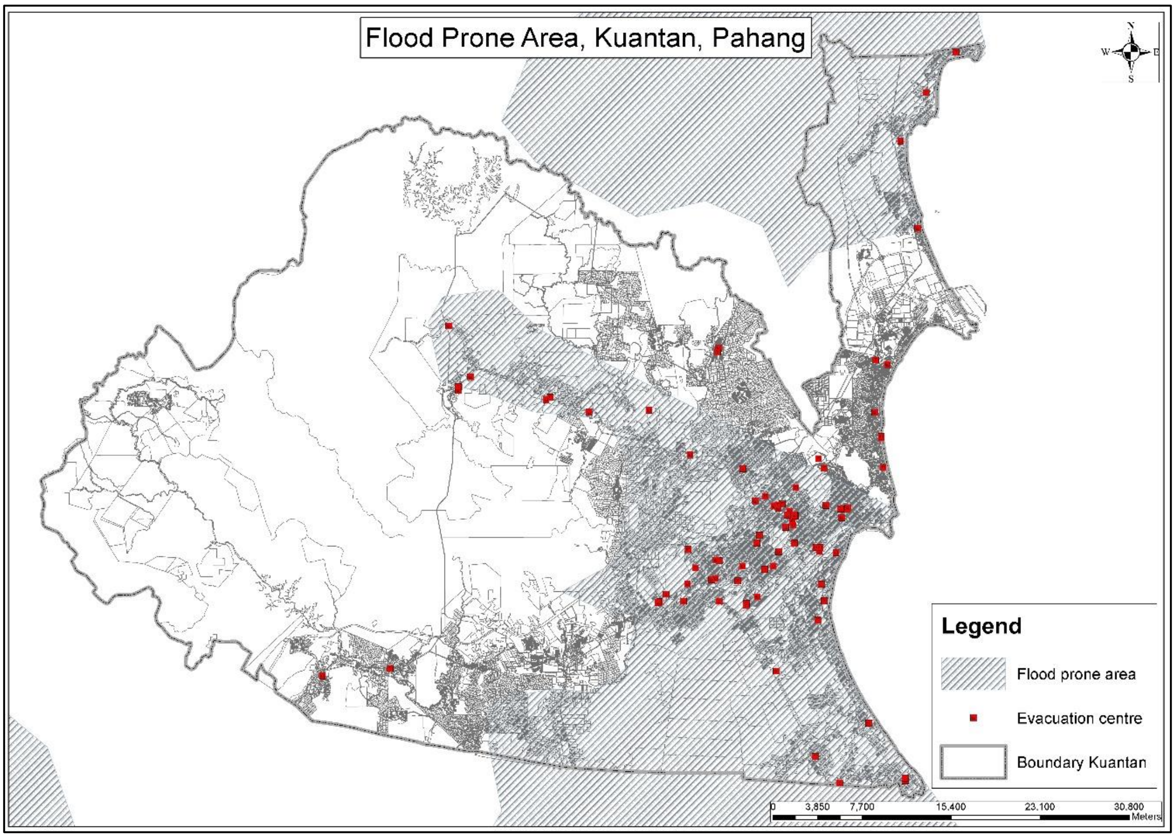

Figure 12: Flood prone area Kuantan

4.4.3 Site suitability layer 2: Secondary disasters (landslides)

Secondary disasters in Malaysia, most notably, landslides, usually occur after heavy rainfall (Chan, 2015a). Using the PLANMalaysia disaster GIS layer, some ECs were found to be in proximity to areas at low risk of landslide (refer to Figure 13). The proximity tool found that 4% of ECs are located 1.4 km to 1.9 km from possible landslide areas while the remaining 96% are more than 9.4 km away. However, since this layer represents a low landslide risk, ECs may not be largely affected by landslides. In addition, the distance travelled by landslide debris depends on elevation and land structure.

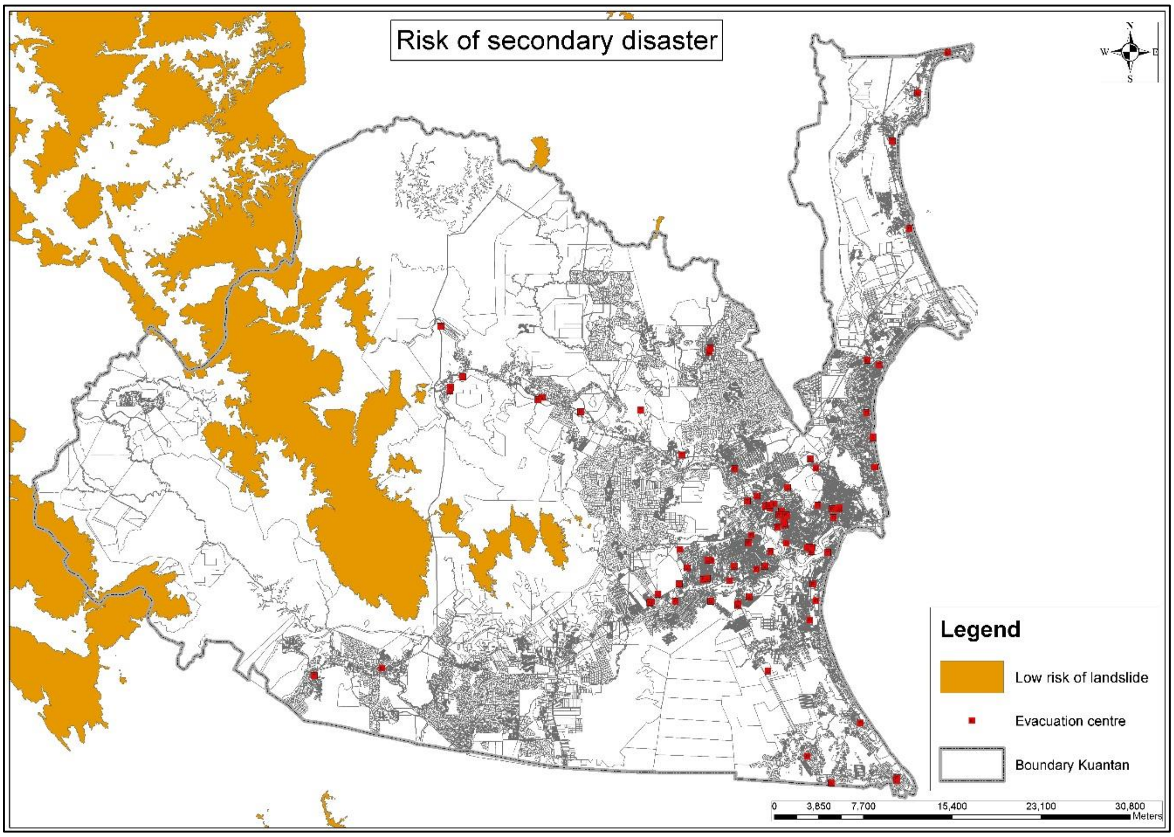

Figure 13: Secondary disaster

4.4.4 Site suitability layer 3: Elevation

The elevation of each EC was determined using DEM in ArcGIS (see Figure 14 and Table 5). The DEM revealed that 2% of ECs are at elevations of 5 m and below, 45% are between 5.1 m and 10 m, 12% are between 10.1 m and 15 m and 41% are above 15 m. The highest flood-prone area is at an elevation of 41 m. Western Kuantan is at a high elevation and is not affected by floods. Here, land is used for forest reserves and development is restricted by law (Majlis Perbandaran Kuantan, 2019b).

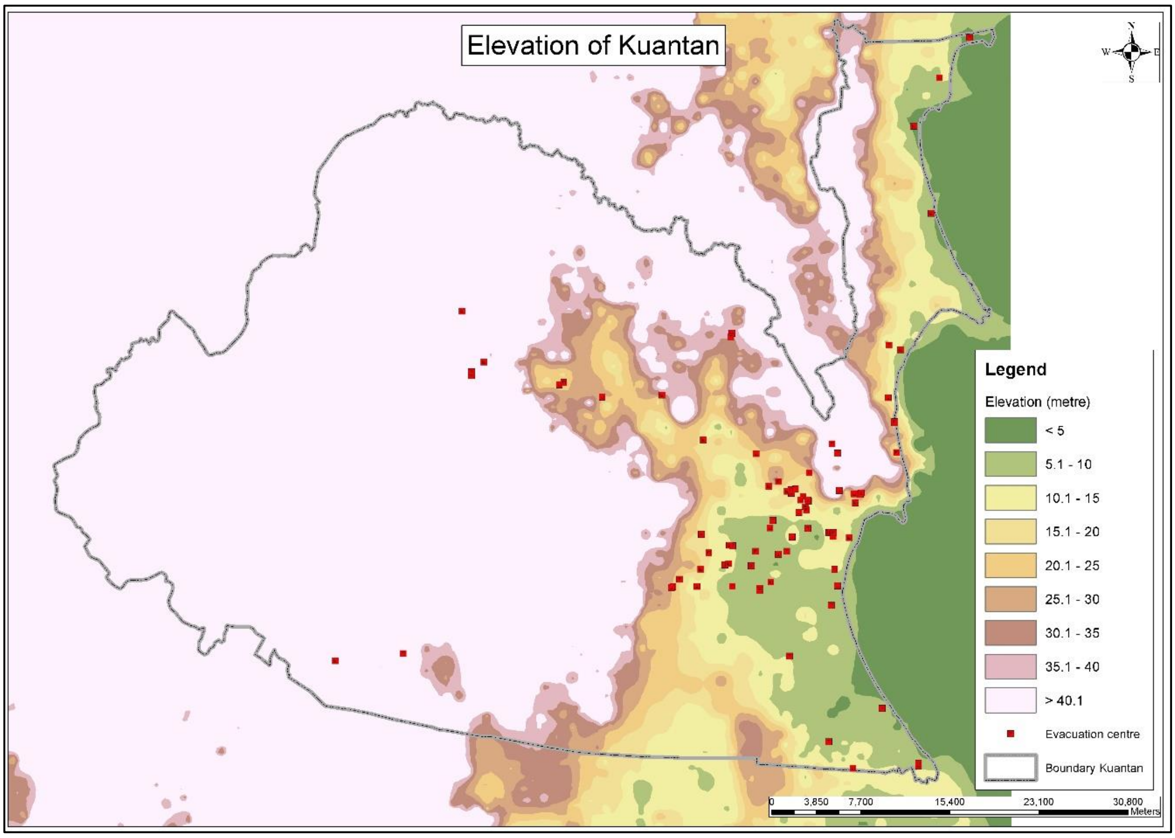

Figure 14: Location of ECs relative to the elevation of Kuantan

Table 5: Elevation of evacuation centres

No.	Evacuation centres (flood shelters)	Building type	Elevation
1.	SJK (c) Chung Ching	School	6
2.	SMK Tanah Putih	School	6
3.	Dewan JPS Kemunting	Public hall	11
4.	Dewan MAKSAK	Public hall	8
5.	Dewan KRT Kemunting	Public hall	6
6.	SEMSAS	School	12
7.	SMK Sri Mahkota	School	20
8.	SK Fakeh Abdul Samad	School	11
9.	Dewan Orang Ramai Sri Damai	Public hall	9
10.	Dewan Orang Ramai Jaya Gading	Public hall	18
11.	SMK Gudang Rasau	School	5
12.	Kolej Kemahiran Tinggi MARA	College	7
13.	SUKPA	Stadium	28
14.	SBP Integrasi Kuantan	School	27
15.	SK Sg. Talam	School	20
16.	SK Indera Mahkota Utama	School	30
17.	SK Tengku Azizah	School	41
18.	SJK (Tamil) Indera Mahkota	School	35
19.	Dewan Indera Mahkota Jaya (IM2)	Public hall	12
20.	SMK Pandan	School	9
21.	SK Pandan	School	9
22.	Wisma Belia	Public hall	12
23.	SMK Panglima Perang	School	15
24.	SMK Cenderawasih	School	9
25.	SK Pendidikan Khas Indera Mahkota	School	20
26.	SK Bukit Setongkol	School	5
27.	SK Indera Mahkota 2	School	20
28.	SK Bukit Sekilau	School	24
29.	SK Bunut Rendang	School	7
30.	SK Mat Kilau	School	7
31.	SMK Mat Kilau	School	7
32.	SK Cherating	School	7
33.	SK Sungai Ular	School	10
34.	SK Kempadang	School	8
35.	SK Sungai Isap Murni	School	14
36.	SK Sungai Karang	School	8
37.	SK Berserah	School	9
38.	SK Kg. Padang	School	22
39.	SMK Tanjung Lumpur	School	7
40.	Dewan PAKR Panching	Public hall	24
41.	Dewan Orang Ramai Kg. Semangat	Public hall	7
42.	Balai Raya Kg. Chendor	Village meeting house	7
43.	Dewan Orang Asli Kg. Bakong	Public hall	25
44.	Dewan Orang Ramai Kampung Kolek	Public hall	19
45.	Rumah Pengerusi JKKK Kampung Seberang	Village meeting house	8
46.	SK Sungai Lembing	School	43
47.	Dewan Semai Bakti Bukit Kuantan	Public hall	27
48.	Dewan Orang Ramai Orang Asli Kg. Sungai Mas	Public hall	39
49.	SJKC Chung Ching 2	School	9
50.	SK Belukar	School	8
51.	SMK Bukit Rangin	School	6
52.	SMK Sungai Isap	School	6
53.	Dewan Orang Ramai Balok	Public hall	7
54.	Dewan Melati Penjara Penor	Public hall	9

55.	SMK Berserah	School	11
56.	SK Cherok Paloh	School	8
57.	SMK Padang Garuda	School	31
58.	SK Galing	School	7
59.	SK (LKTP) Bukit Kuantan	School	19
60.	Dewan Kg Pandan 1	Public hall	17
61.	Polisas	College	51
62.	SK Cenderawasih	School	8
63.	Bahagian Teknologi Pendidikan Negeri Pahang	Government building	11
64.	Balai Polis Sungai Lembing	Government building	32
65.	Dewan SJKC SG.Lembing	School	33
66.	Dewan Orang Ramai Peramu	Public hall	7
67.	SK Kuala Penor	School	8
68.	SJKC Kwang Hwa	School	38
69.	PSDC	Government building	41
70.	SMK Abdul Rahman	School	9
71.	SK Kg Nadak	School	18
72.	SMK Paya Besar	School	6
73.	SK Kampung Ubai	School	14
74.	Sekolah Agama KAFA Aman	School	21
75.	Balairaya Kampung Melayu Sg Lembing	Village meeting house	30
76.	Tadika Perpaduan Sri Mahkota Aman	Kindergarten	20
77.	Dewan Orang Ramai Kg. Kempadang	Public hall	8
78.	Balairaya Bukit Kuin 1	Village meeting house	19
79.	Pusat Kegiatan KRT Sri Mahkota Aman	Village meeting house	20
80.	Dewan Orang Ramai Cherok Paloh	Public hall	8
81.	Dewan Orang Ramai Kg. Paya Bungor	Public hall	49
82.	SK Balok	School	8
83.	Pusat Bina Insan Jaya Gading	Village meeting house	19
84.	Balairaya Kampung Kubang Ikan	Village meeting house	9
85.	Dewan Orang Ramai Kg Gelugour	Public hall	41
		Total	**29,700**

4.4.5 Site suitability layer 4: Slope

Ideally, ECs should be located on slopes between 2% and 5% but not exceeding 7%. An appropriate slope ensures easy access for disabled evacuees and for the transportation of goods. The International Federation of Red Cross and Red Crescent Societies has highlighted the importance of slope in its guidelines for the building of safe emergency shelters. A slope map of Kuantan revealed that 1% of ECs are located on slopes exceeding 7% and are, thus, unsuitable. Meanwhile, 86% of ECs are located on slopes less than 1.5%, 9% are on slopes up to 4%, and 4% on slopes between 4% and 7%. Based on the slope criteria, 99% of ECs in Kuantan are on acceptable slope ranges.

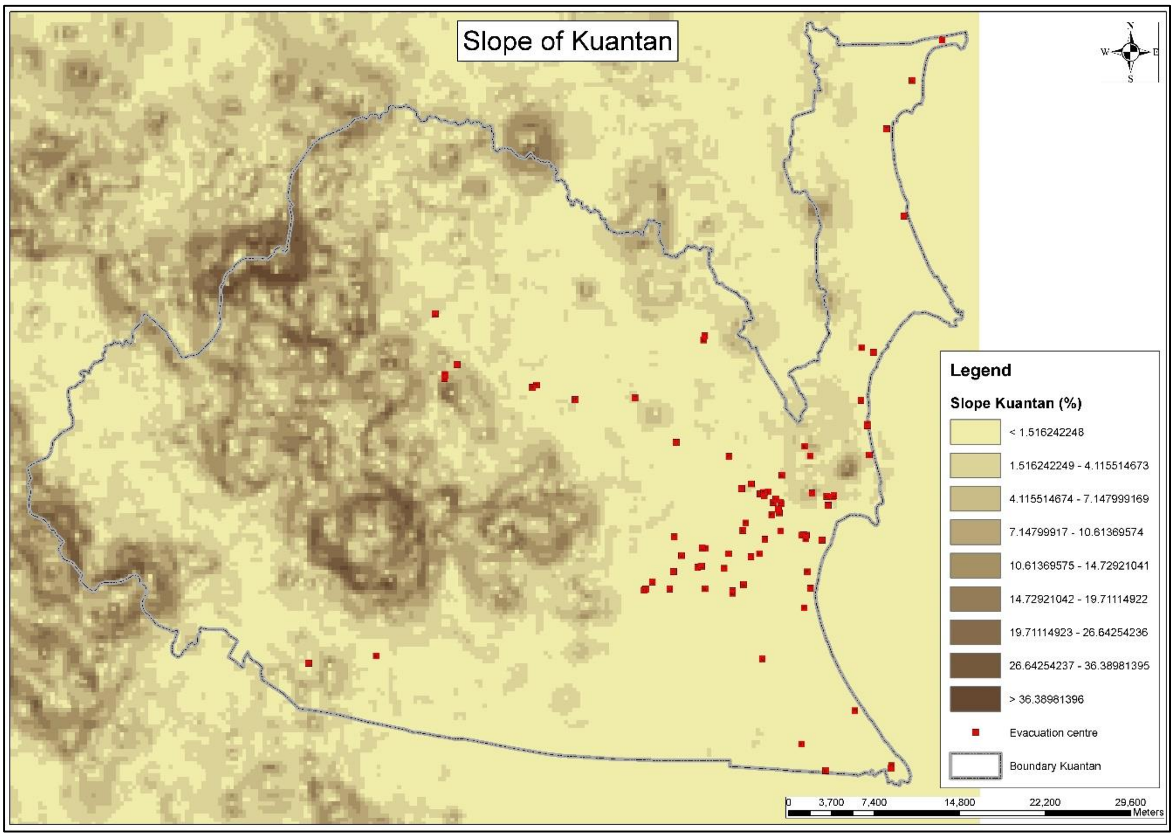

Figure 15: Slope map of Kuantan

4.5 Weighted Overlay Site Suitability Analysis

To analyse final site suitability, all variables (criteria) in the above GIS findings were converted to raster format, reclassified and overlaid using Spatial Analyst – Weighted Overlay.

The weights were processed using the AHP scale to attain the final suitability results. WOA in GIS allows rankings to use 0 for 'not suitable' or to mark them as 'restricted' so that certain elements can be excluded. Here, 'restricted' was chosen to set certain areas as limited or 'very unsuitable' for the siting of ECs due to their vulnerability to risks, such as landslides, or because they were part of the 91.23% of Kuantan that is made up of forest reserve or agricultural land. In addition, industrial areas were classified as restricted, as ECs should not be built near them. The influence, measured as a percentage, of AHP in GIS for every weight was set as equal, as all criteria are equally important in the suitability analysis. Table 6 shows the weighted overlay criteria integrated with AHP in GIS.

The final site suitability map (Figure 16 and Table 7) revealed that 21% of ECs in Kuantan are in unsuitable sites, 32% are in moderate to more suitable sites, 39% are in very suitable sites and 8% are in extremely suitable sites. The least suitable sites are located near industrial areas, in areas with a low risk of landslides, or near rivers or beaches.

Table 6: Weighted overlay

Criteria (raster layer)	Influence (%)	Field	Scale value (AHP)	Description scale
Flood prone area	25%	Flood area	1	Less suitable
Secondary disasters	25%	Landslide	Restricted	Restricted
Elevation	25%	<5 m	1	Less suitable
		5.1 m – 10 m	3	Moderately suitable
		10.1 m – 15m	5	More suitable
		15.1 m – 20 m	7	Very suitable
		>20.1 m	9	Extremely suitable
Slope	25%	1%-1.9%	5	More suitable
		2%-4%	9	Extremely suitable
		4.1%-5%	7	Very suitable
		>5%	1	Less suitable
Land use	25%	Residential	9	Extremely suitable
		Industrial	Restricted	Restricted
		Forest reserve	Restricted	Restricted
		Agriculture	Restricted	Restricted
		Water body (river,beach)	Restricted	Restricted

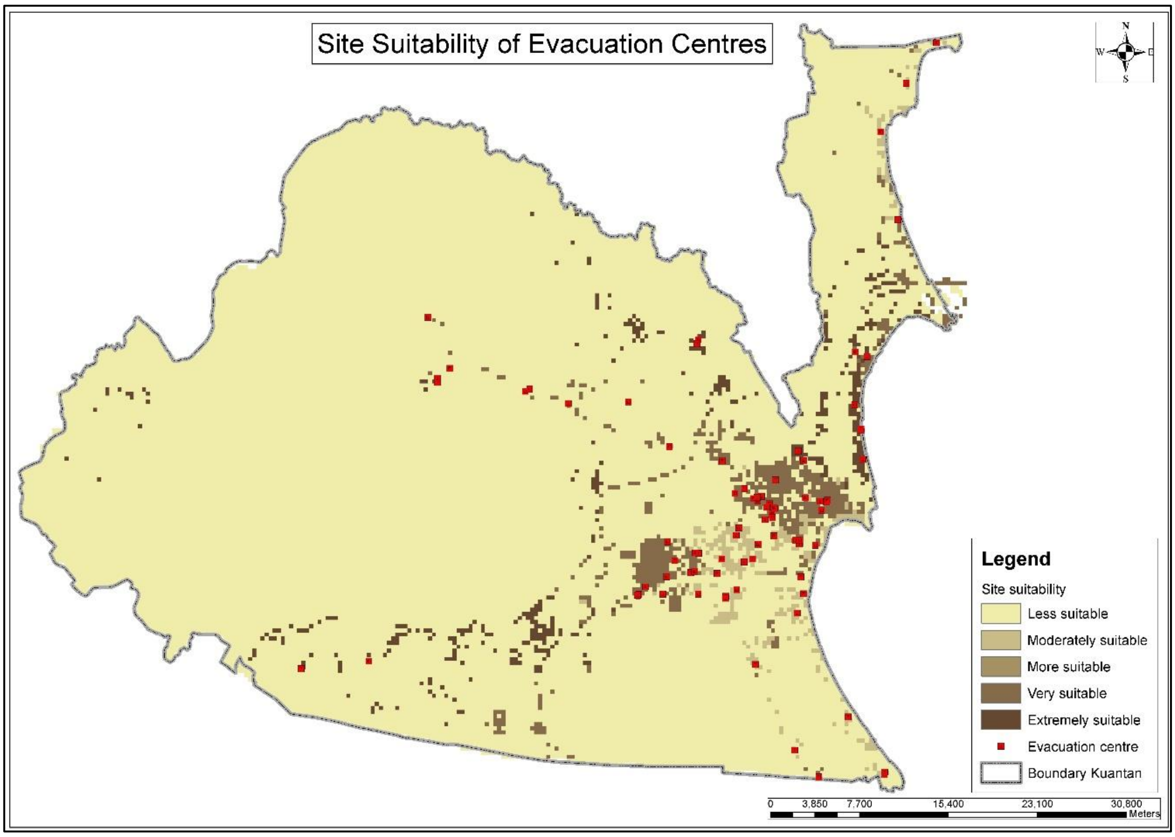

Figure 16: Site suitability of ECs

Table 7: Suitability and floor level of evacuation centre

No.	Evacuation centres (flood shelters)	Building type	Capacity /person	Size (m^2)	Number of storey	Site suitability
1.	SJK (c) Chung Ching	School	1000	1952.9	3	Very suitable
2.	SMK Tanah Putih	School	300	1610.34	3	More suitable
3.	Dewan JPS Kemunting	Public hall	300	680.43	1	More suitable
4.	Dewan MAKSAK	Public hall	200	781.20	1	Very suitable
5.	Dewan KRT Kemunting	Public hall	300	406.93	1	Very suitable
6.	SEMSAS	School	1500	4582.83	4	More suitable
7.	SMK Sri Mahkota	School	200	1414.37	3	Very suitable
8.	SK Fakeh Abdul Samad	School	200	1282.16	4	Very suitable
9.	Dewan Orang Ramai Sri Damai	Public hall	100	182.58	1	More suitable
10.	Dewan Orang Ramai Jaya Gading	Public hall	100	843.72	1	Less suitable
11.	SMK Gudang Rasau	School	1000	5183.48	2	More suitable
12.	Kolej Kemahiran Tinggi MARA	College	1000	2365.56	1	More suitable
13.	SUKPA	Stadium	1500	6583.8	1	Very suitable
14.	SBP Integrasi Kuantan	School	500	1193.95	1	Very suitable
15.	SK Sg. Talam	School	250	1816.28	3	Very suitable
16.	SK Indera Mahkota Utama	School	100	727.51	4	Very suitable
17.	SK Tengku Azizah	School	100	346.92	3	Very suitable
18.	SJK (Tamil) Indera Mahkota	School	50	648.37	3	Very suitable
19.	Dewan Indera Mahkota Jaya (IM2)	Public hall	300	709.63	1	Less suitable
20.	SMK Pandan	School	1000	3786.92	4	More suitable
21.	SK Pandan	School	250	758.71	4	More suitable
22.	Wisma Belia	Public hall	500	1992.66	2	Very suitable
23.	SMK Panglima Perang	School	300	1088	3	More suitable
24.	SMK Cenderawasih	School	1000	2160	4	More suitable
25.	SK Pendidikan Khas Indera Mahkota	School	1000	2015.68	4	Very suitable

26.	SK Bukit Setongkol	School	1000	2483.19	3	More suitable
27.	SK Indera Mahkota 2	School	300	842.44	4	Very suitable
28.	SK Bukit Sekilau	School	300	974.36	3	Very suitable
29.	SK Bunut Rendang	School	500	2101.06	3	More suitable
30.	SK Mat Kilau	School	500	2021.14	3	More suitable
31.	SMK Mat Kilau	School	500	2114.09	4	More suitable
32.	SK Cherating	School	300	1193.88	4	Less suitable
33.	SK Sungai Ular	School	300	1399.9	2	Less suitable
34.	SK Kempadang	School	100	471.66	4	More suitable
35.	SK Sungai Isap Murni	School	300	741.29	3	Very suitable
36.	SK Sungai Karang	School	100	643.95	3	Less suitable
37.	SK Berserah	School	200	720.09	1	Extremely suitable
38.	SK Kg. Padang	School	100	374.43	1	Very suitable
39.	SMK Tanjung Lumpur	School	100	968.54	3	More suitable
40.	Dewan PAKR Panching	Public hall	150	573.40	1	Less suitable
41.	Dewan Orang Ramai Kg. Semangat	Public hall	100	385.06	1	More suitable
42.	Balai Raya Kg. Chendor	Village meeting house	30	133.87	1	More suitable
43.	Dewan Orang Asli Kg. Bakong	Public hall	300	824.28	1	Less suitable
44.	Dewan Orang Ramai Kampung Kolek	Public hall	315	690.86	1	Less suitable
45.	Rumah Pengerusi JKKK Kampung Seberang	Village meeting house	30	156.33	1	Very suitable
46.	SK Sungai Lembing	School	50	180.43	2	Less suitable
47.	Dewan Semai Bakti Bukit Kuantan	Public hall	100	316.48	1	Extremely suitable
48.	Dewan Orang Ramai Orang Asli Kg. Sungai Mas	Public hall	670	1415.14	1	Less suitable
49.	SJKC Chung Ching 2	School	300	697.28	3	Less suitable
50.	SK Belukar	School	200	541.9	1	More suitable
51.	SMK Bukit Rangin	School	1000	2842.09	4	More suitable

52.	SMK Sungai Isap	School	300	1256.23	4	More suitable
53.	Dewan Orang Ramai Balok	Public hall	250	516.17	1	Extremely suitable
54.	Dewan Melati Penjara Penor	Public hall	500	1793.76	1	More suitable
55.	SMK Berserah	School	300	1174.31	1	Extremely suitable
56.	SK Cherok Paloh	School	100	481.23	2	More suitable
57.	SMK Padang Garuda	School	300	849.18	1	Very suitable
58.	SK Galing	School	200	609.23	4	Very suitable
59.	SK (LKTP) Bukit Kuantan	School	100	375.47	1	Extremely suitable
60.	Dewan Kg Pandan 1	Public hall	200	402.98	1	Very suitable
61.	Polisas	College	600	1252.25	2	Extremely suitable
62.	SK Cenderawasih	School	300	1493.92	2	Less suitable
63.	Bahagian Teknologi Pendidikan Negeri Pahang	Governm ent building	150	1073.01	1	Extremely suitable
64.	Balai Polis Sungai Lembing	Governm ent building	500	736.53	3	Very suitable
65.	Dewan SJKC SG.Lembing	School	300	652.62	2	Very suitable
66.	Dewan Orang Ramai Peramu	Public hall	300	693.08	2	Less suitable
67.	SK Kuala Penor	School	100	266.6	1	More suitable
68.	SJKC Kwang Hwa	School	250	1316.59	1	Very suitable
69.	PSDC	Governm ent building	500	1298.49	2	Less suitable
70.	SMK Abdul Rahman	School	300	998.24	4	Very suitable
71.	SK Kg Nadak	School	315	727.16	2	Less suitable
72.	SMK Paya Besar	School	1000	2758.11	3	More suitable
73.	SK Kampung Ubai	School	700	2405.46	1	Very suitable
74.	Sekolah Agama KAFA Aman	School	30	240.25	1	Very suitable
75.	Balairaya Kampung Melayu Sg Lembing	Village meeting house	70	165.56	1	Very suitable
76.	Tadika Perpaduan Sri Mahkota Aman	Kinderga rten	50	186.10	1	Very suitable

77.	Dewan Orang Ramai Kg. Kempadang	Public hall	200	408.31	1	More suitable
78.	Balairaya Bukit Kuin 1	Village meeting house	50	161.24	1	Very suitable
79.	Pusat Kegiatan KRT Sri Mahkota Aman	Village meeting house	30	152.43	1	Very suitable
80.	Dewan Orang Ramai Cherok Paloh	Public hall	100	287.50	1	More suitable
81.	Dewan Orang Ramai Kg. Paya Bungor	Public hall	150	147.50	1	Less suitable
82.	SK Balok	School	300	920.37	4	Very suitable
83.	Pusat Bina Insan Jaya Gading	Village meeting house	30	185.68	1	Very suitable
84.	Balairaya Kampung Kubang Ikan	Village meeting house	30	118.72	1	Less suitable
85.	Dewan Orang Ramai Kg Gelugour	Public hall	200	347.57	1	Less suitable
		Total	**29,700**			

4.7 Accessibility Analysis (Network Service Area)

The site suitability map also identified unsuitable spatial locations for evacuation areas. However, geo-spatial criteria were used to process the map in the absence of an analysis of the centres' accessibility to flood victims. Assuming that a location's suitability might not necessarily correlate with good access, a service area analysis was performed to examine road networks and accessibility.

A service area analysis helps to define the total number of people in a certain area who can reach ECs in a given time, while accessibility analysis identifies whether suitably sited ECs have good accessibility. Service area analysis involves forming a polygon covering all accessible roads within the specified time which, in this case, is 15 minutes. This polygon was overlaid with population data to identify the populations that could access each particular EC.

Of the 85 ECs, 40 are located at very suitable or extremely suitable sites. Therefore, a network service area analysis of these 40 ECs was conducted. The blue polygon in Figure 17 shows the accessibility for population centres, including all streets from which an EC is accessible on foot within 15 minutes.

The service area analysis results showed that 95% of those 40 suitable EC sites, which are, for the most part, located in Kuantan city centre, have good road network accessibility. Only 5% have low accessibility by foot and can be reached by only 70% of people in 15 minutes. This means that 246,418 people can reach an EC on foot in 15 minutes. However, these suitably sited ECs only have the capacity for 12,140 evacuees.

To increase the capacity of ECs at suitable sites, a network service area analysis and a site suitability analysis were performed so that additional ECs may be allocated to areas with high population density. The following section proposes new shelters at the suitable sites identified in the previous analysis.

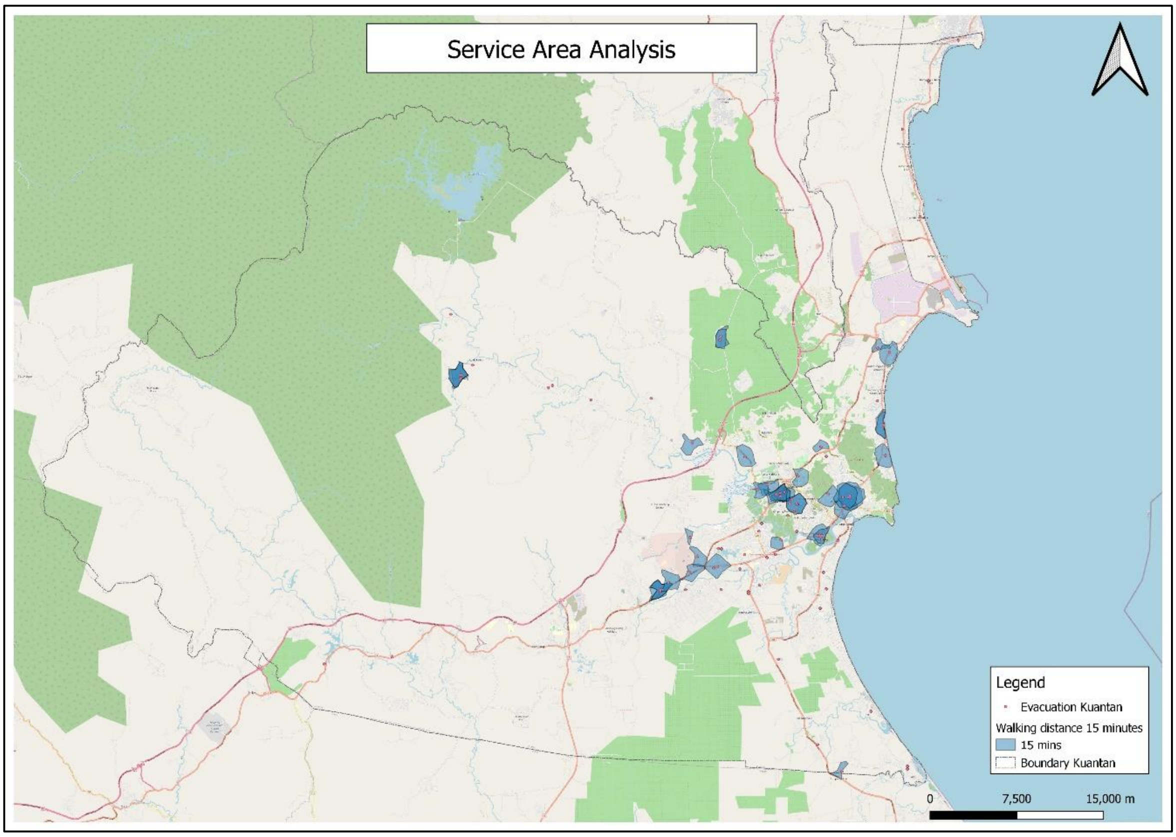

Figure 17: Service area analysis showing location of suitable ECs within 15 minutes walking distance of residential streets

4.8 Proposed Evacuation Centres at Suitable Sites

Based on the site suitability map and service area analysis, additional shelters at very or extremely suitable sites are proposed to increase EC capacity in Kuantan District. Assuming that each person requires 2 m^2 of floor space, flood evacuation building capacity was estimated using the following formula (Budiarjo, 2006; Dewi, 2012; Widyaningrum, 2009):

$$FSBC = (CS \times BA \times NrF) / (SpP)$$

Where FSBC is flood shelter building capacity; CS is capacity score, measured as a percentage (see below); BA is building area, measured in m^2; NrF is number of floors in a building; and SpP is the space required for one person, measured in m^2.

The capacity scores are 78% for mosques, 30% for schools, 23.6% for offices, 23% for markets or malls, 26.3% for hotels and 100% for halls or galleries. According to Dewi (2012) and Budiarjo (2006), the capacity score depends on the type of building since the available space for each will be different.

According to Budiarjo (2006) and Dewi (2012), the capacity score depends on the type of building, as the available space will differ for each. The measure was introduced by Budiarjo (2006) using an architectural approach. For example, a mosque scores 78% for flood evacuation building capacity. This is based on the following calculation: A mosque's size design allocates 1.8 m^2 per person, which consists of 1.2 m^2 for prayer, 0.2 m^2 for circulation and 0.4 m^2 for utilities and other support facilities. The areas of the mosque that could be used to house evacuees are the prayer area (1.2/1.8 = 67%) and the circulation area (0.2/1.8 = 11%). Therefore, the total room space available for evacuation is 78% (67% + 11%) of the total building area (Budiarjo, 2006; Dewi, 2012).

To increase the service area and shelter capacity to meet the size of the population, fourteen additional buildings in Kuantan are proposed as flood shelters at very suitable and extremely suitable sites. Collectively, these shelters have a capacity of 15,464. Figure 18 and Table 8 show the area of the proposed ECs.

While the capacity of these proposed shelters cannot completely compensate for the insufficient capacity of existing ECs, site suitability analysis helped identify suitable locations for additional flood shelters. This demonstrates that future emergency planning activities can determine an even wider range of the most suitable flood shelter locations.

Table 8: Proposed flood shelters

No.	Evacuation centres (flood shelters)	Building type	Capacity /person	Size (m^2)	Number of story	Elevation
1	SK Assunta Convent	School	224	746.34	2	23
2	SK Pengkalan Tentera	School	1213	2021.59	4	22
3	SJKC Kong Min	School	654	1090.98	4	10
4	Dewan SJKC Kong Min	Public hall	276	552.12	1	10
5	SMK Alor Akar	School	998	3329.84	2	11
6	SMK Lepar Hilir	School	1473	3274.53	3	31
7	SMK Tok Sera	School	2907	4846.49	4	23
8	SMK St Thomas	School	646	1076.11	4	13
9	SMK Abu Bakar	School	999	2219.25	3	11
10	SMK Air putih	School	831	791.37	7	11
11	SMK Teknik Kuantan	School	2508	5572.78	3	13
12	Dewan Taman Tas	Public hall	324	648.49	1	10
13	Dewan Serbaguna MPK Air Putih	Public hall	319	637.09	1	21
14	Dewan Serbaguna Indera Mahkota	Public hall	2092	4183.7	1	30
		Total	15464			

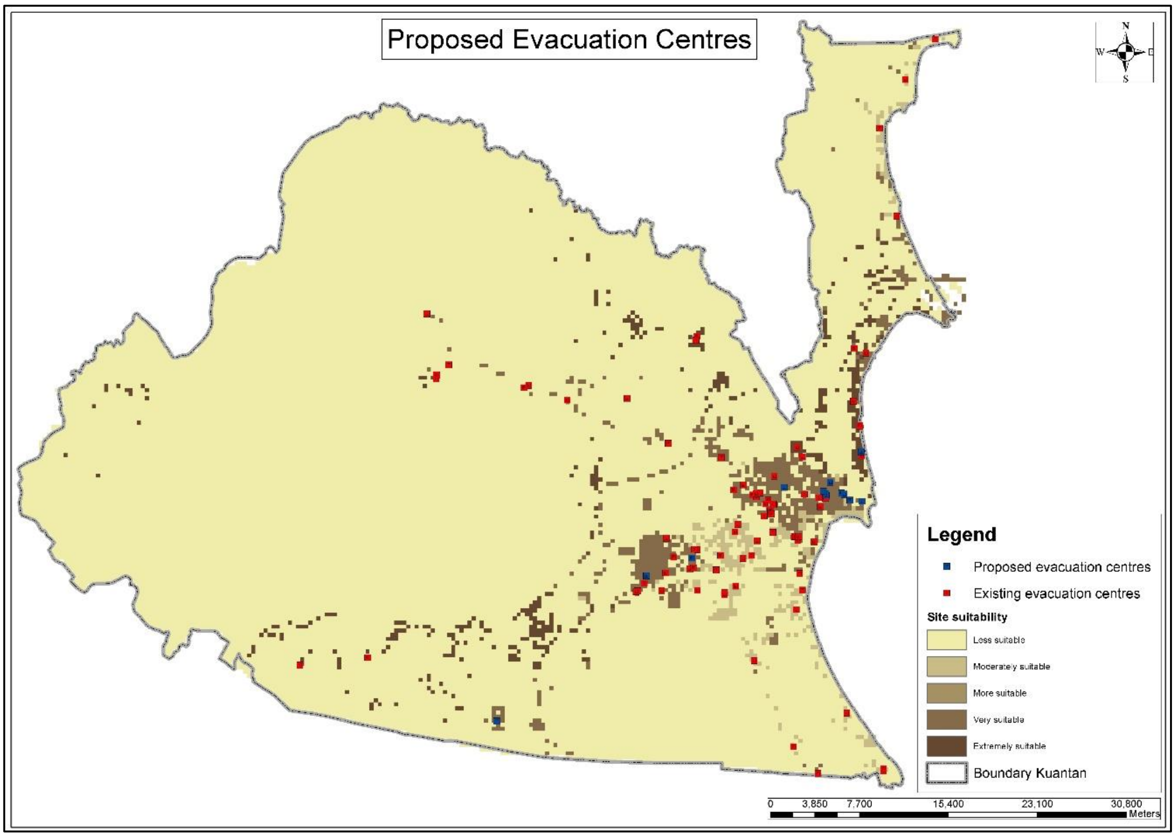

Figure 18: Proposed evacuation centres

4.9 The institutional issues for ECs site suitability

The issues and challenges facing flood-related agencies in Kuantan with regard to EC site suitability include a lack of knowledge of site suitability criteria on the part of the agencies and officers involved. The Local Authority of Kuantan has the authority to ensure that all development proposals must include ECs at safe locations. However, due to a lack of knowledge, the local government is unaware of the importance of providing ECs at safe sites in the face of the climate change emergency and an increase in flooding events. EC elements have not been included in the formulation of the Kuantan Local Plan.

The Kuantan Department of Social Welfare is the agency responsible for selecting and managing ECs. This role and its responsibilities are stipulated in Directive No. 20. However, the agency is independent and unrelated to either FRM or urban planning. Therefore, the selection of ECs is made without consideration for geo-spatial characteristics. For example, SK Sungai Ular, a school building gazetted as an EC, was previously inundated during a flooding event. Specific evacuation rules and policies should be in place at the local level in Kuantan.

Therefore, Kuantan Municipal Council should incorporate the elements of safe EC sites into its development plan. Geo-spatial criteria, rainfall intensity, and annual flood magnitude should be the basis for EC site assessment. Yet, there are no official assessments of existing ECs to examine their suitability. This is due to the lack of a standardised evaluation process, and a lack of government provision for mandatory EC assessment. In addition, those agencies responsible for flood mitigation measures, such as DID, currently only focus on structural measures.

4.10 Results and Discussion

The GIS-based multi-criteria WOA, which consists of a land use map overlaid with other criteria, forms the core of this study. Overlay is important in showing the relationships between criteria. The flood-prone area map (Figure 12) indicates the areas in Kuantan that are affected by floods. Of these, 56.8% are categorised as flood-prone, corresponding to 168,292.9 of Kuantan's total area of 296,042 hectares. The analysis revealed that 82% of ECs in Kuantan are located in flood-prone areas that, according to the defined criteria, were initially unacceptable.

However, from another perspective, Chowdhury et al., (1998) in Sanyal and Lu (2009) argue that a practical way to mitigate flood hazards in developing countries is to build flood shelters in highly flood-prone residential areas to provide maximum protection for planning units and minimise the overall risk of vulnerable communities. This is supported by Kusumo (2016), who found that a majority of residents prefer evacuating to flood-prone areas if they are located within their residential area.

In this case, it would be acceptable to have most flood shelters located in flood-prone areas, as 73.51% of residential settlements are in zones vulnerable to flooding. In addition, 95% of Kuantan's ECs are in or near residential areas (Figure 10). According to buffer analysis and intersect overlay, 59% of residential areas in flood-prone locations are within a 1 km radius of an EC.

At present, ECs in Kuantan have a total capacity for only 29,700 evacuees, compared to the 355,140 residents who are at risk of flooding. In addition, since 66% of affected residential areas are outside the 1 km radius of ECs, the proportion of ECs to affected residential areas and populations is insufficient. There is clearly no scientific basis to evacuation siting decisions, meaning that more ECs need to be built to support disaster-affected residential areas.

The slope on which ECs are located is also an important consideration, with 86% of Kuantan's ECs located on slopes of less than 1.5%, 13% on slopes of less than 7%, and only 1% on steep slopes. Therefore, based on topographic characteristics, most current ECs sites are suitable.

This study conducted a collective analysis of all ECs in order to examine the overall coverage of existing ECs in Kuantan and to identify potential locations for the siting of new or additional ECs. Based on site suitability analysis, 21% of ECs were found to be in unsuitable sites, 32% at moderate to more suitable sites, 39% at very suitable sites and 8% at extremely suitable sites. Those EC sites categorised as unsuitable are located near industrial areas, near places with a low risk of landslides, on steep slopes or near low-elevation streams and beaches with a high possibility of inundation and secondary disasters. This finding is consistent with those of Kar and Hodgson (2008) and Kusumo (2016), who found that emergency shelters near industrial areas, streams and beaches must be considered physically unsuitable.

Overall, only 47% of Kuantan's ECs are located at suitable sites. The network service area analysis found that 95% of these suitably sited ECs have good road network accessibility, mostly in the city centre. Only 5% have low walking accessibility, and only 70%, or 246,418, of people can reach them on foot in 15 minutes.

Integrating the site suitability map and the service area analysis revealed the potential for additional flood shelters at suitable locations, increasing the EC capacity by 12,140 people. Therefore, from the suitability findings, it is highly recommended that more shelters are added at suitable locations. In addition, EC capacity can be increased through construction. Existing shelters should consider the number of floors as one criterion to maximise capacity. The government should take steps to increase the number of ECs to protect vulnerable residential areas.

There is a lack of understanding of the requirements for EC site suitability among the relevant agencies and officers. Development proposals submitted to the local authority lack provision for secure evacuation sites, and evacuation considerations have not been included in the Kuantan Local Plan. The agency responsible for choosing and managing ECs is not associated with FRM or urban planning. The selection of ECs is, therefore, rendered without taking geo-spatial characteristics into consideration. A further problem is the lack of clear evacuation laws and policies at the local level in Kuantan. Research by Jerolleman (2020) has shown that effects can best be mediated at the local level, where the most effective risk reduction measures can be taken and the most effective policies implemented. The Kuantan Municipal Council should integrate EC site safety criteria into its growth plan and local plan.

The exogenous factors affecting the suitability level of existing ECs lie within FRM Malaysia's top-down approach at the flood preparedness and flood response stages. This is because, as stipulated in Directive No. 20, EC locations are under the auspices of local governments. Keicho (2020) argues that one of the biggest challenges to managing ECs in developing countries is weak local government capacity. Therefore, suitable evacuation site regulations and guidelines must be formulated in Malaysia to increase social resilience.

By providing the first analysis of EC site suitability in Kuantan, Pahang, this study can assist the relevant organisations with improving disaster preparedness and response. However, the study had a number of limitations, such as not examining differences in daytime and night time evacuation capabilities.

CHAPTER 5

DISCUSSION

5.1 Discussion

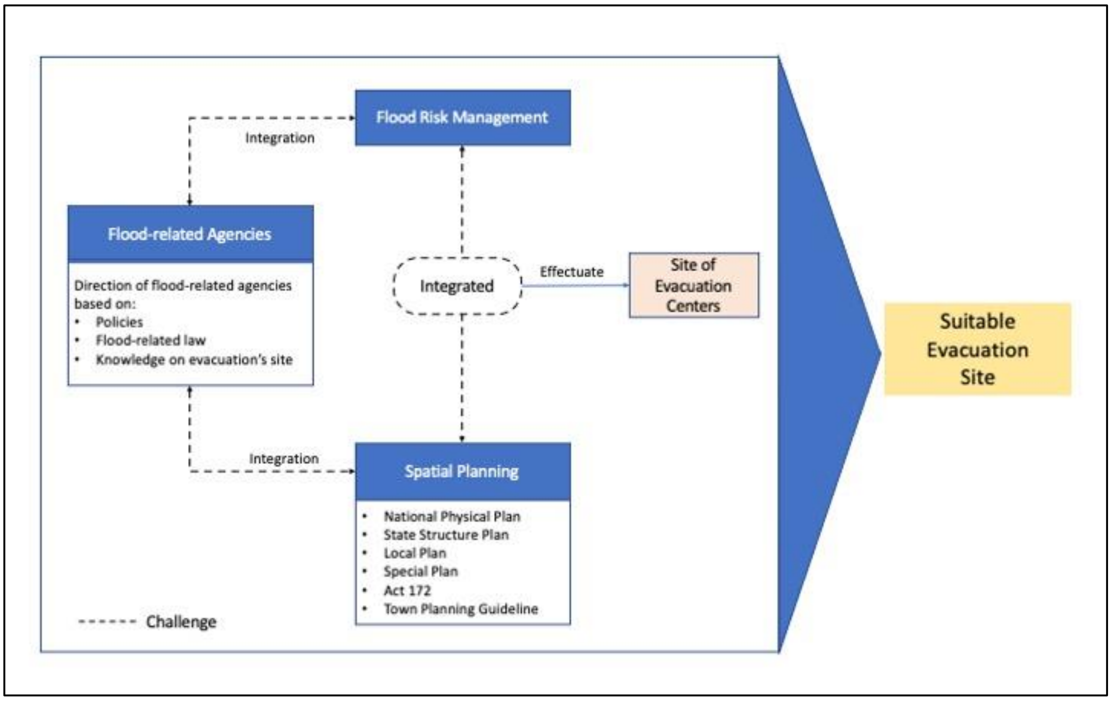

Figure 19: Conceptual framework from Chapter 2

This study followed the conceptual framework constructed in Chapter 2. Malaysia's flood-related agencies face various issues and challenges to achieving EC site suitability. Malaysia does not include evacuation siting in its official spatial plan. The lack of EC site suitability requirements in the Location Plan/FRM results from a lack of understanding between government agencies regarding the suitability of evacuation sites. In addition, Malaysia lacks policies related to emergency planning, resulting in less attention being paid to this matter. This has an impact on the application of appropriateness criteria when choosing or developing ECs. This lack of awareness leads to local government leaders being unwilling to enforce it.

In addition, according to the Planning Guidelines, schools and public halls must be situated in protected areas that are not flood-prone. However, the study found that 82% of ECs in Kuantan are located in flood-prone areas. This proves the need for substantial change in the Planning Guidelines and its implementation. Detailed site requirements should be included to ensure the secure siting of buildings. Because schools and public halls are transformed into ECs during disasters, these guidelines need to be revised.

The study also found a lack of collaborative risk sharing and risk management at all levels of government, making it difficult to incorporate resilience, with regard to evacuation site criteria, into spatial planning. This would require the involvement of local authorities with jurisdiction over land use development and building codes. The reason for this is that FRM and spatial planning are governed by two distinct groups in Malaysia. The first group consists of officers in the field of development, such as those employed by the Local Authority and Land and District Office, and officers in the field of flood risk, such as those employed by DID and NADMA. However, these two groups are in conflict due to a lack of risk sharing. There is also a lack of cooperation between agencies to implement state- and district level flood risk reduction measures, making it more difficult for the relevant spatial planning agencies to cooperate to implement flood risk reduction programmes.

Adequate FRM operations also suffer from insufficient funding and a lack of manpower and assets, in addition to communication barriers between agencies during the evacuation phase of flood response. However, the effective spatial planning of evacuation areas should be strongly linked to flood risk governance. Institutions and stakeholders must conduct urgent flood emergency planning and management so that residents in flood-prone areas can effectively respond to flooding. This study found that, among the challenges facing agencies, is the limited authority and lack of enforcement power to ensure that spatial planning is integrated with FRM. This has led to an increase in flood-prone areas and development that exposes populations to flood hazards.

Spatial plans and policies lack EC safe site criteria. The study identified 21% of ECs located at unsuitable sites that could expose evacuees to secondary risks. The total capacity of existing ECs is 29,700 people, even though the population at risk of flooding is 119,548, meaning that existing ECs can accommodate only 25% of the vulnerable population. The study found no guidelines or laws governing evacuation areas in Malaysia, and the siting of these shelters has not been based on scientific research. Furthermore, ECs fall under the jurisdiction of the Social Welfare Agency, which is not related to either the urban planning group or the FRM group. In addition, the Social Services Department was found to have a lack of awareness regarding the suitability of evacuation sites. This problem affects the application of the requirements for suitability when choosing or developing ECs. The lack of awareness made it undesirable for local government leaders to enforce it. Because of the lack of EC spatial planning and policy criteria, government officials are unaware of the need to check existing EC sites.

Tokyo's high standard (or super) levee serves as an example of how flood mitigation and preparedness can be conducted through the incorporation of spatial planning and urban redevelopment. In addition to their flood protection role, high standard levees serve as large evacuation areas that can accommodate a significant number of flood evacuees (Mabahwi & Nakamura, 2019; Mabahwi et al., 2019) and they are one of Japan's most important flood control activities (Atsumi, 2009). These levees also serve as an example of multisector cooperation in flood risk governance and spatial planning, involving river administration authorities and urban planning authorities. In addition, FRM in Japan is regulated by specific flood laws and certain laws have been revised to integrate spatial planning and FRM. For example, Japan's River Law originally included specific regulations for land use in river zones, but was revised in 1991 to allow portions of the top slope of high standard levees to be special development zones.

Strong governance policy and regulation, as included in the Policies for Protection from Extreme Floods, are key contributing factors to the integration of high standard levees with redevelopment planning. In addition, Japan has specific laws and policies to support FRM, and Japan's National Spatial Strategy specifically mentions evacuation. Furthermore, the Disaster Countermeasures Basic Act of 1961 states that, in their respective capacities, central and local governments and public corporations must be responsible for protecting land and property, and life and limb, against natural disasters. Japan also has a Disaster Relief Act, a Flood Fighting Act, and an Urban River Inundation Prevention Act, all of which play important roles in efficient flood management.

5.2 Direction of Flood-Related Agencies

Flood-related organisations must have a clear direction to create resilience and mitigate flood risk. To achieve this, the government must change its executive orders, regulations and flood management policies to handle flood risk in an acceptable manner. A new Flood Act or River Act must be passed that specifically addresses flood prevention and control. It is also recommended that current policies are changed or that new national policies are established that deal specifically with evacuation. Newly designed strategies must be integrated into urban planning legislation to improve the resilience of neighbourhood floods. This will ensure the scientific analysis of the suitability of ECs. Malaysia currently uses Directive No. 20 as the basis for FRM. Therefore, in order to set clear standards for evacuation among the relevant agencies, Directive No. 20 must include a comprehensive framework for multi-agency collaboration. In addition to amending policies, organisations must explore ways to determine the prospects of new policies with regard to their technological, organisational, fiscal and political viability. Developing multi-agency coordination is vital to the management of flood risk, as it ensures that organisations work towards the same resilience objectives.

5.3 Amending Planning System

None of Malaysia's spatial plans or planning guidelines currently include evacuation considerations. Therefore, the following recommendations can assist in the inclusion of EC site suitability in the formulation of spatial plans.

The amendment of spatial plans to include EC site criteria must be comprehensive and begin from the first base of spatial planning, the NPP. The planning thrust and aim of the NPP must be refined to more specifically focus on community resilience by considering the geo-spatial criteria for the safe location of ECs. This resilience-evacuation aim of the NPP can then be translated into the State Structure Plan. SSP Pahang, for example, would then include planning elements for ECs in flood-prone districts and describes the key policies, plans for development and land use for the state.

By revising the NPP and SSP Pahang to include EC site criteria, the Kuantan District Local Plan could be formulated or amended with specific local EC criteria. This could be implemented through the authority of the Kuantan Municipal Council (i.e., the Kuantan local authority) to gazette buildings or land for public facilities. Planning guidelines must also be amended to include EC site criteria in the Local Plan. In so doing, the criteria for safe EC sites can be included in the Development Proposal Report that must be submitted when applying for planning permission. This would ensure that all new developments at or near flood-prone areas would be obliged to incorporate ECs into their plans. Figure 20 outlines these suggestion for the inclusion of EC site criteria in the Local Plan.

As planning permission must comply with planning guidelines, school and public hall planning guidelines needs to be revised, because these facilities are currently used as collective shelters in Kuantan. The Development and Implementation Guidelines include elements of development planning that need to be taken into account and complied with in order to obtain planning permission approval within the Kuantan District Local Plan 2035 (Substitution) region. These guidelines consist of General Guidelines and Particular Guidelines in support of the proposed map and written statement provided in Volume II of the Kuantan District Local Plan 2035 (Substitution). This comprises a range of important elements that direct those authorities and agencies involved in the implementation of the development proposals set out in the local plan.

The Standards and Planning Development Guidelines are employed by the Kuantan Municipal Council for the processing and decision-making of planning permission applications. The specifics cover different aspects of construction, such as relocation and distance between buildings, building height, building façade, the inclusion of public services, landscaping, open space and parking. This study recommends revising these guidelines for school and public hall sites, as there are currently no specific guidelines for flood shelters.

The implementation of development guidelines in Kuantan District is based on the guidelines, planning and development standards in PLANMalaysia and adopted by the Pahang State Government. Based on the study, the following are recommendations to improve the planning guidelines for schools and public facilities. EC site suitability criteria should be added to the planning guidelines for all school and public halls. Currently, the site criteria are too general and do not include geo-spatial criteria or EC site suitability, even though these buildings are usually used as ECs during disasters. By adding EC site criteria, these dual facility buildings will be developed in areas suitable for ECs.

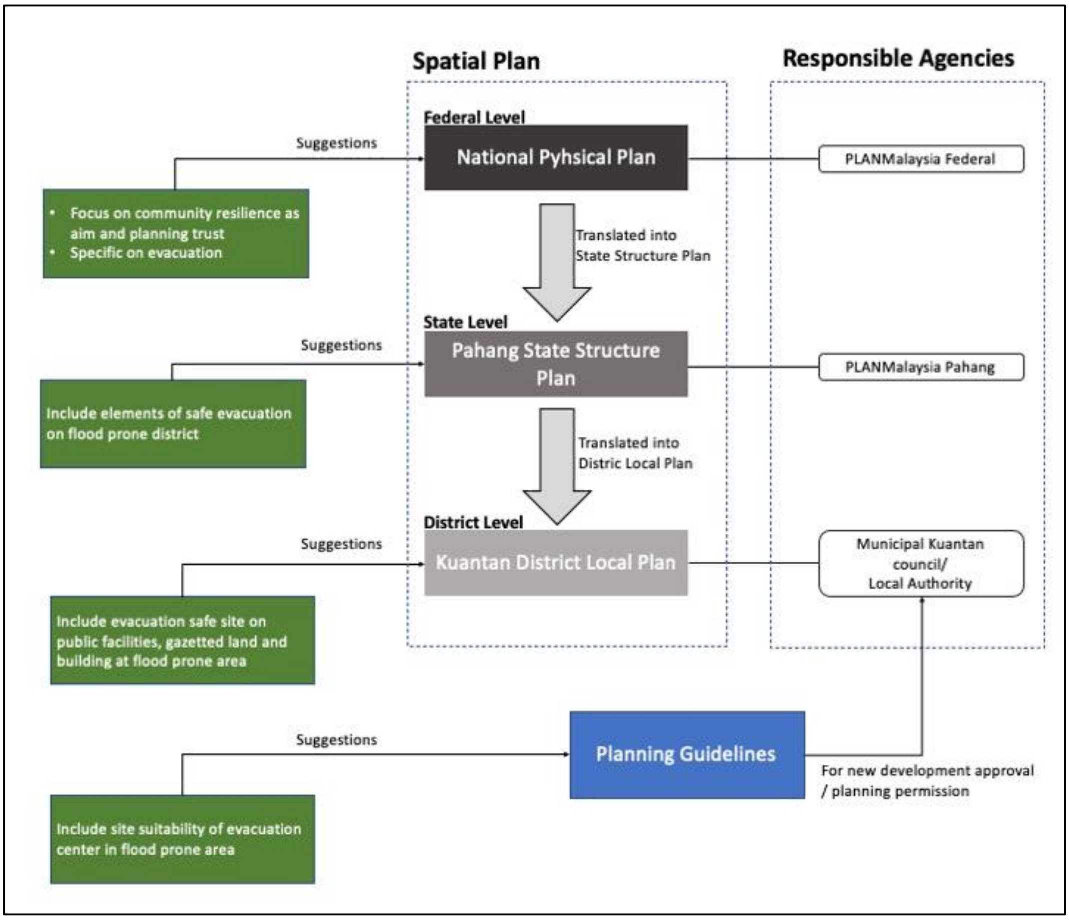

Figure 20: Suggestions to amend spatial plan relationship with ECs

Table 9: Existing public guidelines and suggestions to include evacuation site suitability elements

Planning Guideline	Secondary School	Primary School	Multipurpose Halls	Public Halls
Population	Exceeds 9,000 for 2 or 3 neighbourhood	3,000 – 7,500 population	10,000 population (urban area)	3,000 – 10,000 population (urban area, sub-district)
Site Criteria	• 0.4 – 0.8 km / 5 – 10 minutes' distance from the farthest house • Far from main junction • Accessible by public transportation	• 0.4 – 0.8 km / 5 – 10 minutes' distance from the farthest house • Far from main junction • Accessible by public transportation	Walking distance: 800 metre or 15 minutes Driving distance: 15 minutes	
Site size (minimum)	3.0 – 6.0 hectare (9-15 acre)	2.0 – 4.0 hectare (5-10 acre)	1.2 hectare (3 acre)	0.4 hectare
Suggestions on site criteria	• Located away from disasters prone area • Located on high elevated land and on slopes preferably between 2% and 5% and not exceeding 7% • Located far from hazardous industrial area			

5.4 Research Limitations

It is important to address the limitations of this study. First, the study included a limited number of participants. This might limit the transferability of the results to more comprehensive contexts. Second, the evacuation study was limited to GIS-based geo-spatial criteria and did not analyse road conditions and vulnerability based on age, gender or disability. Third, the AHP variable was also based solely on geo-spatial site suitability criteria. Fourth, network analysis was conducted in the absence of a consideration of human factors. This study did not focus on accessibility analysis, as the scope of study was on geo-spatial analysis. It is highly recommended that future research fills these gaps. In conclusion, a number of issues remain unexplored with regard to how the Malaysian government can be urged to integrate spatial planning and FRM.

5.5 Thesis Contributions

This is the first study to identify and examine the site suitability of ECs in Kuantan, a district that has been classified by the National Physical Plan as at high risk of flooding. As such, this research makes an original contribution to the State of Pahang and, in particular, to the District of Kuantan. It provides the foundational steps to helping the nation to increase flood resilience, by attempting to assist decision-makers and serving as a valuable guide for designing and strengthening EC spatial plans to reduce disaster vulnerability. The evaluation included in this research will provide a reference point for improving disaster preparedness and mitigation and, thus, achieve more effect response to disasters in the future. Designated evacuation services can be effectively distributed and coordinated based on the findings of this research. The availability of information on unsuitable and suitable sites will enable local authorities and policy makers to make decisions on the geographical positioning of ECs. In addition, the study contributes to the improvement of the National Physical Plan, by recommending the amendment of flood-related laws and regulations and the addition of evacuation site criteria to the Local Plan.

CHAPTER 6

OVERALL CONCLUSION AND RECOMMENDATIONS

In Malaysia, institutional heterogeneity, including discrepancies between national and local goals and strategies, or conflicting or inconsistent policies, make it difficult to integrate urban planning with FRM. A lack of flood-related regulations to manage flood events also contributes to a lack of authority and enforcement power. Malaysia should adapt risk sharing cooperation mechanisms to connect organisations and agencies and should establish collaborative FRM structures to minimise the current shift away from accountability. In this way, direct and indirect coordination between flood-related entities will begin to take place.

Currently, evacuation site criteria are not included in the primary policy guiding physical development. In addition, development planning proposals submitted to local authorities are not required to include details of safe evacuation sites, and evacuation elements have not been included in the Local Plan. Amending current legislation, the Planning Guidelines, and requiring the inclusion of EC site suitability criteria in planning permission applications will contribute to the inclusion of elements of site suitability in spatial planning. All of this must be supported by laws, regulation and enforcement and can be achieved through the formulation of national policies or the amendment of Directive No. 20 Act 172, the Town and Country Planning Act and Planning Guideline.

In addition to the amendment of legislation, specific measures to ensure the geo-spatial siting of ECs must be included in the country's three-tier spatial plan. To ensure this, an executive order must be issued directing the state, district governments and local authorities to consider emergency planning in all developments. Spatial plans must include the element of evacuation, especially in flood-prone areas. It is also highly recommended that gazetted safe land and buildings are included as ECs in all local plans.

Currently, only 47% of the ECs in the flood-prone city of Kuantan are appropriately located, due to the department responsible for the choosing and management of ECs having no affiliation with FRM or urban planning. There is also a lack of understanding of EC site suitability criteria among the departments and officers involved. This lack of understanding made it undesirable for local government leaders to enforce it. The selection of ECs is, therefore, made without accounting for geo-spatial characteristics.

The Malaysian Government must take action to increase the number of ECs in order to protect vulnerable residential areas. It is recommended that local authorities strengthen their evacuation capacity by adding more floors through the renovation of existing shelters and increase the number of ECs. It is also recommended that state governments provide subsidies to residents living in floodplain areas to elevate their houses. This will ensure that Malaysia can employ the concept of 'shelter in place'. In this way, the capacity of ECs can be improved.

Lastly, this study's detailed investigation into increasing evacuation capacity, identifying suitable EC sites and suggestions for the effective integration of FRM with spatial planning will benefit future research. I hope this study will guide amendments to the National Physical Plan, the State Structure Plan and the Local Plan through the incorporation of geo-spatial criteria for the location of ECs and that local authorities will take EC site suitability as a serious matter to ensure community resilience.

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